Office of National Marine Sanctuaries
Office of Response and Restoration

Screening Level Risk Assessment Package

Fernstream

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National Oceanic and
Atmospheric Administration

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Table of Contents

Project Background

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

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

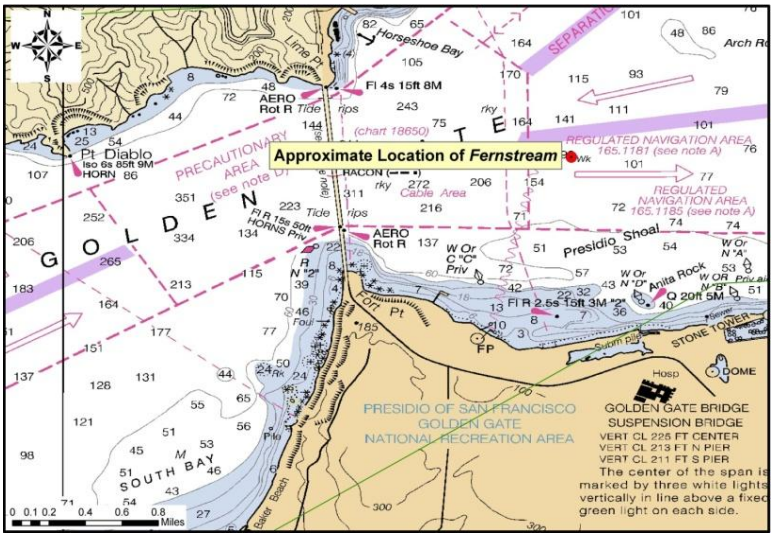
The potential polluting shipwrecks were identified through searching a broad variety of historical sources. NOAA then worked with Research Planning, Inc., RPS ASA, and Environmental Research Consulting to conduct the modeling forecasts, and the ecological and environmental resources at risk assessments.

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

Additional ongoing research has revealed that 87 wrecks pose a potential pollution threat due to the violent nature in which some ships sank and the structural reduction and demolition of those that were navigational hazards. To further screen and prioritize these vessels, risk factors and scores have been applied to elements such as the amount of oil that could be on board and the potential ecological or environmental impact.

Executive Summary: *Fernstream*

The motor vessel *Fernstream*, sunk after a collision just inside the Golden Gate, San Francisco in 1952, was identified as a potential pollution threat, thus a screening-level risk assessment was conducted. The different sections of this document summarize what is known about the *Fernstream*, 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, *Fernstream* scores High with 15 points; for the Most Probable Discharge (10% of the Worse Case volume), *Fernstream* scores Medium with 13 points. Given these scores, and higher level of data certainty, NOAA recommends that this site be reflected within the Area Contingency Plans and be considered for further assessment to determine the vessel condition, amount of oil onboard, and feasibility of oil removal action. At a minimum an active monitoring program should be implemented. Outreach efforts with 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.

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Vessel Risk Factors		Risk Score	
Pollution Potential Factors	A1: Oil Volume (total bbl)	Med	
	A2: Oil Type		
	B: Wreck Clearance		
	C1: Burning of the Ship		
	C2: Oil on Water		
	D1: Nature of Casualty		
	D2: Structural Breakup		
Archaeological Assessment	Archaeological Assessment	Not Scored	
Operational Factors	Wreck Orientation	Not Scored	
	Depth		
	Confirmation of Site Condition		
	Other Hazardous Materials		
	Munitions Onboard		
	Gravesite (Civilian/Military)		
	Historical Protection Eligibility		
		WCD	MP (10%)
Ecological Resources	3A: Water Column Resources	Med	Low
	3B: Water Surface Resources	Med	Med
	3C: Shore Resources	Med	Low
Socio-Economic Resources	4A: Water Column Resources	Low	Low
	4B: Water Surface Resources	High	High
	4C: Shore Resources	High	High
Summary Risk Scores		15	13

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

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

Vessel Particulars

Official Name: *Fernstream*

Official Number: Unknown

Vessel Type: Freighter

Vessel Class: N/A

Former Names: N/A

Year Built: 1949

Builder: Eriksbergs Varv, Goteborg (Gothenburg)

Builder's Hull Number: Unknown

Flag: Norwegian

Owner at Loss: Glittre A/S, Oslo (Old Christiania) (Fearnley & Eger. Managers)

Controlled by: N/A **Chartered to:** N/A

Operated by: Unknown

Homeport: Oslo, Norway

Length: 416 feet **Beam:** 58 feet **Depth:** 25 feet

Gross Tonnage: 4980 **Net Tonnage:** 2796

Hull Material: Steel **Hull Fastenings:** Unknown **Powered by:** Oil Engines

Bunker Type: Medium Fuel Oil (Marine Diesel) **Bunker Capacity (bbl):** Unknown

Average Bunker Consumption (bbl) per 24 hours: Unknown

Liquid Cargo Capacity (bbl): N/A **Dry Cargo Capacity:** Unknown

Tank or Hold Description: Unknown

Casualty Information

Port Departed: San Francisco, CA

Destination Port: Manila, Philippines

Date Departed: December 11, 1952

Date Lost: December 11, 1952

Number of Days Sailing: 1

Cause of Sinking: Collision with freighter *Hawaiian Rancher*

Latitude (DD): 37.82

Longitude (DD): -122.4596

Nautical Miles to Shore: 0.82

Nautical Miles to NMS: 4.25

Nautical Miles to MPA: 0.66

Nautical Miles to Fisheries: Unknown

Approximate Water Depth (Ft): 150

Bottom Type: Unknown

Is There a Wreck at This Location? Yes, although the precision of these coordinates is not known

Wreck Orientation: Unknown

Vessel Armament: None

Cargo Carried when Lost: 3,000 tons of soy beans and general cargo including mail

Cargo Oil Carried (bbl): 0

Cargo Oil Type: N/A

Probable Fuel Oil Remaining (bbl): Unknown ≤ 12,500

Fuel Type: Medium Fuel Oil (Diesel)

Total Oil Carried (bbl): ≤ 12,500

Dangerous Cargo or Munitions: No

Munitions Carried: None

Demolished after Sinking: No

Salvaged: No

Cargo Lost: Yes

Reportedly Leaking: No

Historically Significant: Unknown

Gravesite: No

Salvage Owner: Not known if any

Wreck Location

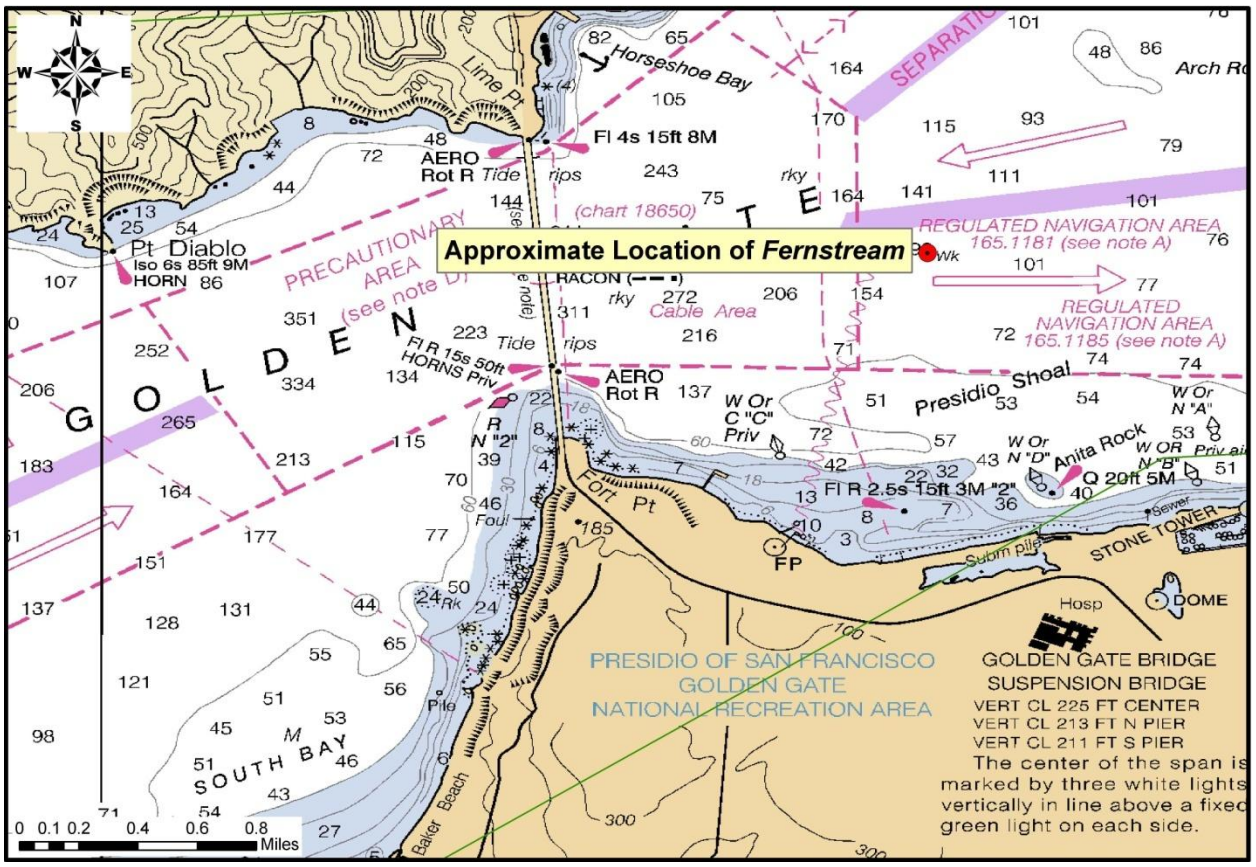

Chart Number: 18649

Casualty Narrative

"On 11 December 1952, the SS *Hawaiian Rancher*, a cargo vessel of 8,353 gross tons, was inbound in San Francisco Bay and proceeding to an anchorage, and the MV *Fernstream* (Norwegian) was outbound proceeding to sea. The weather was foggy, with visibility from 1/4 to 7/10 mile, and the sea calm. Both vessels were sounding regulation fog signals and their respective radars were manned by competent personnel. While proceeding on various courses and speeds, errors in judgment of course and speed were made and both vessels collided at 0730, 11 December 1952, in position 121 degrees True, 0.8 miles from Lime Point Lighthouse. The *Fernstream* sank with no loss of life and the *Hawaiian Rancher* suffered bow damage.

The *Fernstream* departed from the north side of pier 22 at about 0652 on 11 December 1952, bound for Manila, Philippines Islands. It carried 42 crew, 11 persons in addition to the crew and was fully loaded with 6,378 tons of cargo, consisting of 3,000 tons of soybeans in bulk, the balance general cargo and mail. The draft on the departure was 23'09" forward and 28' 00" aft. (25' 101/2" mean). The *Fernstream* was loaded down to one inch above it allowable load line. The vessels collided at an angle of about 20 degrees. The port bow and stem of the *Hawaiian Rancher* first come in contact with the port side of the *Fernstream* just abaft the bridge, damaging the lifeboat and superstructure. It penetrated the hull at the after part of the engine room, damaging the watertight bulkhead to No. 4 hold. The bow of the *Hawaiian*

Rancher withdrew from the hole in the *Fernstream* within a few seconds. The *Fernstream* had one or two knots headway when the collision occurred. After the collision, the *Fernstream*'s engine room crew had no time to close the watertight door to the shaft alley. Its power failed immediately and the *Hawaiian Rancher* radioed a message which was intercepted by the U.S. Coast Guard Fort Point Lifeboat Station. The *Hawaiian Rancher* immediately lowered a lifeboat to assist and stood close by. “
-U.S. Coast Guard Report, Washington DC, 8 May 1953 [in part] (summary by Robert Schwemmer, NOAA)

General Notes

AWOIS Data:

CL44/53--SAME AS NM4/53. H9793/78--OPR-L123-RA-78; WK LOCATED IN LAT 37-49-12.5N, LONG 122-27-31.0W, 99FT ECHOSOUNDER DEPTH ACQUIRED IS NOT NECESSARILY LEAST DEPTH, RECOMMENDS RETAIN CHARTED SWEPTED DEPTH IN LOCATION OF PRESENT SURVEY, DELETE (PA). (UPDATED 8/87 RWD) H10456/93--WK NOT INVESTIGATED, CARRIED FORWARD AS 30.2M. (UPDATED 1/95 RWD)

DESCRIPTION 24 NO.1368; 4980 GT, SUNK 12/25/52, WD CLEARED TO 60 FT, POS ACCURACY 1 MILE AT LAT.37-49-12N, LONG.122-29-29W.

Wreck Condition/Salvage History

Unknown; however, wreck is probably in good condition since it was determined to be too deep to be a hazard to navigation and was not demolished.

Archaeological Assessment

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

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

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

Assessment

No archaeological assessment was prepared for *Fernstream*. Records relating to the loss of the vessel were not part of the National Archives record groups examined by NOAA archaeologists. Since the shipwreck is located within San Francisco Bay, it is likely that the local U.S. Coast Guard District or Sector may have access to more records about this wreck than are available at the National Archives. This means that the best assessment on the sinking of the ship probably still comes from the U.S. Coast Guard's Marine Board of Investigation Report written about this vessel.

Background Information References

Vessel Image Sources: N/A

Construction Diagrams or Plans in RULET Database? No

Text References:
AWOIS database #50112
CA Lands database #1435
http://www.uscg.mil/hq/cg5/docs/boards/hawaiianrancher.pdf
Google newspapers

Vessel Risk Factors

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

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

Each risk factor is characterized as 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

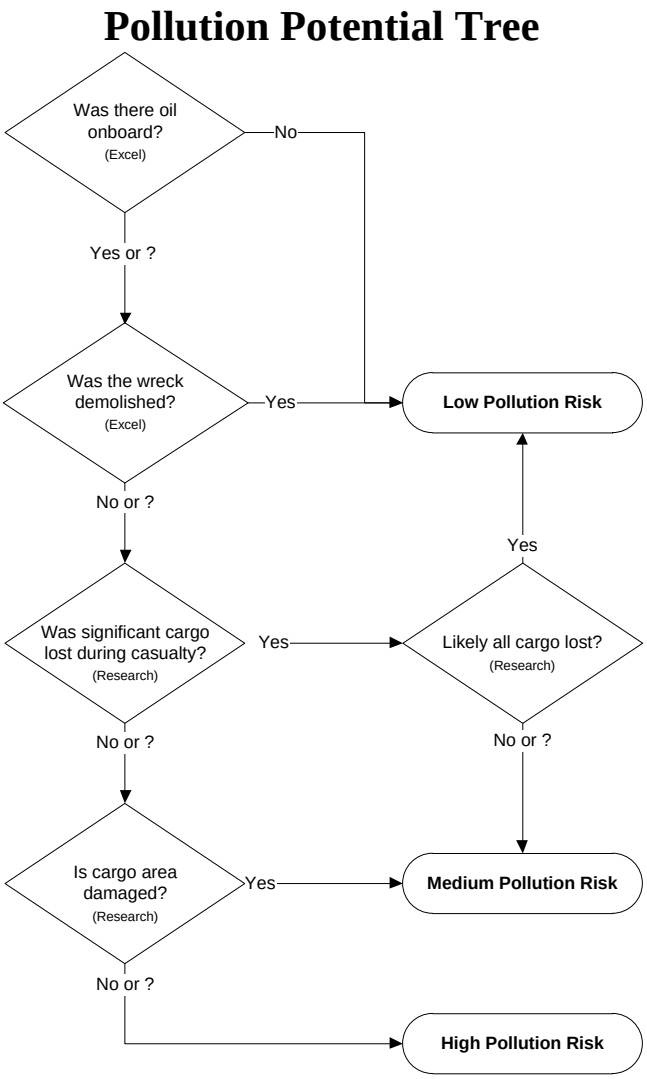

Figure 1-1: U.S. Coast Guard Salvage Engineering Response Team (SERT) developed the above Pollution Potential Decision Tree.

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 *Fernstream* 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 *Fernstream i*s ranked as High Volume because it is thought to have a potential for up to 12,500 bbl, although some of that may have been lost at the time of the casualty or since the vessel sank. Data quality is low because the exact bunker capacity of *Fernstream* is not known.

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

Risk Factor A2: Oil Type

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

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

The *Fernstream* is classified as Medium Risk because the bunker oil is diesel oil, a Group II oil type. Data quality is high.

Was the wreck demolished?

Risk Factor B: Wreck Clearance

This risk factor addresses whether or not the vessel was historically reported to have been demolished as a hazard to navigation or by other means such as depth charges or aerial bombs. This risk factor is based on

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

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 *Fernstream* 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 *Fernstream* 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 *Fernstream* is classified as High Risk because no oil is known to have been reported spreading across the water as the vessel went down. Data quality is low because complete sinking reports were not located.

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 *Fernstream* is classified as High Risk because it sank as the result of a collision. 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 *Fernstream* is classified as High Risk because the vessel is not broken into multiple pieces and remains as one contiguous piece. Data quality is high.

Factors That May Impact Potential Operations

Orientation (degrees)

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

The *Fernstream* is believed to be resting on one side. Data quality is medium.

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 *Fernstream* is approximately 150 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 *Fernstream* is known and charted. 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 *Fernstream* did not carry any munitions. Data quality is high.

Vessel Risk Factors Summary

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

Table 1-1: Summary matrix for the vessel risk factors for the *Fernstream*.

Vessel Risk Factors		Data Quality Score	Comments	Risk Score
Pollution Potential Factors	A1: Oil Volume (total bbl)	Low	Maximum of 12,500 bbl, not reported to be leaking	**Med**
	A2: Oil Type	Medium	Bunker oil is diesel oil, a Group II 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	Low	No oil was known to have been reported on the water	
	D1: Nature of Casualty	High	Collision	
	D2: Structural Breakup	High	The vessel remains in one contiguous piece	
Archaeological Assessment	Archaeological Assessment	Low	The best sinking assessment still comes from the U.S. Coast Guard Marine Board of Investigation so a detailed assessment was not prepared	**Not Scored**
Operational Factors	Wreck Orientation	Medium	Believed to be on one side	**Not Scored**
	Depth	High	150 ft	
	Visual or Remote Sensing Confirmation of Site Condition	High	Location is known and charted	
	Other Hazardous Materials Onboard	High	No	
	Munitions Onboard	High	No	
	Gravesite (Civilian/Military)	High	No	
	Historical Protection Eligibility (NHPA/SMCA)	Medium	Possibly NHPA	

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 *Fernstream* this would be 13,000 bbl (rounded up from 12,500 bbl) based on estimates of the maximum amount of oil remaining onboard the wreck at the time the models were run.

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

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

The model results here are based on running the RPS ASA Spill Impact Model Application Package (SIMAP) two hundred times for each of the five spill volumes shown in Table 2-1. The model randomly selects the date of the release, and corresponding environmental, wind, and ocean current information from a long-term wind and current database. When a spill occurs, the trajectory, fate, and effects of the oil will depend on environmental variables, such as the wind and current directions over the course of the oil release, as well as seasonal effects. The magnitude and nature of potential impacts to resources will also generally have a strong seasonal component (e.g., timing of bird migrations, turtle nesting periods, fishing seasons, and tourism seasons).

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

Scenario Type	Release per Episode	Time Period	Release Rate	Relative Likelihood	Response Tier
Chronic (0.1% of WCD)	13 bbl	Fairly regular intervals or constant	100 bbl over several days	More likely	Tier 1
Episodic (1% of WCD)	130 bbl	Irregular intervals	Over several hours or days	Most Probable	Tier 1-2
Most Probable (10% of WCD)	1,300 bbl	One-time release	Over several hours or days	Most Probable	Tier 2
Large (50% of WCD)	6,500 bbl	One-time release	Over several hours or days	Less likely	Tier 2-3
Worst Case	13,000 bbl	One-time release	Over several hours or days	Least likely	Tier 3

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

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

It is important to acknowledge that these scenarios are only for this screening-level assessment. Detailed site/vessel/and seasonally specific modeling would need to be conducted prior to any intervention on a specific wreck.

Oil Type for Release

The *Fernstream* contained marine diesel (a Group II oil) as fuel. Thus, the oil spill model was run using light fuel oil.

Oil Thickness Thresholds

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

For oil stranded onshore, a thickness of 1 g/m^2 was used as the threshold for socio-economic impacts because that amount of oil would conservatively trigger the need for shoreline cleanup on amenity beaches. A thickness of 100 g/m^2 was used as the threshold for ecological impacts based on a synthesis of the literature showing that shoreline life has been affected by this degree of oiling.[2] Because oil often strands onshore as tarballs, Table 2-2a 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 will be determined by the volume of leakage. Because oil from sunken vessels will be released at low pressures, the droplet sizes will be large enough for the oil to float to the surface. Therefore, impacts to water column resources will result from the natural dispersion of the floating oil slicks on the surface, which is limited to about the top 33 feet. The metric used for ranking impacts to the water column is the area of water surface in mi^2 that has been contaminated by 1 part per billion (ppb) oil to a depth of 33 feet. At 1 ppb, there are likely to be impacts to sensitive organisms in the water column and potential tainting of seafood, so this concentration is used as a screening threshold for both the ecological and socio-economic risk factors for water column resource impacts. To assist planners in understanding the scale of potential impacts for different leakage volumes, a regression curve was generated for the water column volume oiled using the five volume scenarios, shown in Figure 2-1. Using this figure, the water column impacts can be estimated for any spill volume.

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

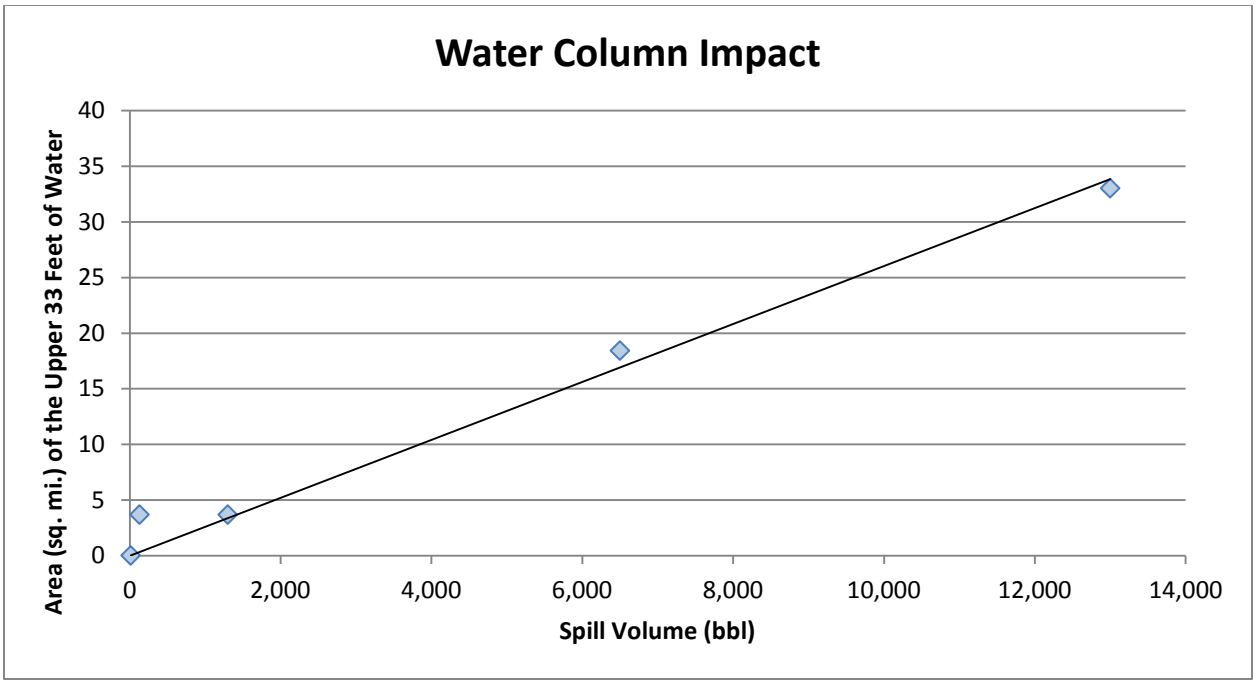

Figure 2-1: Regression curve for estimating the volume of water column impacted at or above 1 ppb aromatics as a function of spill volume for the *Fernstream*.

Potential Water Surface Slick

The slick size from an oil release from the *Fernstream* is a function of the quantity released. The estimated water surface coverage by a fresh slick (the total water surface area "swept" by oil over time) for the various scenarios is shown in Table 2-3, as the mean result of the 200 model runs. Note that this is an estimate of total water surface affected over a 30-day period. The slick will not be continuous but rather be broken and patchy due to the subsurface release of the oil. Surface expression is likely to be in the form of sheens and streamers.

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

Scenario Type	Oil Volume (bbl)	Estimated Slick Area Swept Mean of All Models	
		0.01 g/m²	10 g/m²
Chronic	13	45 mi²	20 mi²
Episodic	130	497 mi²	156 mi²
Most Probable	1,300	500 mi²	156 mi²
Large	6,500	1,260 mi²	310 mi²
Worst Case Discharge	13,000	1,940 mi²	530 mi²

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

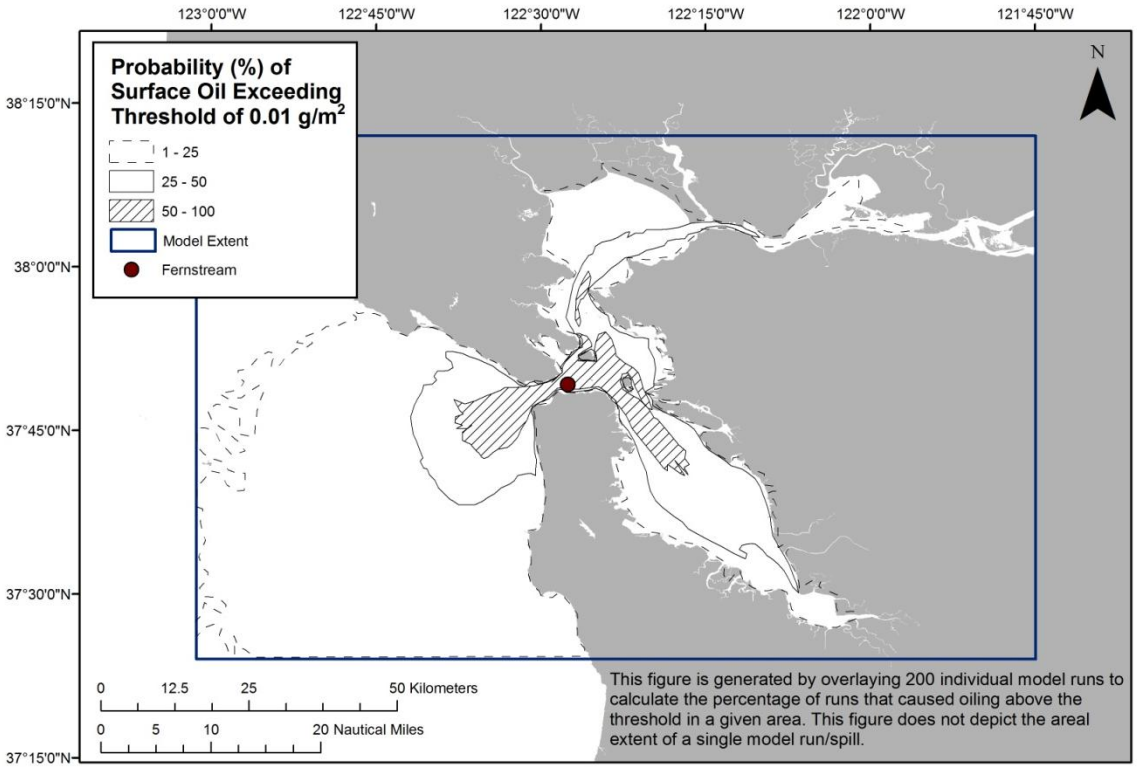

Figure 2-2: Probability of surface oil (exceeding 0.01 g/m^2) from the Most Probable spill of 1,300 bbl of light fuel oil from the *Fernstream* at the threshold for socio-economic resources at risk.

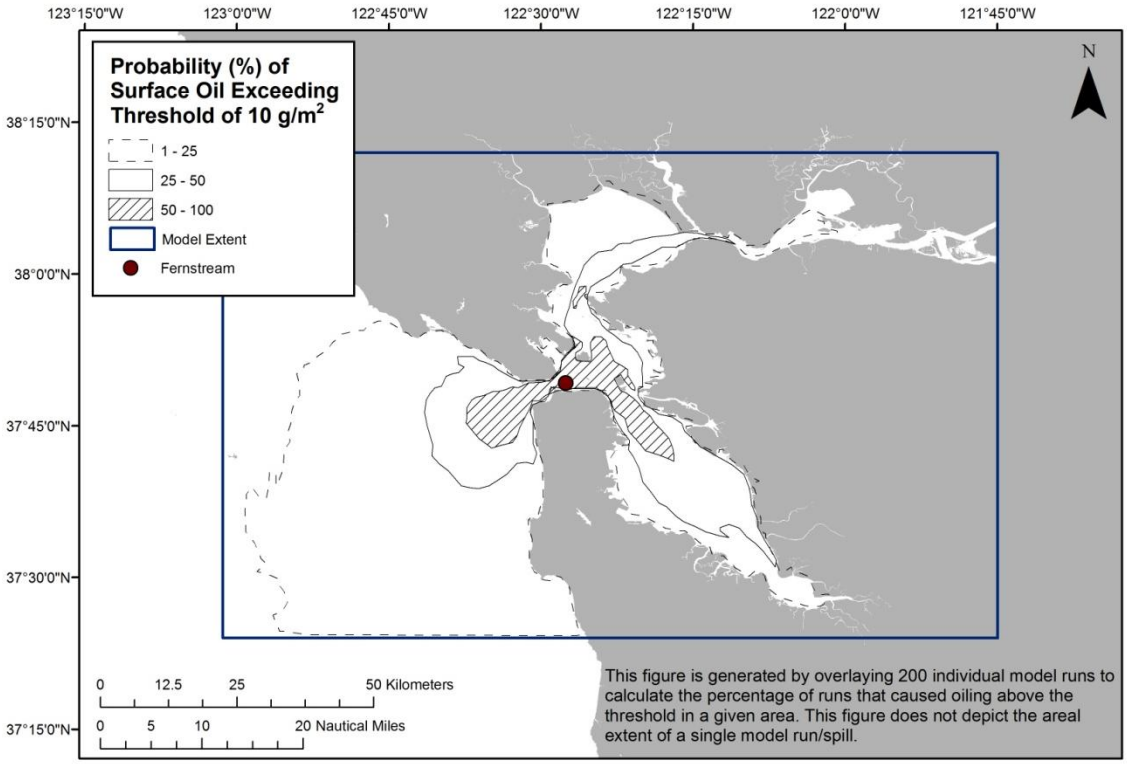

Figure 2-3: Probability of surface oil (exceeding 10 g/m^2) from the Most Probable spill of 1,300 bbl of light fuel oil from the *Fernstream* at the threshold for ecological resources at risk.

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

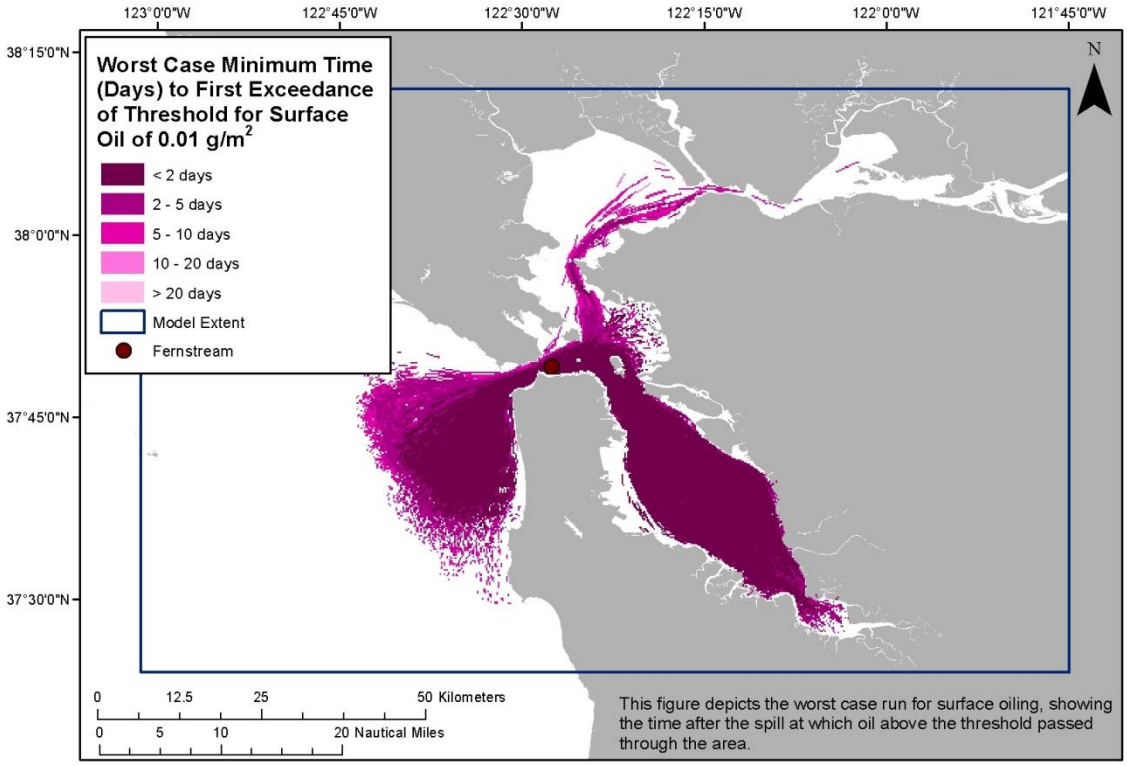

Figure 2-4: Water surface oiling from the Most Probable spill of 1,300 bbl of light fuel oil from the *Fernstream* shown as the area over which the oil spreads at different time intervals.

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

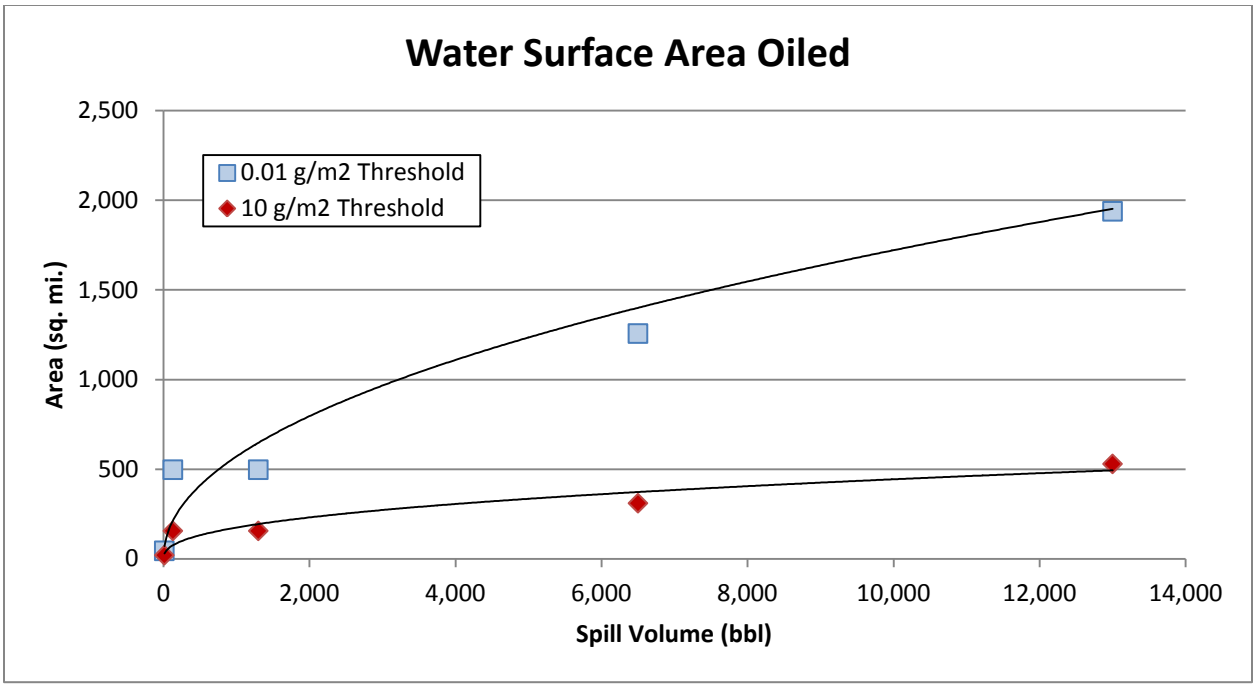

Figure 2-5: Regression curve for estimating the amount of water surface oiling as a function of spill volume for the *Fernstream*, showing both the ecological threshold of 10 g/m^2 and socio-economic threshold of 0.01 g/m^2.

Potential Shoreline Impacts

Based on these modeling results, shorelines f along all of San Francisco Bay and the outer shore from Bolinas Head to Half Moon Bay are at risk. Figure 2-6 shows the probability of oil stranding on the shoreline at concentrations that exceed the threshold of 1 g/m^2, for the Most Probable release of 1,300 bbl. However, the specific areas that would be oiled will depend on the currents and winds at the time of the oil release(s), as well as on the amount of oil released. Figure 2-7 shows the single oil spill scenario that resulted in the maximum extent of shoreline oiling for the Most Probable volume. Estimated miles of shoreline oiling above the threshold of 1 g/m^2 by scenario type are shown in Table 2-4.

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

Scenario Type	Volume (bbl)	Estimated Miles of Shoreline Oiling Above 1 g/m^2			
		Rock/Gravel/Artificial	Sand	Wetland/Mudflat	Total
Chronic	13	0	0	0	0
Episodic	130	10	0	1	11
Most Probable	1,300	10	0	1	11
Large	6,500	17	1	5	23
Worst Case Discharge	13,000	20	2	9	32

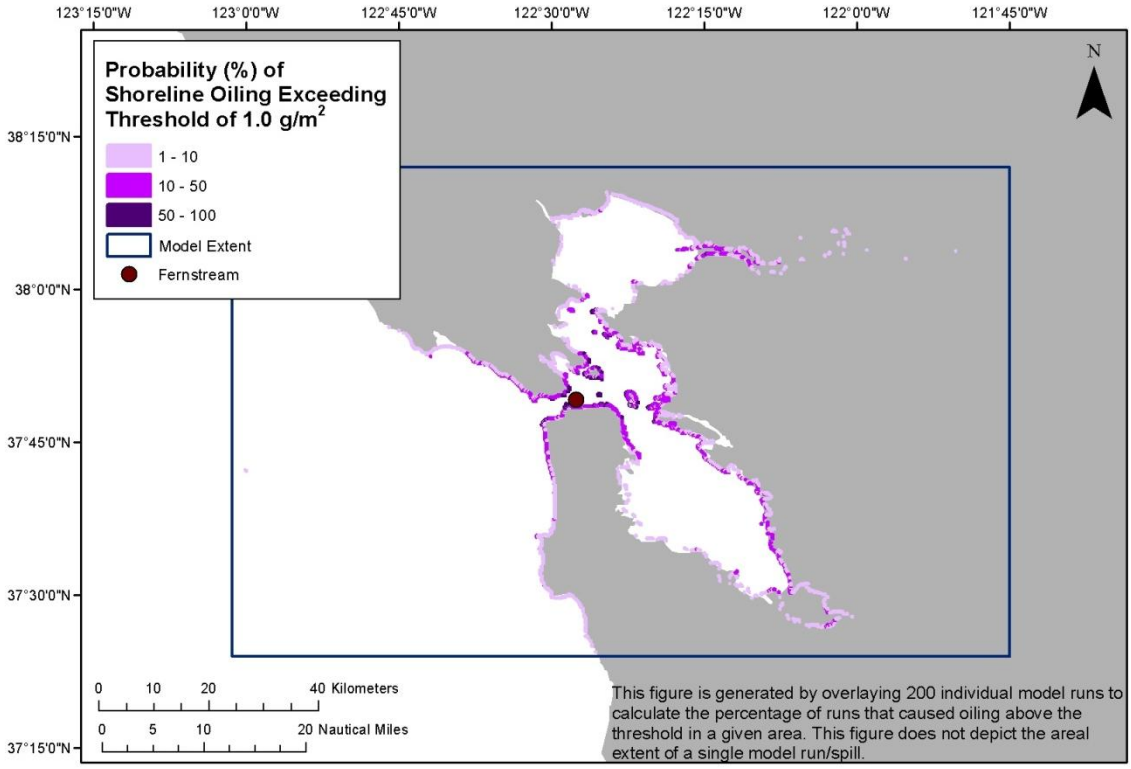

Figure 2-6: Probability of shoreline oiling (exceeding 1.0 g/m^2) from the Most Probable Discharge of 1,300 bbl of light fuel oil from the *Fernstream*.

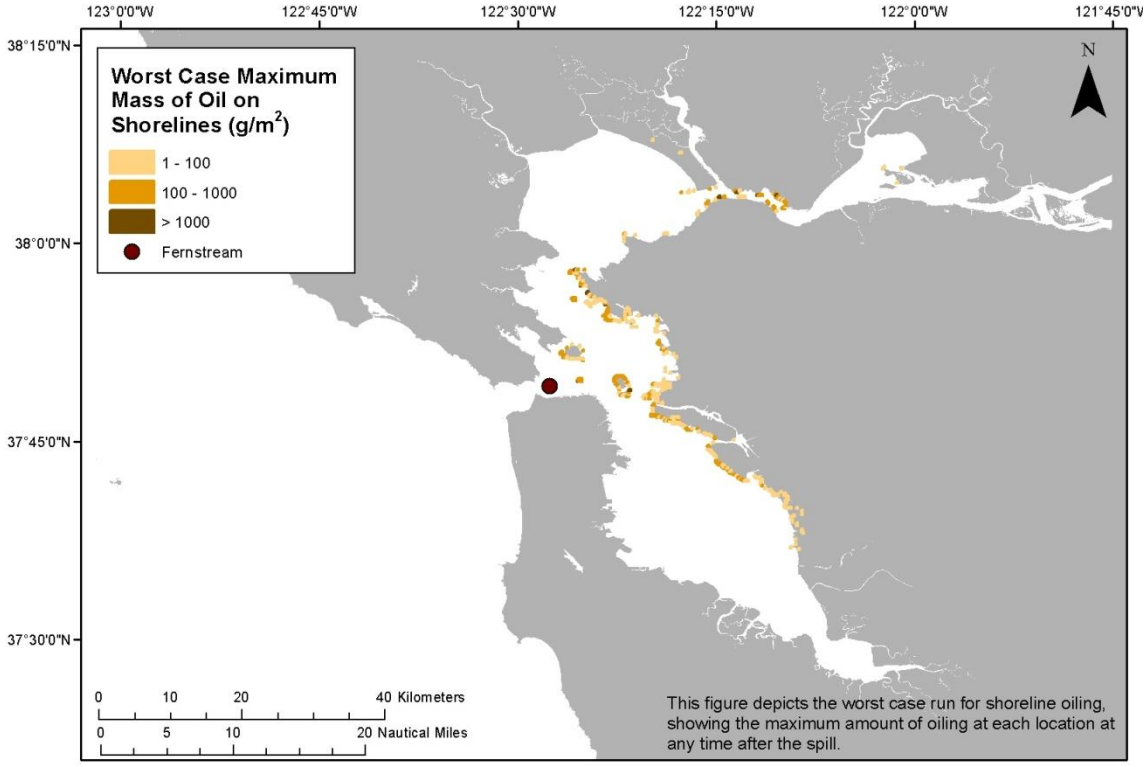

Figure 2-7: The extent and degree of shoreline oiling from the single model run of the Most Probable Discharge of 1,300 bbl of light fuel oil from the *Fernstream* that resulted in the greatest shoreline oiling.

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

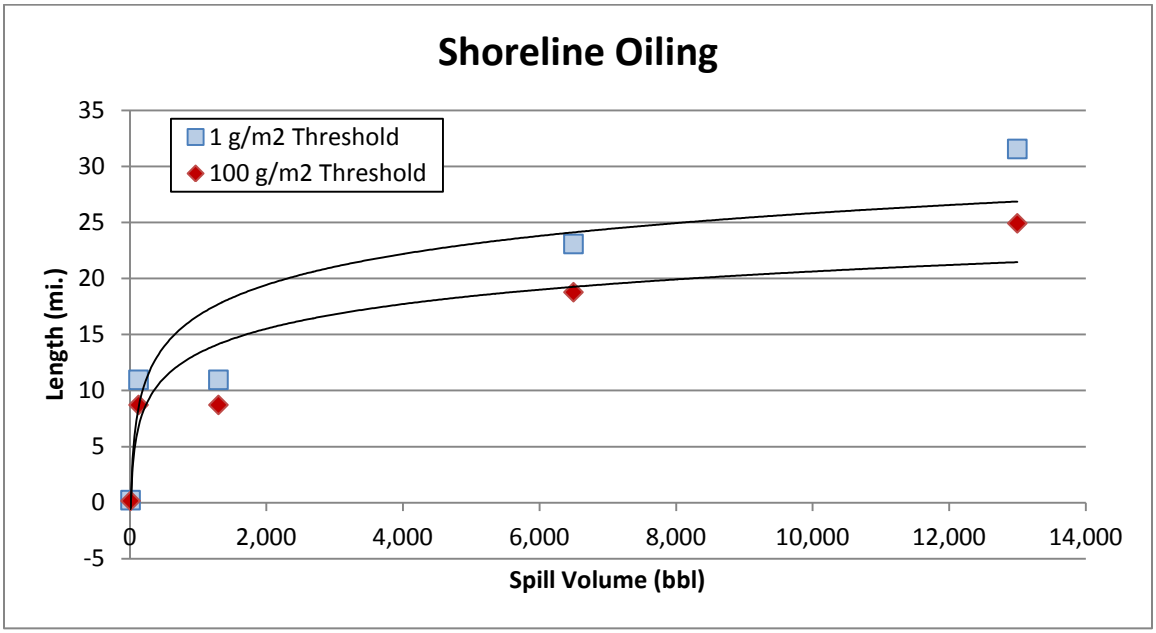

Figure 2-8: Regression curve for estimating the amount of shoreline oiling at different thresholds as a function of spill volume for the *Fernstream*.

The worst case scenario for shoreline exposure along the potentially impacted area for the WCD volume (Table 2-5) and the Most Probable volume (Table 2-6) consists primarily of rocky and artificial shores and gravel beaches. Salt marshes and tidal flats are at risk from larger spills.

Table 2-5: Worst case scenario shoreline impact by habitat type and oil thickness for a leakage of 13,000 bbl from the *Fernstream*.

Shoreline/Habitat Type	Lighter Oiling Oil Thickness <1 mm Oil Thickness >1 g/m²	Heavier Oiling Oil Thickness >1 mm Oil Thickness >100 g/m²
Rocky and artificial shores/Gravel beaches	32 miles	31 miles
Sand beaches	3 miles	2 miles
Salt marshes and tidal flats	16 miles	3 miles

Table 2-6: Worst case scenario shoreline impact by habitat type and oil thickness for a leakage of 1,300 bbl from the *Fernstream*.

Shoreline/Habitat Type	Lighter Oiling Oil Thickness <1 mm Oil Thickness >1 g/m²	Heavier Oiling Oil Thickness >1 mm Oil Thickness >100 g/m²
Rocky and artificial shores/Gravel beaches	18 miles	15 miles
Sand beaches	0 miles	0 miles
Salt marshes and tidal flats	1 mile	0 miles

SECTION 3: ECOLOGICAL RESOURCES AT RISK

Ecological resources at risk from a catastrophic release of oil from the *Fernstream* include numerous guilds of birds and marine mammals (Table 3-1). Intertidal habitats in the San Francisco Bay region are important stopover points for birds on the Pacific flyway and wintering areas for many other species. Significant bird nesting colonies and marine mammal haul-out sites occur in the region. The San Francisco Bay estuary is an important nursery ground for commercially valuable fish and invertebrates and migratory corridor for endangered salmon. Leatherback sea turtles forage in coastal waters 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 *Fernstream*.
(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, 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 San Francisco Bay is one of the largest overwintering areas in North America, supporting over 700,000 wintering waterfowl • >200,000 diving ducks,140,000 scaups, and the largest population of canvasbacks in Pacific flyway	Storm-petrels, sooty shearwater: Mar-Nov Loons, grebes, scoters, overwintering waterfowl: Sept-May
Bird Nesting and Hotspots	<u>*Suisun Bay and surrounding marshes:*</u> • High concentrations of overwintering snow goose (100s), Canada goose (1000s), tundra swan, greater white-fronted goose (1000s), grebes and ducks • High concentrations California clapper rail (FE, SE), California black rail (ST), and other wading birds in marshes <u>*North Bay:*</u> • High concentrations of wading birds, including California clapper rail, California black rail in marshes • High concentrations of double-crested cormorant, brown pelican, surf scoter, overwintering birds foraging in water • Salt ponds support 30-50% of the wintering waterfowl (including diving ducks, ruddy duck, canvasback) present in the bay • Up to 50% (~140,000) of the winter population of diving ducks • Intertidal areas on north shore are important foraging grounds for shorebirds <u>*Golden Gate Strait and adjacent waters:*</u> • Very high concentration of overwintering western grebes, high concentrations of other grebes, loons and scoters • Common murres are common in the area • Peregrine falcons present at Golden Gate NRA • Pigeon guillemot, Brandt's cormorant, pelagic cormorant, black oystercatcher nesting on Alcatraz • Wading birds, including great egret, black-crowned night heron, snowy egret present on Alcatraz • High concentrations of shorebirds and wading birds on Angel Island	*Nesting*: California black rail: Mar-May Western gull: Apr-Aug Double-crested cormorant: Mar-Aug *Seasonal presence*: Shorebirds: Jul-May Overwintering birds: Sep-May California brown pelican: May-Nov *Overwintering*: Grebes, scoters, loons: Oct-Apr/May *Nesting*: Black oystercatcher" May-Oct Pelagic cormorant: Feb-Sep: Brandt's cormorant:

Species Group	Species Subgroup and Geography	Seasonal Presence
	• Black oystercatchers nesting on Yerba Buena Island *South Bay*: Alameda Island: • Caspian tern and California least tern (FE, SE) nesting • Brown pelican, high concentrations of shorebirds and wading birds present • Overwintering western grebe, Canada goose, canvasback, diving ducks Mowry Slough and surrounding waters: • Salt ponds support high concentrations of shorebirds, including phalaropes, stilts and dowitchers, ruddy duck and western snowy plover (FT) • Red knots roost in salt ponds and use intertidal areas during migration • High concentrations of shorebirds on tidal flats on eastern shore of South Bay • South Bay salt ponds support ~27% of the Bay's wintering waterfowl *Golden Gate Strait 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 (FT,SE) nesting on beaches • Bank swallow (ST) nesting sites High concentrations of grebes, gulls, scoters, shorebirds, pelicans, low-moderate concentration of many other species *Half Moon Bay*: Nesting (number of birds): • Colonial nesters (5 sites): 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	Mar-Sep Western gull: Apr-Aug California least tern May-Aug Caspian tern: Apr-Aug *Migrating*: Red knot: Spring, fall *Nesting:* Bank swallow: Mar-Aug *Nesting:* Marbled murrelet: Apr-Jul Wading birds: Feb-Aug Black oystercatcher: Mar-Sep
Reptiles and Amphibians	Leatherback sea turtles (FE): • High concentrations offshore of San Francisco • Med concentrations in nearshore waters Olive ridley (FT) and green (FT) sea turtles can also occur but are not common Coastal streams can also be home to California red-legged frog (FT) and San Francisco garter (SE, FE) snake	Leatherback: May-Nov:
Otters and Pinnipeds	Harbor seals and California sea lions are common to rocky outcroppings throughout the area. River otters can be found in Suisun Bay and surrounding marshes *San Francisco Bay Estuary* Harbor seal haul-outs • *Central Bay:* Sister's Island in Muzzi Marsh, Garner's Point, Castro Rocks, Brooks Island, floating abandoned dock near Sausalito, Angel Island, Yerba Buena Island, and a breakwater at the Oakland entrance into Alameda Harbor • *South Bay:* Coyote Point, Seal Slough, Belmont Slough, Bair Island, Corkscrew Slough, Greco Island, Ravenswood Point, Hayward Slough, Dumbarton Point, Newark Slough, Mowry Slough, Calaveras Point, Drawbridge, and Guadalupe Slough	*Pupping:* Sea otter: Jan-Mar & Sep-Nov 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 All species present year

Species Group	Species Subgroup and Geography	Seasonal Presence
	California sea lion haul-outs: Pier 39, occasionally Angel Island and Seal Rock (outside Golden Gate) *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) *Pacific Grove*: • Harbor seal (~ 500) • California sea lion (~ 1100) • Sea otter (~254)	round
Whales and dolphins	*Coastal*: Gray whale, harbor porpoise (San Francisco stock – 8500, Monterey Bay stock – 1600), bottlenose dolphin *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	*Seasonal presence:* Blue whale: Jun-Nov *Calving*: Minke whale: Mar-May
Fish	<u>*Anadromous:*</u> • Coho salmon (FE/SE) – spawn in 5 coastal streams • Steelhead (FT/ST) – all coastal streams in this area are critical habitat • Striped bass (nearshore May- Sep) • Adults coho and steelhead concentrated in nearshore habitats Oct-Jun and further offshore from Apr-Sep • San Francisco Bay estuary is a migratory corridor/juvenile habitat for chinook salmon (FT), striped bass, green sturgeon, white sturgeon, American shad <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 • Leopard sharks are abundant • Pacific herring spawn in higher salinity coastal areas of San Francisco Bay <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>*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	*Spawning*: Coho: Nov-Feb Steelhead: Nov-Apr Juveniles migrate out of coastal streams mid-Jun *Migrating*: Chinook salmon can run at any time of year *Spawning/parturition*: California grunion" Mar-Aug Leopard shark: Mar-Jun Pacific herring: Nov-Mar

Species Group	Species Subgroup and Geography	Seasonal Presence
	• Much of the area is groundfish EFH	
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) Soft bottom 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 • Clams - Geoducks, manila, gaper, razor clam, pismo clam • Bay shrimp (California and blacktail) spawn near the mouth of the San Francisco Bay Estuary Areas of high invertebrate concentration or diversity: • Intertidal - Bird Island, Moss Beach, James V. Fitzgerald Marine Reserve • North Bay, San Pablo Bay and Suisun Bay marsh shorelines are nursery habitat for high concentrations of juvenile shrimp and crabs	*Mating:* Dungeness crab: Spring *Spawning*: Dungeness crab: Jun-Sep Bay shrimp: Jan-Mar
Benthic Habitats	Large kelp beds are important concentration areas for many marine species 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 *Fernstream* are generally available at each U.S. Coast Guard Sector. They can also be downloaded at: http://response.restoration.noaa.gov/esi. These maps show detailed spatial information on the distribution of sensitive shoreline habitats, biological resources, and human-use resources. The tables on the back of the maps provide more detailed life-history information for each species and location. The ESI atlases should be consulted to assess the potential environmental resources at risk for specific spill scenarios. In addition, the Geographic Response Plans within the Area Contingency Plans prepared by the Area Committee for each U.S. Coast Guard Sector have detailed information on the nearshore and shoreline ecological resources at risk and should be consulted.

Ecological Risk Factors

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

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

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

The impacts from an oil release from the wreck would depend greatly on the direction in which the oil slick moves, which would, in turn, depend on wind direction and currents at the time of and after the oil

release. Impacts are characterized in the risk analysis based on the likelihood of any measurable impact, as well as the degree of impact that would be expected if there is an impact. The measure of the degree of impact is based on the median case for which there is at least some impact. The median case is the "middle case" – half of the cases with significant impacts have less impact than this case, and half have more.

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

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

In the following sections, the definition of low, medium, and high for each ecological risk factor is provided. Also, the classification for the *Fernstream* is provided, both as text and as shading of the applicable probability of risk bullet, for the WCD release of 13,000 bbl and a border around the degree of risk bullet for the Most Probable Discharge of 1,300 bbl.

Risk Factor 3A: Water Column Impacts to EcoRAR

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

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

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

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

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

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

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

The *Fernstream* is classified as High Risk for oiling probability for water column ecological resources for the WCD of 13,000 bbl because 98% of the model runs resulted in contamination of more than 0.2 mi^2 of the upper 33 feet of the water column above the threshold of 1 ppb aromatics. It is classified as Medium Risk for degree of oiling because the mean volume of water contaminated was 33 mi^2 of the upper 33 feet of the water column. For the Most Probable Discharge of 1,300 bbl, the *Fernstream* is classified as High Risk for oiling probability for water column ecological resources because 66% of the model runs resulted in contamination of more than 0.2 mi^2 of the upper 33 feet of the water column above the threshold of 1 ppb aromatics. It is classified as Medium Risk for degree of oiling because the mean volume of water contaminated was 4 mi^2 of the upper 33 feet of the water column.

Risk Factor 3B: Water Surface Impacts to EcoRAR

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

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

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

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

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

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

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

The *Fernstream* is classified as Medium Risk for oiling probability for water surface ecological resources for the WCD because 10% of the model runs resulted in at least 1,000 mi^2 of the water surface affected above the threshold of 10 g/m^2. It is Low Risk for degree of oiling because the mean area of water contaminated was 530 mi^2. The *Fernstream* is classified as Low Risk for oiling probability for water surface ecological resources for the Most Probable Discharge because 1% of the model runs resulted in at least 1,000 mi^2 of the water surface affected above the threshold of 10 g/m^2. It is classified as Low Risk for degree of oiling because the mean area of water contaminated was 156 mi^2.

Risk Factor 3C: Shoreline Impacts to EcoRAR

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

sensitive (weighted as "2"), and sand beaches (weighted as "1") are the least sensitive to ecological impacts of oil.

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

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

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

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

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

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

The *Fernstream* is classified as High Risk for oiling probability for shoreline ecological resources for the WCD because 100% of the model runs resulted in shorelines affected above the threshold of 100 g/m^2. It is classified as Medium Risk for degree of oiling because the mean weighted length of shoreline contaminated was 52 miles. The *Fernstream* is classified as High Risk for oiling probability to shoreline ecological resources for the Most Probable Discharge because 100% of the model runs resulted in shorelines affected above the threshold of 100 g/m^2. It is classified as Medium Risk for degree of oiling because the mean weighted length of shoreline contaminated was 18 miles.

Considering the modeled risk scores and the ecological resources at risk, the ecological risk from potential releases of the WCD of 13,000 bbl of light fuel oil from the *Fernstream* is summarized as listed below and indicated in the far-right column in Table 3-2:

- Water column resources – Medium, because of the importance of nearshore habitats in San Francisco Bay as spawning and rearing habitat for commercially important fish and shellfish
- Water surface resources – Medium, because of the very large numbers of wintering, nesting, and migratory birds and marine mammals that use ocean and coastal habitats at risk; endangered leatherback sea turtles could also be at risk
- Shoreline resources – Medium, because light fuel oils are generally not persistent on shorelines though there can be acute impacts to shoreline biota, particularly rich rocky intertidal habitats

Table 3-2: Ecological risk factor scores for the **Worst Case Discharge of 13,000 bbl** of light fuel oil from the *Fernstream.*

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
3A-1: Water Column Probability EcoRAR Oiling	**Low**	**Medium**	**High**	98% of the model runs resulted in at least 0.2 mi^2 of the upper 33 feet of the water column contaminated above 1 ppb aromatics	**Med**
3A-2: Water Column Degree EcoRAR Oiling	**Low**	**Medium**	**High**	The mean volume of water contaminated above 1 ppb was 33 mi^2 of the upper 33 feet of the water column	
3B-1: Water Surface Probability EcoRAR Oiling	**Low**	**Medium**	**High**	10% of the model runs resulted in at least 1,000 mi^2 of water surface covered by at least 10 g/m^2	**Med**
3B-2: Water Surface Degree EcoRAR Oiling	**Low**	**Medium**	**High**	The mean area of water contaminated above 10 g/m^2 was 530 mi^2	
3C-1: Shoreline Probability EcoRAR Oiling	**Low**	**Medium**	**High**	100% of the model runs resulted in shoreline oiling of 100 g/m^2	**Med**
3C-2: Shoreline Degree EcoRAR Oiling	**Low**	**Medium**	**High**	The length of shoreline contaminated by at least 100 g/m^2 was 52 mi	

For the Most Probable Discharge of 1,300 bbl, the ecological risk from potential releases from the *Fernstream* is summarized as listed below and indicated in the far-right column in Table 3-3:

- Water column resources – Low, because of the very small area of water column impacts likely
- Water surface resources – Medium, because of the very large numbers of wintering, nesting, and migratory birds and marine mammals that use ocean and coastal habitats at risk
- Shoreline resources – Low, because light fuel oils are generally not persistent on shorelines and mostly man-made shorelines are at greatest risk

Table 3-3: Ecological risk factor scores for the **Most Probable Discharge of 1,300 bbl** of light fuel oil from the *Fernstream*.

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
3A-1: Water Column Probability EcoRAR Oiling	**Low**	**Medium**	**High**	66% of the model runs resulted in at least 0.2 mi^2 of the upper 33 feet of the water column contaminated above 1 ppb aromatics	**Low**
3A-2: Water Column Degree EcoRAR Oiling	**Low**	**Medium**	**High**	The mean volume of water contaminated above 1 ppb was 4 mi^2 of the upper 33 feet of the water column	
3B-1: Water Surface Probability EcoRAR Oiling	**Low**	**Medium**	**High**	1% of the model runs resulted in at least 1,000 mi^2 of water surface covered by at least 10 g/m^2	**Med**
3B-2: Water Surface Degree EcoRAR Oiling	**Low**	**Medium**	**High**	The mean area of water contaminated above 10 g/m^2 was 156 mi^2	
3C-1: Shoreline Probability EcoRAR Oiling	**Low**	**Medium**	**High**	100% of the model runs resulted in shoreline oiling of 100 g/m^2	**Low**
3C-2: Shoreline Degree EcoRAR Oiling	**Low**	**Medium**	**High**	The length of shoreline contaminated by at least 100 g/m^2 was 18 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 *Fernstream* include very highly utilized recreational beaches along the California coast. Many areas along the entire potential spill zone are widely popular seaside resorts and support recreational activities such as boating, diving, sightseeing, sailing, fishing, and wildlife viewing. Two national marine sanctuaries, three national park areas, and a national seashore are in the potential impact area. There are numerous state parks and beaches, as well as beach-front communities.

The waterfront of San Francisco and Sausalito, as well as other cities along the coast of San Francisco Bay, are important tourist areas. Shipping lanes run through the area of impact into the port of San Francisco, which had 2,997 vessel port calls annually with 180.5 million tonnage. Commercial fishing is economically important to the region. Regional commercial landings for 2010 exceeded $31.3 million.

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

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

Resource Type	Resource Name	Economic Activities
Beaches	El Granada Half Moon Bay Moss Beach Pacifica Pescadero Stinson Beach	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 into early fall months.

Resource Type	Resource Name	Economic Activities
National Seashores	Point Reyes National Seashore	National seashores provide recreation for local and tourist populations as well as preserve and protect the nation's natural shoreline treasures. National seashores are coastal areas federally designated as being of natural and recreational significance as a preserved area.
National Parks	Fort Point National Historic Site Golden Gate National Recreation Area San Francisco National Maritime Historical Park	National parks provide recreational activities and historical study opportunities.
National Marine Sanctuaries	Gulf of the Farrallones NMS Monterey Bay NMS	National marine sanctuaries provide unique opportunities for recreation and nature study.
State Parks	Angel Island State Park Bean Hollow State Beach Candlestick Point State Recreation Area China Camp SP Grey Whale Cove SP Montara State Beach Mt. Tamalpais SP Robert W. Crown Memorial State Beach San Gregorio 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	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

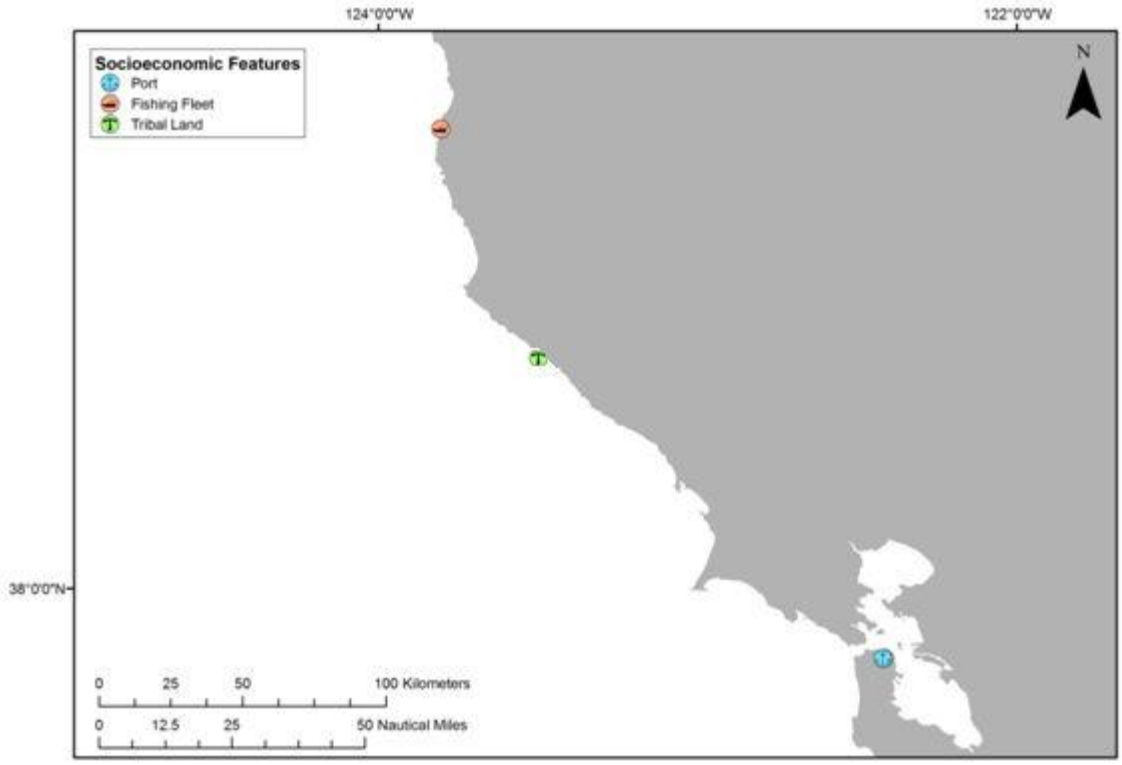

Figure 4-1: Tribal lands, ports, and commercial fishing fleets at risk from a release from the *Fernstream*.

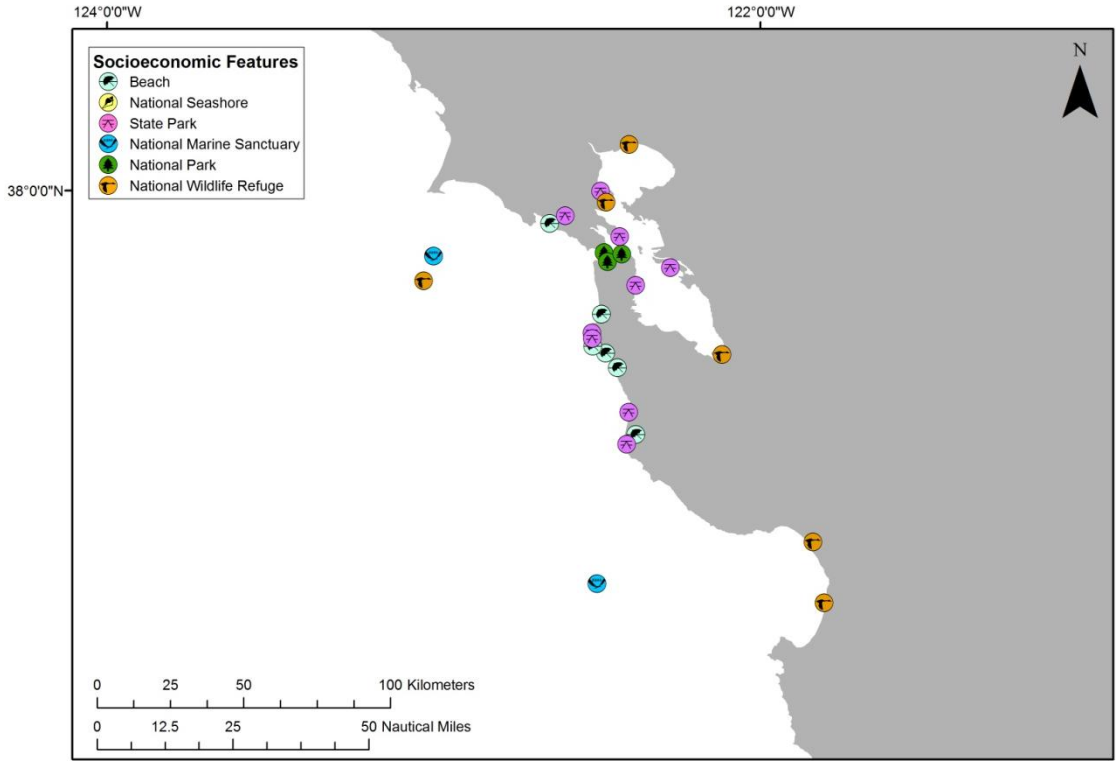

Figure 4-2: Beaches, coastal state parks, and Federal protected areas at risk from a release from the *Fernstream*.

Socio-Economic Risk Factors

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

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

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

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

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

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

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

In the following sections, the definition of low, medium, and high for each socio-economic risk factor is provided. Also, in the text classification for the *Fernstream* shading indicates the degree of risk, for the WCD release of 13,000 bbl and a border indicates degree of risk for the Most Probable Discharge of 1,300 bbl.

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

This risk factor reflects the probability that at least 0.2 mi2 of the upper 33 feet of the water column would be contaminated with a high enough concentration of oil to cause socio-economic impacts. The threshold for water column impact to socio-economic resources at risk is an oil concentration of 1 ppb (i.e., 1 part oil per one billion parts water). At this concentration and above, one would expect impacts and potential tainting to socio-economic resources (e.g., fish and shellfish) in the water column; this concentration is used as a screening threshold for both the ecological and socio-economic risk factors.

The three risk scores for oiling are:

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

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

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

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

The *Fernstream* is classified as High Risk for oiling probability and Medium Risk for degree of oiling for water column socio-economic resources for the WCD of 13,000 bbl because 98% of the model runs resulted in contamination of more than 0.2 mi^2 of the upper 33 feet of the water column above the threshold of 1 ppb aromatics, and the mean volume of water contaminated was 33 mi^2 of the upper 33 feet of the water column. For the Most Probable Discharge of 1,300 bbl, the *Fernstream* is classified as High Risk for oiling probability for water column socio-economic resources because 66% of the model runs resulted in contamination of more than 0.2 mi^2 of the upper 33 feet of the water column above the threshold of 1 ppb aromatics. It is classified as Medium Risk for oil degree because the mean volume of water contaminated was 4 mi^2 of the upper 33 feet of the water column.

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

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

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

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

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

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

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

The *Fernstream* is classified as High Risk for oiling probability and Medium Risk for degree of oiling for water surface socio-economic resources for the WCD because 71% of the model runs resulted in at least 1,000 mi^2 of the water surface affected above the threshold of 0.01 g/m^2, and the mean area of water contaminated was 1,940 mi^2. The *Fernstream* is classified as Medium Risk for oiling probability for water surface socio-economic resources for the Most Probable Discharge because 13% of the model runs resulted in at least 1,000 mi^2 of the water surface affected above the threshold of 0.01 g/m^2. It is classified as Low Risk for degree of oiling because the mean area of water contaminated was 497 mi^2.

Risk Factor 4C: Shoreline Impacts to SRAR

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

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

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

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

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

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

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

The *Fernstream* is classified as High Risk for oiling probability for shoreline socio-economic resources for the WCD because 100% of the model runs resulted in shorelines affected above the threshold of 1 g/m^2. It is classified as Medium Risk for degree of oiling because the mean length of weighted shoreline contaminated was 56 miles. The *Fernstream* is classified as High Risk for oiling probability and Medium Risk for degree of oiling for shoreline socio-economic resources for the Most Probable Discharge as 100% of the model runs resulted in shorelines affected above the threshold of 1 g/m^2, and the mean length of weighted shoreline contaminated was 21 miles.

Considering the modeled risk scores and the socio-economic resources at risk, the socio-economic risk from potential releases of the WCD of 13,000 bbl of light fuel oil from the *Fernstream* is summarized as listed below and indicated in the far-right column in Table 4-2:

- Water column resources – Low, because a relatively small area of water column would be impacted in an area with limited fishing activities
- Water surface resources – High, because a very large part of San Francisco Bay would be impacted interfering with shipping and other offshore activities. 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 – High, because although the shoreline impact would involve a relatively moderate length, there are many high-value socio-economic resources at risk

Table 4-2: Socio-economic risk factor ranks for the **Worst Case Discharge of 13,000 bbl** of light fuel oil from the *Fernstream*.

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
4A-1: Water Column Probability SRAR Oiling	**Low**	**Medium**	**High**	98% of the model runs resulted in at least 0.2 mi^2 of the upper 33 feet of the water column contaminated above 1 ppb aromatics	**Low**
4A-2: Water Column Degree SRAR Oiling	**Low**	**Medium**	**High**	The mean volume of water contaminated above 1 ppb was 33 mi^2 of the upper 33 feet of the water column	
4B-1: Water Surface Probability SRAR Oiling	**Low**	**Medium**	**High**	71% of the model runs resulted in at least 1,000 mi^2 of water surface covered by at least 0.01 g/m^2	**High**
4B-2: Water Surface Degree SRAR Oiling	**Low**	**Medium**	**High**	The mean area of water contaminated above 0.01 g/m^2 was 1,940 mi^2	
4C-1: Shoreline Probability SRAR Oiling	**Low**	**Medium**	**High**	100% of the model runs resulted in shoreline oiling of 1 g/m^2	**High**
4C-2: Shoreline Degree SRAR Oiling	**Low**	**Medium**	**High**	The length of shoreline contaminated by at least 1 g/m^2 was 56 mi	

For the Most Probable Discharge of 1,300 bbl, the socio-economic risk from potential releases of light fuel oil from the *Fernstream* is summarized as listed below and indicated in the far-right column in Table 4-3:

- Water column resources – Low, because a relatively small area of water column would be impacted in an area with limited fishing activities
- Water surface resources – High, because a very large part of San Francisco Bay would be impacted interfering with shipping and other offshore activities. 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 – High, because although the shoreline impact would involve a relatively moderate length, there are many high-value socio-economic resources at risk

Table 4-3: Socio-economic risk factor ranks for the **Most Probable Discharge of 1,300 bbl** of light fuel oil from the *Fernstream*.

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
4A-1: Water Column Probability SRAR Oiling	**Low**	**Medium**	**High**	66% of the model runs resulted in at least 0.2 mi^2 of the upper 33 feet of the water column contaminated above 1 ppb aromatics	**Low**
4A-2: Water Column Degree SRAR Oiling	**Low**	**Medium**	**High**	The mean volume of water contaminated above 1 ppb was 4 mi^2 of the upper 33 feet The mean volume of water contaminated of the water column	
4B-1: Water Surface Probability SRAR Oiling	**Low**	**Medium**	**High**	13% of the model runs resulted in at least 497 mi^2 of water surface covered by at least 0.01 g/m^2	**High**
4B-2: Water Surface Degree SRAR Oiling	**Low**	**Medium**	**High**	The mean area of water contaminated above 0.01g/m^2 was 497 mi^2	
4C-1: Shoreline Probability SRAR Oiling	**Low**	**Medium**	**High**	100% of the model runs resulted in shoreline oiling of 1 g/m^2	**High**
4C-2: Shoreline Degree SRAR Oiling	**Low**	**Medium**	**High**	The length of shoreline contaminated by at least 1 g/m^2 was 21 mi	

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

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

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

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

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

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

For the Worst Case Discharge, *Fernstream* scores High with 15 points; for the Most Probable Discharge, *Fernstream* scores Medium with 13 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 *Fernstream*. The final determination of what type of action, if any, rests with the U.S. Coast Guard.

Fernstream	**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 *Fernstream*.

Vessel Risk Factors		Data Quality Score	Comments		Risk Score
Pollution Potential Factors	A1: Oil Volume (total bbl)	Low	Maximum of 12,500 bbl, not reported to be leaking		**Med**
	A2: Oil Type	Med	Bunker oil is diesel oil, a Group II 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	Low	No oil was known to have been reported on the water		
	D1: Nature of Casualty	High	Collision		
	D2: Structural Breakup	High	The vessel remains in one contiguous piece		
Archaeological Assessment	Archaeological Assessment	Low	The best sinking assessment still comes from the U.S. Coast Guard Marine Board of Investigation so a detailed assessment was not prepared		**Not Scored**
Operational Factors	Wreck Orientation	Medium	Believed to be on one side		**Not Scored**
	Depth	High	150 ft		
	Visual or Remote Sensing Confirmation of Site Condition	High	Location is known and charted		
	Other Hazardous Materials Onboard	High	No		
	Munitions Onboard	High	No		
	Gravesite (Civilian/Military)	High	No		
	Historical Protection Eligibility (NHPA/SMCA)	Medium	Possibly NHPA		
				WCD	**Most Probable**
Ecological Resources	3A: Water Column Resources	High	Larger releases potentially impact important spawning habitat in the Bay	**Med**	**Low**
	3B: Water Surface Resources	High	Very large numbers of marine birds and mammals would be at risk	**Med**	**Med**
	3C: Shore Resources	High	Light fuel oils are not persistent but could affect rich intertidal rocky shore habitats	**Med**	**Low**
Socio-Economic Resources	4A: Water Column Resources	High	Relatively small area of water column would be impacted in an area with limited fishing activities	**Low**	**Low**
	4B: Water Surface Resources	High	Very large part of San Francisco Bay would be impacted interfering with shipping and other offshore activities	**High**	**High**
	4C: Shore Resources	High	Although the shoreline impact would involve a relatively moderate length, there are many high-value socio-economic resources at risk.	**High**	**High**
Summary Risk Scores				**15**	**13**