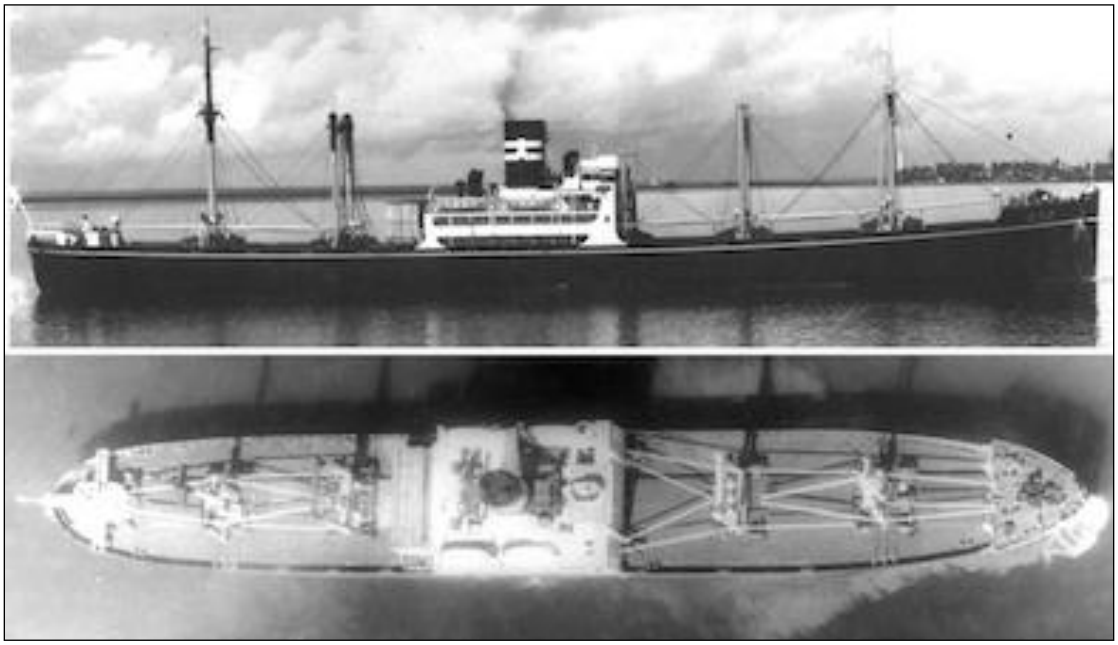
Office of National Marine Sanctuaries
Office of Response and Restoration

Screening Level Risk Assessment Package

Tokai Maru



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National Oceanic and
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Photo: Photograph of *Tokai Maru*
Source: http://www.scubaguam.com/Harbor/tokaimaru1.htm

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.

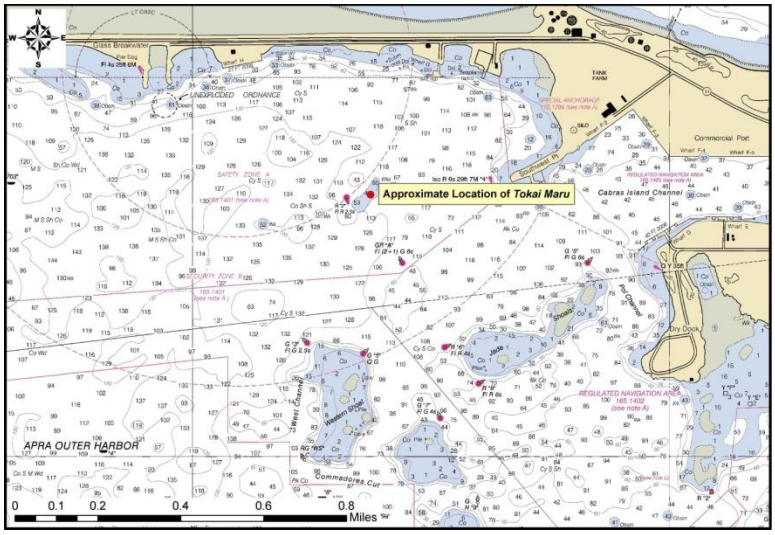
The potential polluting shipwrecks were identified through searching a broad variety of historical sources. NOAA then worked with Research Planning, Inc., RPS ASA, and Environmental Research Consulting to conduct the modeling forecasts, and the ecological and environmental resources at risk assessments.

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: *Tokai Maru*

The Japanese freighter *Tokai Maru*, torpedoed and sunk during World War II in Apra Harbor, Guam in 1944, 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 *Tokai Maru*, 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.



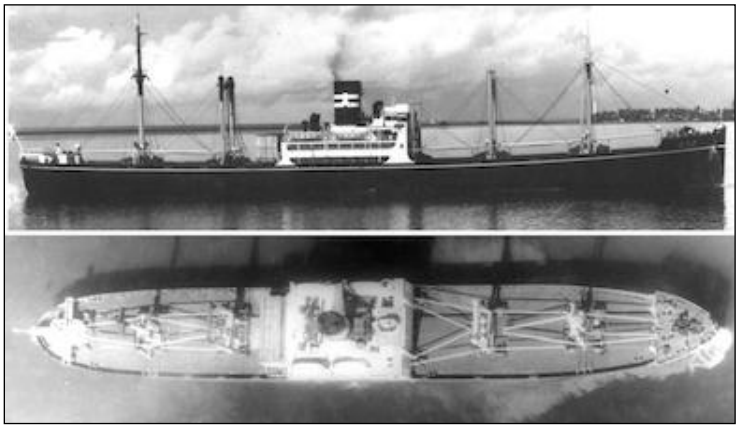
Based on this screening-level assessment, each vessel was assigned a summary score calculated using the seven risk criteria described in this report. For the Worst Case Discharge, *Tokai Maru* scores Medium with 12 points; for the Most Probable Discharge (10% of the Worse Case volume), *Tokai Maru* scores Low with 9 points. Given these scores, and the higher level of data certainty, NOAA recommends that this site be noted in Area Contingency Plans so that if a mystery spill is reported in the general area, this vessel could be investigated as a source. It could be considered for further assessment if the resources at risk are underrepresented in this assessment. Outreach efforts with the technical and recreational dive community as well as commercial and recreational fishermen who frequent the area would be helpful to gain awareness of localized spills in the site.

Vessel Risk Factors		Risk Score	
Pollution Potential Factors	A1: Oil Volume (total bbl)	Med	
	A2: Oil Type		
	B: Wreck Clearance		
	C1: Burning of the Ship		
	C2: Oil on Water		
	D1: Nature of Casualty		
	D2: Structural Breakup		
Archaeological Assessment	Archaeological Assessment	Not Scored	
Operational Factors	Wreck Orientation	Not Scored	
	Depth		
	Confirmation of Site Condition		
	Other Hazardous Materials		
	Munitions Onboard		
	Gravesite (Civilian/Military)		
	Historical Protection Eligibility		
		WCD	MP (10%)
Ecological Resources	3A: Water Column Resources	Med	Low
	3B: Water Surface Resources	Low	Low
	3C: Shore Resources	Low	Low
Socio-Economic Resources	4A: Water Column Resources	Med	Low
	4B: Water Surface Resources	High	Med
	4C: Shore Resources	Low	Low
Summary Risk Scores		12	9

The determination of each risk factor is explained in the document. This summary table is found on page 36.

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

Vessel Particulars



Official Name: *Tokai Maru*

Official Number: 36099

Vessel Type: Freighter

Vessel Class: Unknown

Former Names: Unknown

Year Built: 1930

Builder: Mitsubishi Zosen Kaisha Ld., Nagasaki, Japan

Builder's Hull Number: Unknown

Flag: Japanese

Owner at Loss: Osaka Shosen Company

Controlled by: Unknown **Chartered to:** Japanese Imperial Navy

Operated by: Unknown

Homeport: Osaka, Japan

Length: 446 feet **Beam:** 60 feet **Depth:** 40 feet

Gross Tonnage: 8,360 **Net Tonnage:** 5,038

Hull Material: Steel **Hull Fastenings:** Riveted **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): Unknown **Dry Cargo Capacity:** Unknown

Tank or Hold Description: Vessel had five large cargo holds

Casualty Information

Port Departed: At anchor in Apra Harbor, Guam

Destination Port: N/A

Date Departed: N/A

Date Lost: August 27, 1944

Number of Days Sailing: 0

Cause of Sinking: Act of War (Torpedoes)

Latitude (DD): 13.461

Longitude (DD): 144.651

Nautical Miles to Shore: 0.11

Nautical Miles to NMS: N/A

Nautical Miles to MPA: 0.14

Nautical Miles to Fisheries: Unknown

Approximate Water Depth (Ft): 130

Bottom Type: Sand

Is There a Wreck at This Location? Yes, the wreck has been positively located and identified

Wreck Orientation: Resting on its port side

Vessel Armament: Unknown

Cargo Carried when Lost: War supplies, trucks, beds, and scrap steel

Cargo Oil Carried (bbl): 0

Cargo Oil Type: N/A

Probable Fuel Oil Remaining (bbl): Unknown ≤10,000

Fuel Type: Medium Fuel Oil (Diesel)

Total Oil Carried (bbl): ≤ 10,000

Dangerous Cargo or Munitions: Yes

Munitions Carried: Unknown, vessel was carrying war supplies and is known to contain at least four depth charges

Demolished after Sinking: No

Salvaged: Unknown

Cargo Lost: Yes, partially

Reportedly Leaking: No, Last reported in 1998

Historically Significant: Yes

Gravesite: Unknown

Salvage Owner: Not known if any

Wreck Location

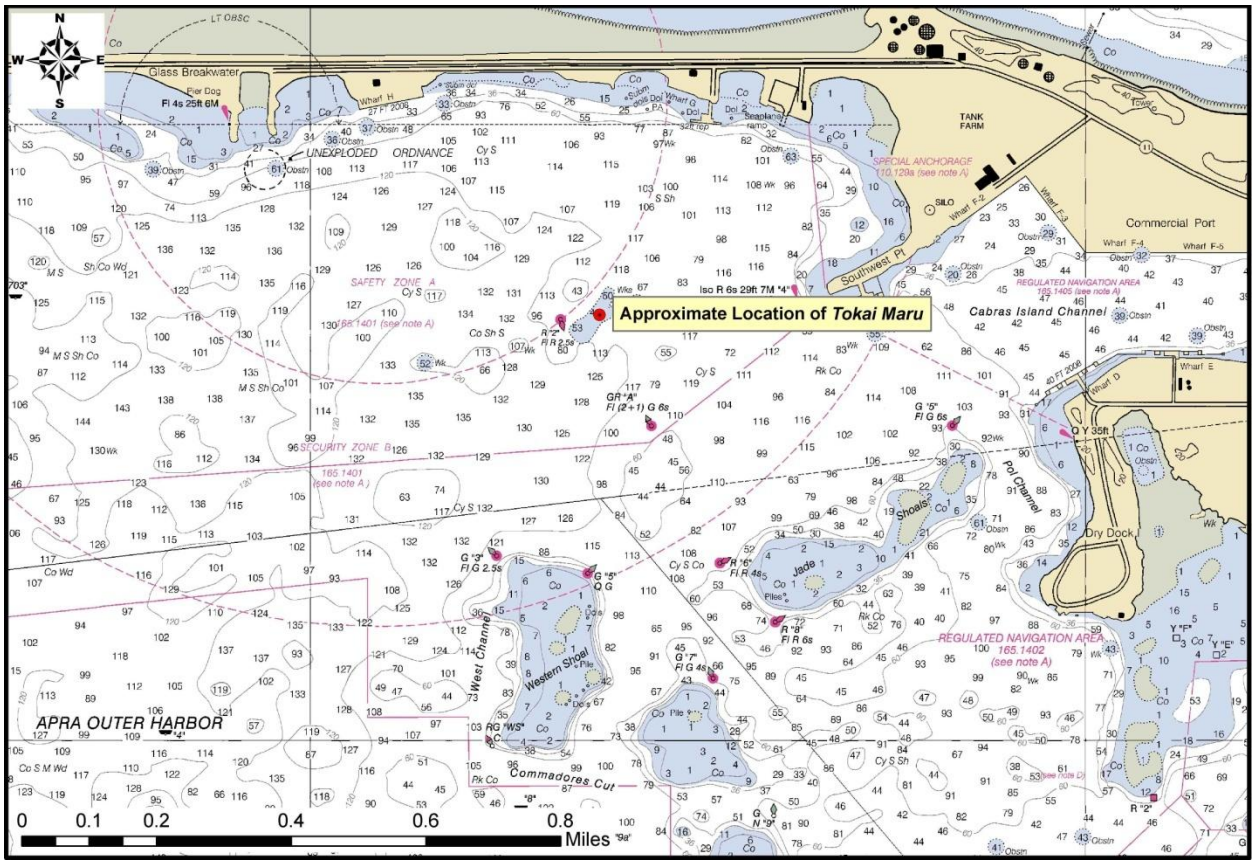


Chart Number: 81054

Casualty Narrative

"The *Tokai Maru* was a Japanese passenger-cargo freighter put in service in August, 1930. She was a "state-of-the-art" vessel, and was used by the Osaka Shosen Company as one of their modern fast luxury freighters on the Tokyo to New York City run.

She was re-commissioned as a freighter under contract to the Japanese Imperial Navy in October 1941 and was used to transport war materials and personnel throughout the Pacific.

On January 24, 1943 the *Tokai* was observed anchored in Apra Harbor by the U.S. submarine *Flying Fish*. Assuming that the ship was soon to leave the harbor, the *Flying Fish* waited outside the entrance for 3 days. With no movement of the ship or any other vessels, the *Flying Fish* fired two torpedoes set to run at 15' depth (to cross over a very shallow reef). One of the torpedoes ran aground on the reef, but the other struck the *Tokai* causing considerable damage, but not sinking her.

Seven months later, the U.S. submarine *Snapper*, patrolling west of Guam, spotted two ships in the harbor. Not knowing at the time that these were the *Tokai Maru* and another damaged ship (*Nichiyo Maru*), the submarine patiently waited for one week, and then made a submerged attack under the eyes of a Japanese patrol vessel less than two miles away.

At 3:23 on the afternoon of August 27th, the *Snapper* fired a spread of four torpedoes, three at the nearest ship (*Tokai*) and the fourth at the other (*Nichiu Maru*). The *Snapper* immediately headed west for safer waters. Over the next few hours numerous explosions were heard, and the *Tokai* was observed with the bow at an extreme "up angle", indicating that the stern was on the bottom. A few minutes later the *Tokai* slipped beneath the surface.

FROM THE SUB COMMANDER: An interesting side note was made by Commander M.K. Clementson in the submarine's log about the patrol vessel:

'For the next 10-15 minutes heard some very faint distant explosions undoubtedly inside the harbor and one explosion about 100 yards away (from the submarine), probably from the patrol vessel. His screws were not heard after this so it is believed possible that this nicely in-efficient gent probably de-commissioned himself. Departed from the area at good speed, and depth, however.'"
-http://www.scubaguam.com/Harbor/tokaimaru1.htm

General Notes

Vessel was surveyed years ago by the National Park Service's Submerged Resources Center.

Wreck Condition/Salvage History

"The *Tokai* was damaged by the USS *Flying Fish* and later sunk by the USS *Snapper* (both United States fleet submarines) in World War II. Coincidentally, the ship sunk adjacent to the SMS *Cormoran*, which was sunk during World War I. This is a unique site because it holds two wrecks from two separate wars.

The *Tokai* is lying at on steep incline on her port side and is in very good condition considering her age. This is a very big ship and divers can see the entire length by staying between 60-80ft and swimming slowly over the main deck.

Bomb damaged can be found on the bow and the actual torpedo hole that sunk her is in the #4 hold. There is very little in the holds and there's still crude oil trapped in the forward "tween" decks.

The shallowest part of the wreck is at the forward part of the bridge, around 45ft, and the deepest deck level is at the stern around 80ft. There are at least 4 depth charges, which look like large bbl, laying in the silt inside the stern on the port side. You can clearly see these, but don't touch them.

The Tokai is a perfect wreck for NITROX divers.

The German ship SMS *Cormoran* can be found by following the side contours directly below the aft portion of the bridge down to 80 feet."
-http://www.scubaguam.com/Harbor/tokaimaru.htm

Archaeological Assessment

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

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

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

Assessment

The wreck of the freighter *Tokai Maru* is located within recreational SCUBA diving depths in Apra Harbor, Guam. The shipwreck is reportedly in very good condition and is resting on its port side. This vessel has been given a higher priority rating for this study because of its close proximity to shore and because several dive company websites report that there is still some “crude oil” trapped between decks in the forward section of the ship. Considering that this wreck is listed in Lloyd’s Register of British and Merchant shipping as a motor vessel and not a steamship, it is unlikely that this is a heavy fuel oil and is more likely marine diesel oil unless the ship had a small steam powered Donkey Engine for deck machinery.

This shipwreck is listed on the National Register of Historic Places because of its significance to World War II history and because this wreck is adjacent to the remains of the German Auxiliary Cruiser SMS *Cormoran* lost during World War I. Requests for additional historical and archaeological information about this shipwreck can be obtained by viewing the National Register of Historical Places register form at http://pdfhost.focus.nps.gov/docs/NRHP/Text/88000967.pdf, or by contacting the National Park Service’s Submerged Resources Center.

Given that there are few reports of oil on this wreck despite it being a common dive site and located in a busy harbor, it is unlikely that much oil remains inside the shipwreck. If the U.S. Coast Guard does assess the site, it should also be noted that this vessel is of historic significance and will require appropriate actions be taken under the National Historic Preservation Act (NHPA) and possibly the Sunken Military Craft Act (SMCA) prior to any actions that could impact the integrity of the vessel.

Background Information References

Vessel Image Sources: http://www.scubaguam.com/Harbor/tokaimaru1.htm; http://www.pacificwrecks.com/ships/maru/tokai.html

Construction Diagrams or Plans in RULET Database? No

Text References:
http://www.pacificwrecks.com/ships/maru/tokai.html
http://www.scubaguam.com/Harbor/tokaimaru.htm
http://www.scubaguam.com/Harbor/tokaimaru1.htm

Vessel Risk Factors

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

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.

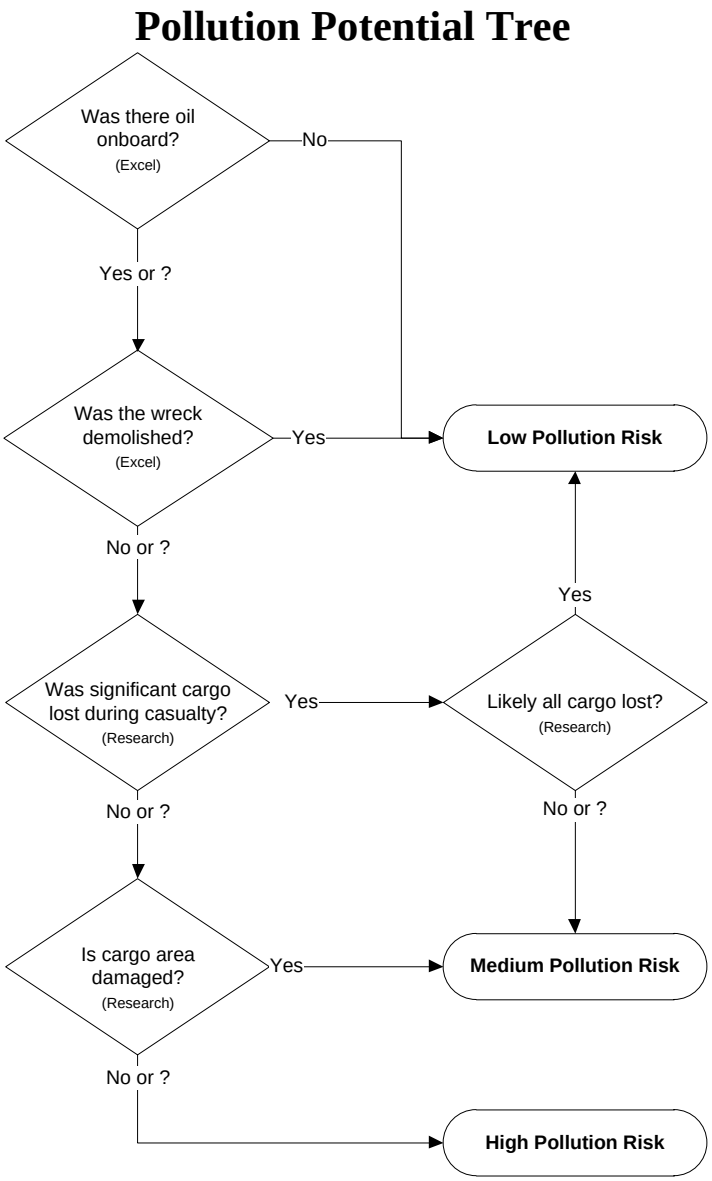


Figure 1-1: U.S. Coast Guard Salvage Engineering Response Team (SERT) developed the above Pollution Potential Decision Tree.

In the following sections, the definition of low, medium, and high for each risk factor is provided. Also, the classification for the *Tokai Maru* 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 *Tokai Maru i*s ranked as Medium Volume because it is thought to have a potential for up to 2,000 bbl, although some of that may have been lost at the time of the casualty due to the explosion and breakup of the vessel. This volume is an approximation based on the location of the oil reported to still exist inside the wreck. The oil is reportedly between decks in the forward section of the ship and was assumed to have possibly come from a forward deep tank onboard the ship. These deep tanks often had an oil capacity of approximately 1,900 bbl. Data quality is low since the exact bunker capacity and amount of oil remaining is unknown.

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 *Tokai Maru,* but several dive company websites say that some oil remains trapped in the wreck.

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 *Tokai Maru* is classified as Medium Risk because the bunker oil is diesel fuel oil, a Group II oil type. Data quality is low because *Tokai Maru* may have had donkey boilers for steam powered machinery that would have used a heavy fuel oil.

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

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

- **Medium Risk:** 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 *Tokai Maru* 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 *Tokai Maru* is classified as Unknown Risk because it is not known whether or not the vessel burned at the time of casualty. Data quality is low.

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 *Tokai Maru* is classified as Unknown Risk because it is not known if oil was reported to have spread across the water as the vessel went down. Data quality is Low.

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 *Tokai Maru* is classified as Low Risk because there were multiple torpedo detonations. 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 *Tokai Maru* is classified as High Risk because it is not broken apart 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 *Tokai Maru* is resting on its port 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 *Tokai Maru* is 130 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 *Tokai Maru* is a popular recreational dive site. 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 *Tokai Maru* may have had munitions for onboard weapons and has at least four depth charges located in the stern section. 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 *Tokai Maru*.

Table 1-1: Summary matrix for the vessel risk factors for the *Tokai Maru* 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)	Low	Maximum of 1,900 bbl, not reported to be leaking	**Med**
	A2: Oil Type	Low	Bunker oil is diesel, but it is possible the vessel used heavy oil for donkey boilers	
	B: Wreck Clearance	High	Vessel not reported as cleared	
	C1: Burning of the Ship	Low	Unknown fire at time of loss	
	C2: Oil on Water	Low	Unknown loss of oil	
	D1: Nature of Casualty	High	Multiple torpedo explosions	
	D2: Structural Breakup	High	The vessel is in one contiguous piece	
Archaeological Assessment	Archaeological Assessment	Low	The best archaeological assessment still comes from the National Park Service, so a detailed assessment was not prepared	**Not Scored**
Operational Factors	Wreck Orientation	High	Resting on its port side	**Not Scored**
	Depth	High	Depth is 130 feet	
	Visual or Remote Sensing Confirmation of Site Condition	High	Wreck is a popular dive site	
	Other Hazardous Materials Onboard	High	No	
	Munitions Onboard	High	At least four depth charges and possibly other munitions	
	Gravesite (Civilian/Military)	Low	Unknown	
	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 *Tokai Maru* this would be about 2,000 bbl, based on reports that the oil is between decks in the forward section of the ship and was assumed to have possibly come from a forward deep tank onboard the ship. These deep tanks often had an oil capacity of approximately 1,900 bbl.

The likeliest scenario of oil release from most sunken wrecks, including the *Tokai Maru*, 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 *Tokai Maru*.

Scenario Type	Release per Episode	Time Period	Release Rate	Relative Likelihood	Response Tier
Chronic (0.1% of WCD)	2 bbl	Fairly regular intervals or constant	100 bbl over several days	More likely	Tier 1
Episodic (1% of WCD)	20 bbl	Irregular intervals	Over several hours or days	Most Probable	Tier 1-2
Most Probable (10% of WCD)	200 bbl	One-time release	Over several hours or days	Most Probable	Tier 2
Large (50% of WCD)	1,000 bbl	One-time release	Over several hours or days	Less likely	Tier 2-3
Worst Case	2,000 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 *Tokai Maru* contained a maximum of 1,900 bbl of diesel (a Group II oil) as bunker 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 2-2b shows the number of tarballs per m^2 on the shoreline for these oil thickness thresholds, assuming that each tarball was a sphere that was 1 inch in diameter.

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

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

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

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

Potential Impacts to the Water Column

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

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

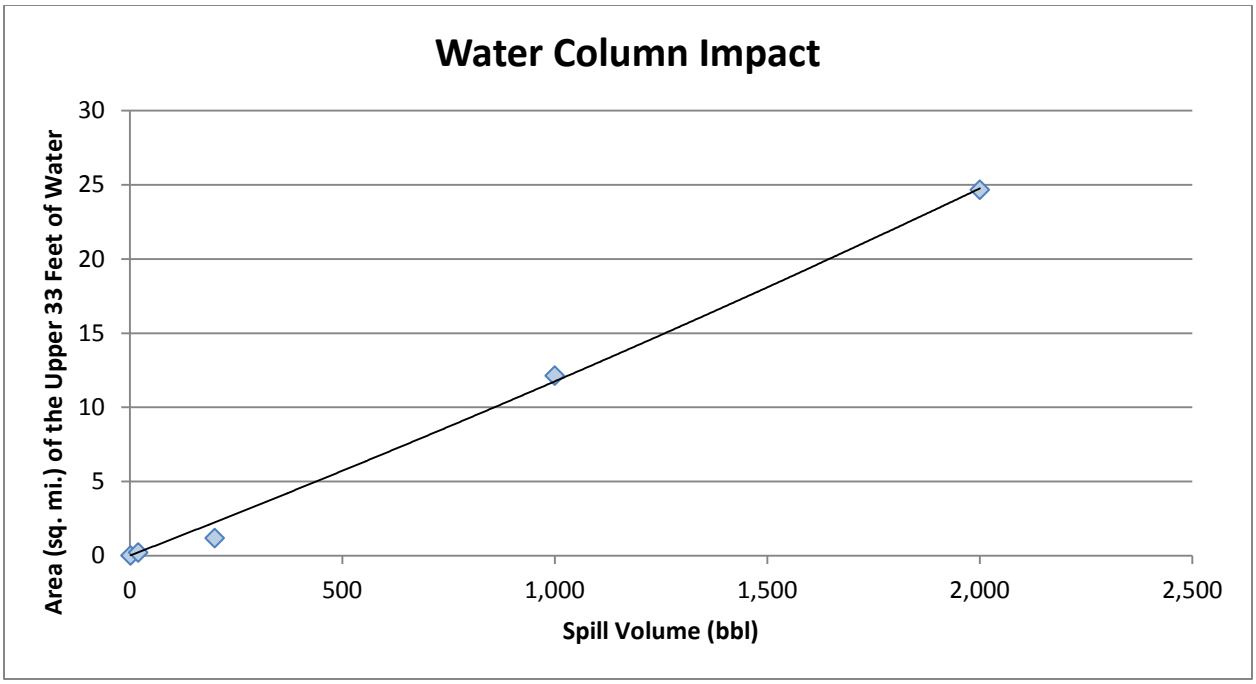


Figure 2-1: Regression curve for estimating the volume of water column at or above 1 ppb aromatics impacted as a function of spill volume for the *Tokai Maru*.

Potential Water Surface Slick

The slick size from an oil release from the *Tokai Maru* is a function of the quantity released. The estimated water surface coverage by a fresh slick (the total water surface area "swept" by oil over time) for the various scenarios is shown in Table 2-3, as the median result of the 200 model runs. 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, tarballs, and streamers.

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

Scenario Type	Oil Volume (bbl)	Estimated Slick Area Swept Mean of All Models	
		0.01 g/m²	10 g/m²
Chronic	2	3 mi²	1 mi²
Episodic	20	20 mi²	5 mi²
Most Probable	200	125 mi²	35 mi²
Large	1,000	420 mi²	140 mi²
Worst Case Discharge	2,000	680 mi²	230 mi²

The location, size, shape, and spread of the oil slick(s) from an oil release from the *Tokai Maru* 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.

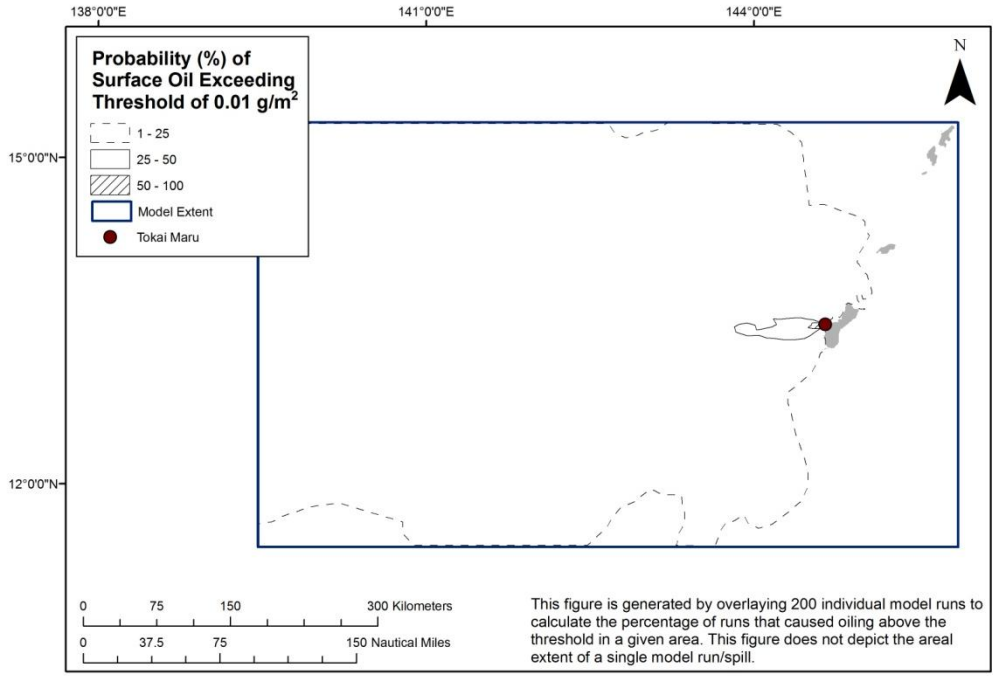


Figure 2-2: Probability of surface oil (exceeding 0.01 g/m^2) from the Most Probable spill of 200 bbl of light fuel oil from the *Tokai Maru* at the threshold for socio-economic resources at risk.

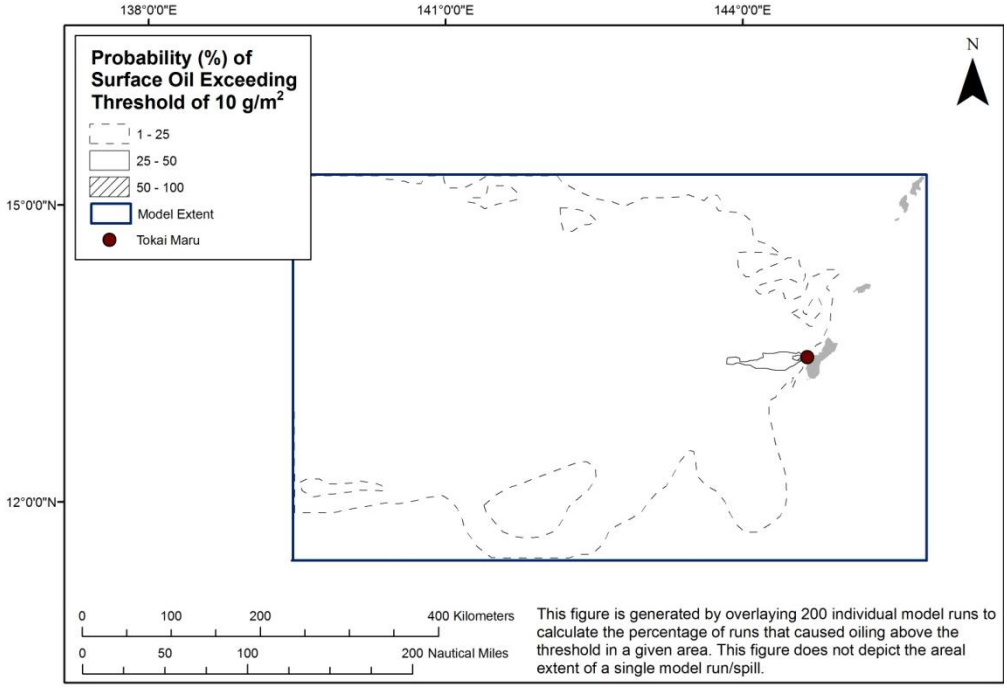


Figure 2-3: Probability of surface oil (exceeding 10 g/m^2) from the Most Probable spill of 200 bbl of light fuel oil from the *Tokai Maru* at the threshold for ecological resources at risk.

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.

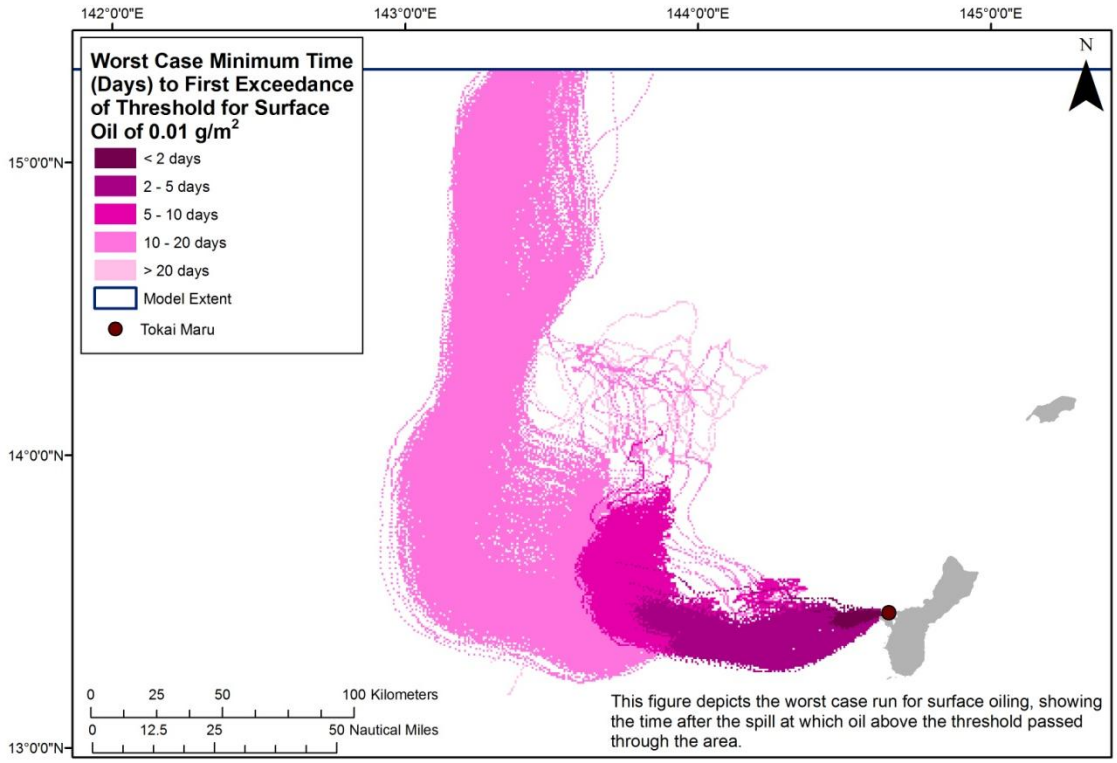


Figure 2-4: Water surface oiling from the Most Probable spill of 200 bbl of light fuel oil from the *Tokai Maru* shown as the area over which the oil spreads at different time intervals.

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.

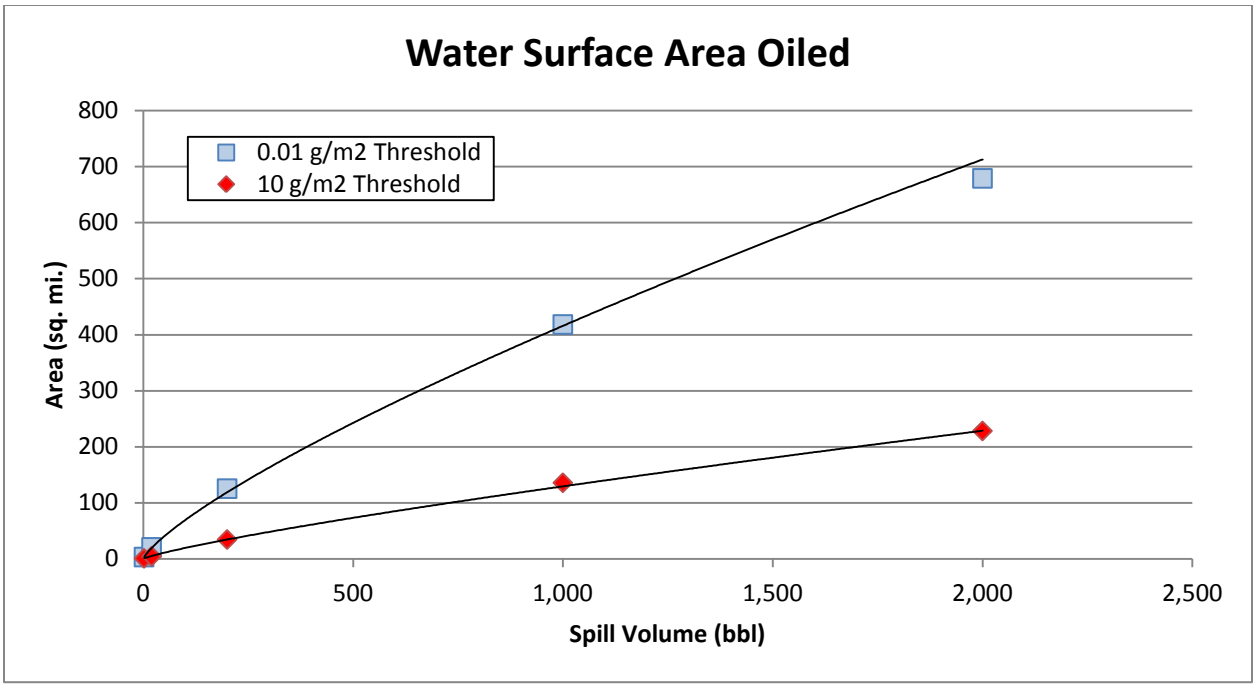


Figure 2-5: Regression curve for estimating the amount of water surface oiling as a function of spill volume for the *Tokai Maru*, showing both the ecological threshold of 10 g/m^2 and socio-economic threshold of 0.01 g/m^2.

Potential Shoreline Impacts

Based on these modeling results, shorelines along the western half of Guam 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 200 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 *Tokai Maru*.

Scenario Type	Volume (bbl)	Estimated Miles of Shoreline Oiling Above 1 g/m^2			
		Rock/Gravel/Artificial	Sand	Wetland/Mudflat	Total
Chronic	2	0	0	0	0
Episodic	20	0	0	0	0.2
Most Probable	200	0	0	0	0.1
Large	1,000	0	0	0	0.5
Worst Case Discharge	2,000	0	0	0	0.6

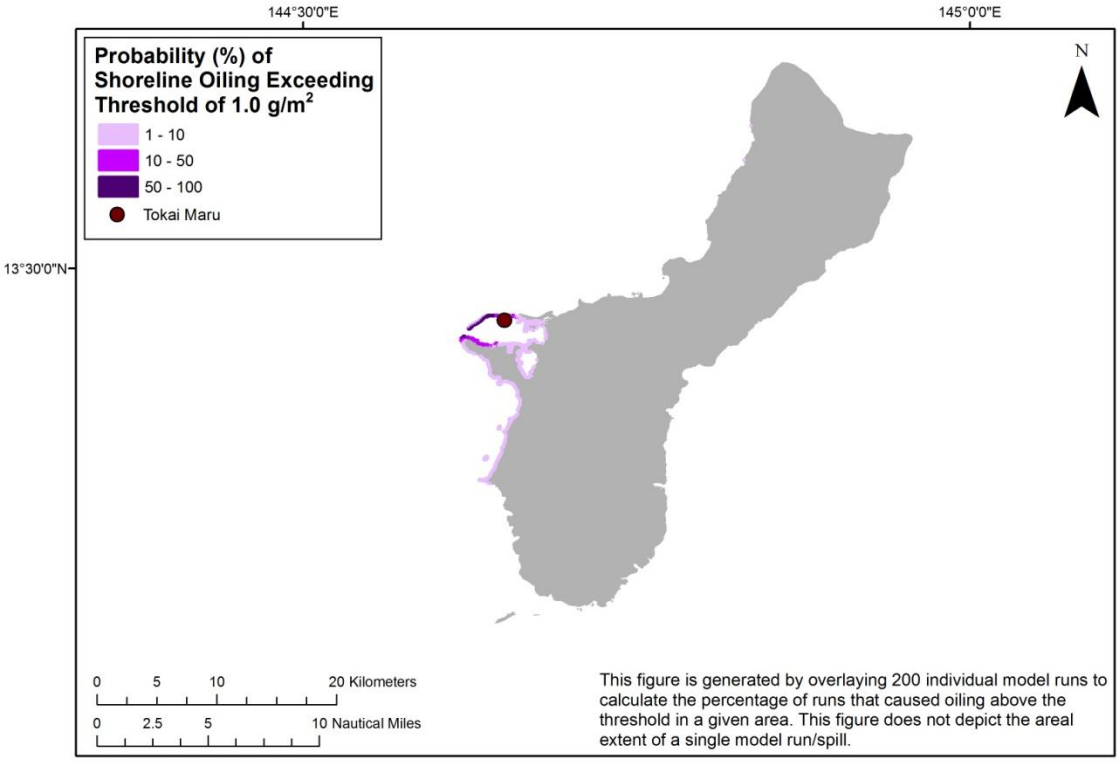


Figure 2-6: Probability of shoreline oiling (exceeding 1.0 g/m^2) from the Most Probable Discharge of 200 bbl of light fuel oil from the *Tokai Maru*.

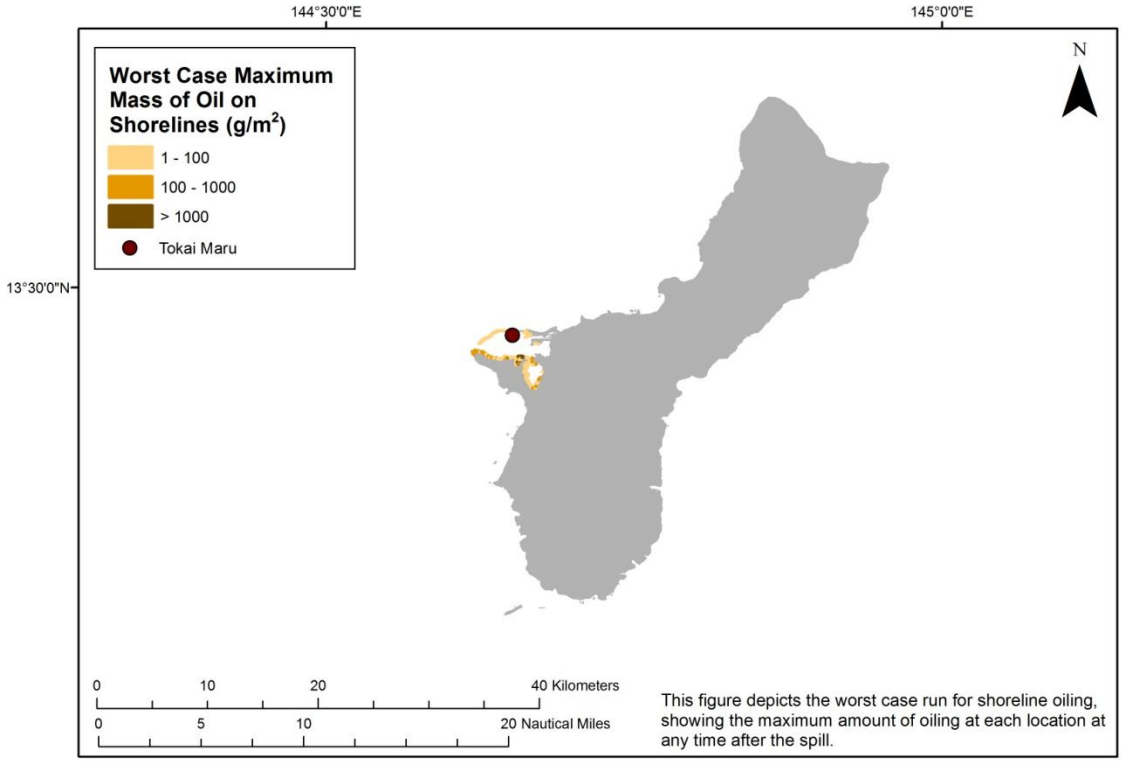


Figure 2-7: The extent and degree of shoreline oiling from the single model run of the Most Probable Discharge of 200 bbl of light fuel oil from the *Tokai Maru* that resulted in the greatest shoreline oiling.

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.

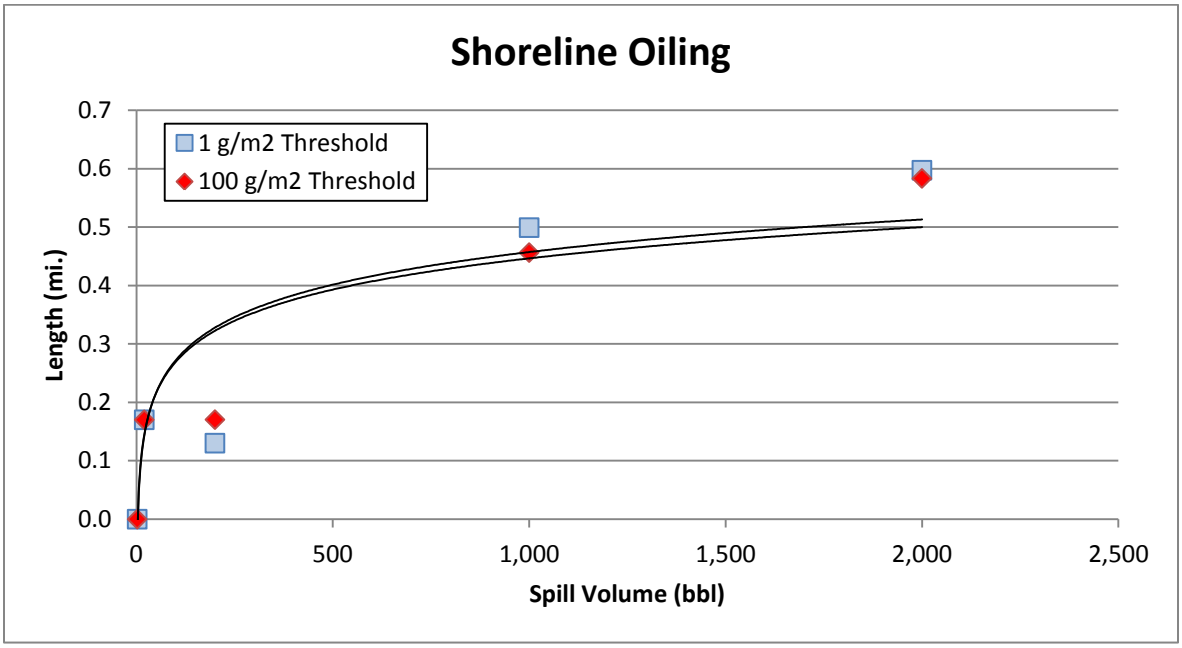


Figure 2-8: Regression curve for estimating the amount of shoreline oiling at different thresholds as a function of spill volume for the *Tokai Maru*.

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

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

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	4 miles	4 miles
Sand beaches	0 miles	0 miles
Salt marshes and tidal flats	2 miles	0 miles

Table 2-6: Worst case scenario shoreline impact by habitat type and oil thickness for a leakage of 200 bbl from the *Tokai Maru*.

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	1 mile	1 mile
Sand beaches	0 miles	0 miles
Salt marshes and tidal flats	0 miles	0 miles

SECTION 3: ECOLOGICAL RESOURCES AT RISK

Ecological resources at risk from a catastrophic release of oil from the *Tokai Maru* (Table 3-1) include sensitive marine resources, specifically coral reef habitats, coastal marine mammals, and sea turtles nesting in the region.

Table 3-1: Ecological resources at risk from a release of oil from the *Tokai Maru*.
(FT = Federal threatened; FE = Federal endangered).

Species Group	Species Subgroup and Geography	Seasonal Presence
Seabirds and shorebirds	Many seabirds have been extirpated from mainland Guam by introduced predators. Remaining seabirds nest on offshore islets • Brown noddy, Pacific reef-heron, and white tern are residents that commonly forage in Apra Harbor and nest on offshore islets (Neye Island, Anae and Alutom Islands and offshore of Apaoa Point and Facpi Point) • Yellow bittern can be found in wetland habitats • Black noddy and short-tailed shearwater are common transient species • Brown and red-footed boobies, wedge-tailed shearwater, Matsudaira's storm-petrel, white-tailed and red-tailed tropicbirds, great frigatebird, gulls, and terns are all less common visitors	Pacific reef-heron nests Apr-Jul Resident species present year round
Sea turtles	Green (FT) and hawksbill (FE) sea turtles nest on sandy beaches in Apra Harbor, Sella Bay, and Cetti Bay • Guam is minor nesting habitat for green sea turtles (FT) • Green sea turtles are associated with seagrass beds and reef flats in Apra Harbor and Sasa Bay • Hawksbill (FE) nesting is sporadic in Guam • Hawksbills feed on sponges in Sasa Bay Leatherback (FE), loggerhead (FE), and olive ridley (FT) sea turtles are occasional transient visitors	Greens nest Apr-Jul Hawksbills nest Jan-Mar Nesting seasonality shown are peaks, evidence of nesting has occurred other times of year
Mammals	Spinner dolphins are common throughout coastal waters of Guam • Pods of 40 dolphins and 80 dolphins are present in coastal regions in the area of impact Bottlenose dolphins and pan-tropical spotted dolphins are also frequently sighted in nearshore waters	Year round
Fish and Invertebrates	Coral reefs are highly diverse habitat that include many species of barracudas, emperors, goatfishes, groupers, mullets, parrotfishes, puffers, snappers, surgeonfishes, wrasses, rays, and invertebrates • >5,000 species of marine organisms live on Guam's coral reefs; hundreds of species are important fishery resources • Scalloped hammerhead pupping in Apra Harbor • High concentrations of forage fish can be found in Apra Harbor • Giant clams can be found on reef flats out to 60' of depth • Octopus, sea cucumbers, spiny lobsters, swimming crabs, sponges (high), bivalves (high) can all be found in Sasa Bay Marine Preserve	Scalloped hammerhead pups Jan-Mar Forage fish aggregations in Jun-Dec
Benthic Habitats	Coral reef and colonized hard bottom, coralline algae, turf algae, macroalgae, and seagrass beds are common adjacent to shorelines and shallow areas in the area of impact • Several coral areas of special significance (identified by local resource experts) are present in Apra Harbor	

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

Ecological Risk Factors

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

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

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

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

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

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

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

In the following sections, the definition of low, medium, and high for each ecological risk factor is provided. Also, the classification for the *Tokai Maru* is provided, both as text and as shading of the applicable degree of risk bullet, for the WCD release of 2000 bbl and a border around the Most Probable Discharge of 200 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 *Tokai Maru* is classified as High Risk for oiling probability for water column ecological resources for the WCD of 2,000 bbl because 100% of the model runs resulted in contamination of more than 0.2 mi^2 of the upper 33 feet of the water column above the threshold of 1 ppb aromatics. It is classified as Medium Risk for degree of oiling because the mean volume of water contaminated in the model runs was 25 mi^2 of the upper 33 feet of the water column. For the Most Probable Discharge of 200 bbl, the *Tokai Maru* is classified as High Risk for oiling probability for water column ecological resources because 58% of the model runs resulted in contamination of more than 0.2 mi^2 of the upper 33 feet of the water column above the threshold of 1 ppb aromatics. It is classified as Medium Risk for degree of oiling because the mean volume of water contaminated was 1 mi^2 of the upper 33 feet of the water column.

Risk Factor 3B: Water Surface Impacts to EcoRAR

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

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

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

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

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

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

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

The *Tokai Maru* is classified as Low Risk for oiling probability for water surface ecological resources for the WCD because 7% 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 230 mi^2. The *Tokai Maru* is classified as Low Risk for oiling probability for water surface ecological resources for the Most Probable Discharge because 0% 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 also classified as Low Risk for degree of oiling because the mean area of water contaminated was 35 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 *Tokai Maru* is classified as Medium Risk for oiling probability for shoreline ecological resources for the WCD because 18% of the model runs resulted in shorelines affected above the threshold of 100 g/m^2. It is classified as Low Risk for degree of oiling because the mean weighted length of shoreline contaminated was 1 mile. The *Tokai Maru* is classified as Low Risk for oiling probability to shoreline ecological resources for the Most Probable Discharge because 6% of the model runs resulted in shorelines affected above the threshold of 100 g/m^2. It is classified as Low Risk for degree of oiling because the mean weighted length of shoreline contaminated was 0 miles.

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

- Water column resources – Medium, because of the sensitivity of coral reef habitat and the many fish and invertebrates associated with this habitat
- Water surface resources – Low, because dense concentrations of birds are not likely in the areas potentially covered by oil above thresholds. It should be noted that oil on the surface will not be continuous but rather be broken and patchy and in the form of sheens and streamers
- Shoreline resources – Low, because little to no shoreline oiling is likely

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

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
3A-1: Water Column Probability EcoRAR Oiling	Low	Medium	High	100% of the model runs resulted in at least 0.2 mi^2 of the upper 33 feet of the water column contaminated above 1 ppb aromatics	Med
3A-2: Water Column Degree EcoRAR Oiling	Low	Medium	High	The mean volume of water contaminated above 1 ppb was 25 mi^2 of the upper 33 feet of the water column	
3B-1: Water Surface Probability EcoRAR Oiling	Low	Medium	High	7% of the model runs resulted in at least 1,000 mi^2 of water surface covered by at least 10 g/m^2	Low
3B-2: Water Surface Degree EcoRAR Oiling	Low	Medium	High	The mean area of water contaminated above 10 g/m^2 was 228 mi^2	
3C-1: Shoreline Probability EcoRAR Oiling	Low	Medium	High	18% 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 1 mi	

For the Most Probable Discharge of 200 bbl, the ecological risk from potential releases of light fuel oil from the *Tokai Maru* is summarized as listed below and indicated in the far-right column in Table 3-3:

- Water column resources – Low, because very little area of water is potentially affected above the impact thresholds, even for sensitive species
- Water surface resources – Low, because of the smaller area of potential impact and dense concentrations of birds are not likely in the areas potentially covered by oil above thresholds. It should be noted that oil on the surface will not be continuous but rather be broken and patchy and in the form of sheens and streamers
- Shoreline resources – Low, because little to no shoreline oiling is likely

Table 3-3: Ecological risk factor scores for the **Most Probable Discharge of 200 bbl** of light fuel oil from the *Tokai Maru*.

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
3A-1: Water Column Probability EcoRAR Oiling	Low	Medium	High	58% of the model runs resulted in at least 0.2 mi^2 of the upper 33 feet of the water column contaminated above 1 ppb aromatics	Low
3A-2: Water Column Degree EcoRAR Oiling	Low	Medium	High	The mean volume of water contaminated above 1 ppb was 1 mi^2 of the upper 33 feet of the water column	
3B-1: Water Surface Probability EcoRAR Oiling	Low	Medium	High	0% of the model runs resulted in at least 1,000 mi^2 of water surface covered by at least 10 g/m^2	Low
3B-2: Water Surface Degree EcoRAR Oiling	Low	Medium	High	The mean area of water contaminated above 10 g/m^2 was 35 mi^2	
3C-1: Shoreline Probability EcoRAR Oiling	Low	Medium	High	6% 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 0 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 *Tokai Maru* include the Apra Harbor, a deep-water port on the western side of the U.S. territory of Guam. The southern end of the harbor is the location of the Naval Base Guam. The northern end of the harbor is a commercial port which handles 331 port vessel calls per year. There is also recreational diving that occurs in the harbor, including at the site of the *Tokai Maru* wreck.

There are several state parks along the western shore of the island that would also be at risk.

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 *Tokai Maru* 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 *Tokai Maru*.

Resource Type	Resource Name	Economic Activities
State Parks	Apaca Point State Park Bishop Ohaz Park Ga'an Point Park Nimitz Beach Park	Coastal state parks are significant recreational resources for the public (e.g., swimming, boating, recreational fishing, wildlife viewing, nature study, sports, dining, camping, and amusement parks). They provide income to the states.
Ports	There are a number of significant commercial ports in the Northeast that could potentially be impacted by spillage and spill response activities. The port call numbers below are for large vessels only. There are many more, smaller vessels (under 400 GRT) that also use these ports.	
	Apra Harbor, Guam	331 port calls annually

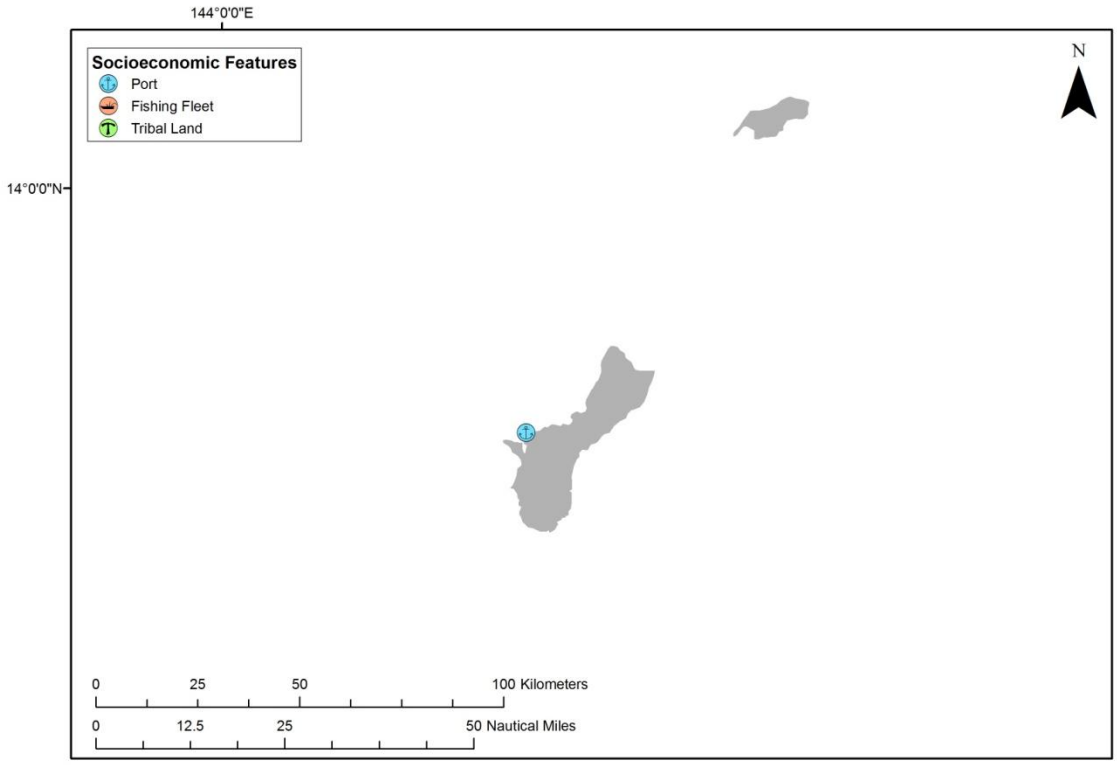


Figure 4-1: Tribal lands, ports, and commercial fishing fleets at risk from a release from the *Tokai Maru*. (Note that there are no tribal lands or fishing fleets at risk.)

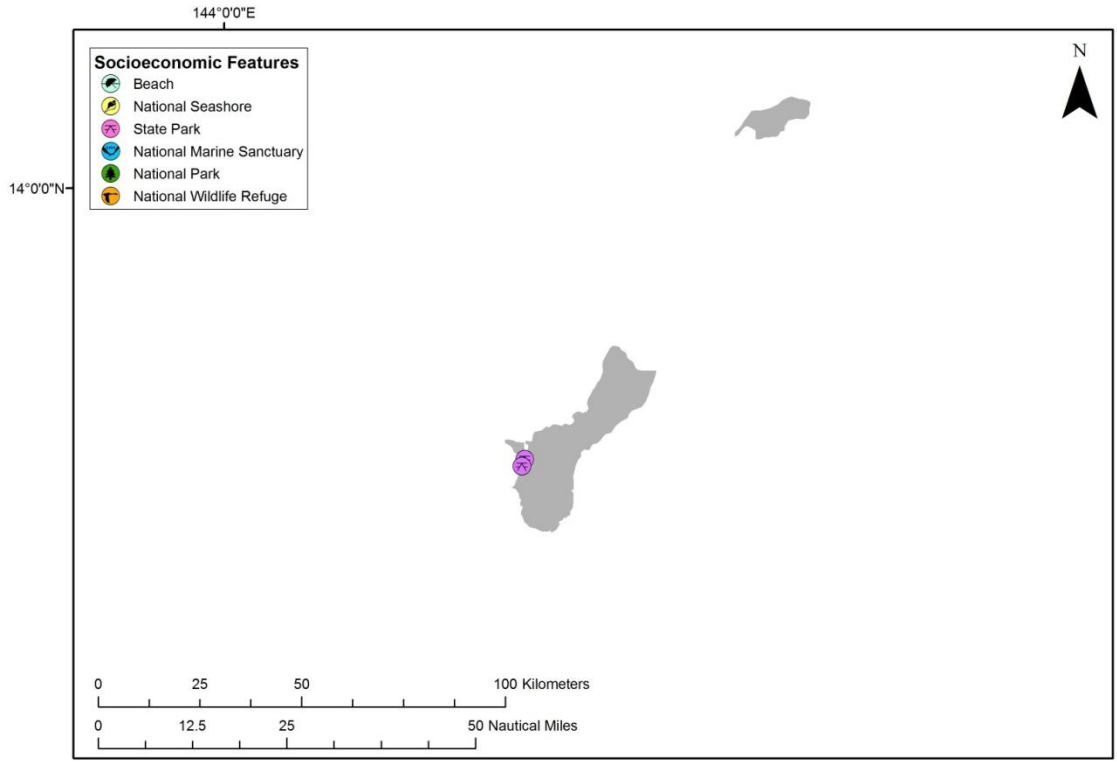


Figure 4-2: Beaches, coastal state parks, and Federal protected areas at risk from a release from the *Tokai Maru*.

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 ere are significant impacts have less impact than this case, and half have more.

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

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

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

In the following sections, the definition of low, medium, and high for each socio-economic risk factor is provided. Also, the classification for the *Tokai Maru* is provided, both as text and as shading indicates the degree of risk, for the WCD release of 2,000 bbl and a border indicates degree of risk for the Most Probable Discharge of 200 bbl.

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

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

The three risk scores for oiling are:

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

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

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

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

The *Tokai Maru* 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 2,000 bbl because 100% of the model runs resulted in contamination of more than 0.2 mi^2 of the upper 33 feet of the water column above the threshold of 1 ppb aromatics, and the mean volume of water contaminated was 25 mi^2 of the upper 33 feet of the water column. For the Most Probable Discharge of 200 bbl, the *Tokai Maru* is classified as High Risk for oiling probability for water column socio-economic resources because 58% of the model runs resulted in contamination of more than 0.2 mi^2 of the upper 33 feet of the water column above the threshold of 1 ppb aromatics. It is classified as Medium Risk for degree of oiling because the mean volume of water contaminated was 1 mi^2 of the upper 33 feet of the water column.

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

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

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

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

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

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

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

The *Tokai Maru* is classified as Medium Risk for oiling probability and Low Risk for degree of oiling for water surface socio-economic resources for the WCD because 24% 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 680 mi^2. The *Tokai Maru* is classified as Low Risk for oiling probability for water surface socio-economic 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 0.01 g/m^2. It is classified as Low Risk for degree of oiling because the mean area of water contaminated was 125 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 *Tokai Maru* is classified as Medium Risk for oiling probability for shoreline socio-economic resources for the WCD because 21% of the model runs resulted in shorelines affected above the threshold of 1 g/m^2. It is classified as Low Risk degree of oiling because the mean length of weighted shoreline contaminated was 1 mile. The *Tokai Maru* is classified as Medium Risk for oiling probability and Low Risk degree of oiling for shoreline socio-economic resources for the Most Probable Discharge as 17% 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 0 miles.

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

- Water column resources – Medium, because a moderate area of water column would be impacted in an area with minimal fishing, although much of that impact would be in an enclosed harbor area
- Water surface resources – High, because although a moderate area of water surface would be impacted much of that impact would be in an enclosed harbor area. It should be noted that oil on the surface will not be continuous but rather be broken and patchy and in the form of sheens, tarballs, and streamers
- Shoreline resources – Low, because a very small length of shoreline would be impacted

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

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
4A-1: Water Column Probability SRAR Oiling	Low	Medium	High	100% of the model runs resulted in at least 0.2 mi^2 of the upper 33 feet of the water column contaminated above 1 ppb aromatics	Med
4A-2: Water Column Degree SRAR Oiling	Low	Medium	High	The mean volume of water contaminated above 1 ppb was 25 mi^2 of the upper 33 feet of the water column	
4B-1: Water Surface Probability SRAR Oiling	Low	Medium	High	24% 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 680 mi^2	
4C-1: Shoreline Probability SRAR Oiling	Low	Medium	High	21% of the model runs resulted in shoreline oiling of 1 g/m^2	Low
4C-2: Shoreline Degree SRAR Oiling	Low	Medium	High	The length of shoreline contaminated by at least 1 g/m^2 was 1 mi	

For the Most Probable Discharge of 200 bbl, the socio-economic risk from potential releases of light fuel oil from the *Tokai Maru* is summarized as listed below and indicated in the far-right column in Table 4-3:

- Water column resources – Low, because a small area of water column would be impacted in an area with minimal fishing, although much of that impact would be in an enclosed harbor area
- Water surface resources – Medium, because although a relatively small area of water surface would be impacted much of that impact would be in an enclosed harbor area. It should be noted that oil on the surface will not be continuous but rather be broken and patchy and in the form of sheens, tarballs, and streamers
- Shoreline resources – Low, because a virtually no shoreline would be impacted

Table 4-3: Socio-economic risk factor ranks for the **Most Probable Discharge of 200 bbl** of light fuel oil from the *Tokai Maru*.

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
4A-1: Water Column Probability SRAR Oiling	**Low**	**Medium**	**High**	58% 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 1 mi^2 of the upper 33 feet of the water column	
4B-1: Water Surface Probability SRAR Oiling	**Low**	**Medium**	**High**	2% of the model runs resulted in at least 1,000 mi^2 of water surface covered by at least 0.01 g/m^2	**Med**
4B-2: Water Surface Degree SRAR Oiling	**Low**	**Medium**	**High**	The mean area of water contaminated above 0.01 g/m^2 was 125 mi^2	
4C-1: Shoreline Probability SRAR Oiling	**Low**	**Medium**	**High**	17% of the model runs resulted in shoreline oiling of 1 g/m^2	**Low**
4C-2: Shoreline Degree SRAR Oiling	**Low**	**Medium**	**High**	The length of shoreline contaminated by at least 1 g/m^2 was 0 mi	

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

The overall risk assessment for the *Tokai Maru* 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.)

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

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

For the Worst Case Discharge, the *Tokai Maru* scores Medium with 12 points; for the Most Probable Discharge, the *Tokai Maru* scores Low with 9 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 *Tokai Maru*. The final determination rests with the U.S. Coast Guard.

Tokai Maru	**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 *Tokai Maru*.

Vessel Risk Factors		Data Quality Score	Comments		Risk Score
Pollution Potential Factors	A1: Oil Volume (total bbl)	Low	Maximum of 1,900 bbl, not reported to be leaking		**Med**
	A2: Oil Type	Low	Bunker fuel is diesel, but it is possible the vessel used heavy oil for donkey boilers		
	B: Wreck Clearance	High	Vessel not reported as cleared		
	C1: Burning of the Ship	Low	Unknown fire at time of loss		
	C2: Oil on Water	Low	Unknown loss of oil		
	D1: Nature of Casualty	High	Multiple torpedo explosions		
	D2: Structural Breakup	High	The vessel is in one contiguous piece		
Archaeological Assessment	Archaeological Assessment	Low	The best archaeological assessment still comes from the National Park Service, so a detailed assessment was not prepared		**Not Scored**
Operational Factors	Wreck Orientation	High	Resting on its port side		**Not Scored**
	Visual or Remote Sensing Confirmation of Site Condition	High	Depth is 130 feet		
	Other Hazardous Materials Onboard	High	Wreck is a popular dive site		
	Munitions Onboard	High	No		
	Gravesite (Civilian/Military)	High	At least four depth charges and possibly other munitions		
	Historical Protection Eligibility (NHPA/SMCA)	Low	Unknown		
				WCD	**Most Probable**
Ecological Resources	3A: Water Column Resources	High	Larger releases could possible affect sensitive coral reef habitat and associated biota	**Med**	**Low**
	3B: Water Surface Resources	High	Areas swept by sheens above thresholds are not likely to include areas with high bird concentrations	**Low**	**Low**
	3C: Shore Resources	High	Very little shoreline impact is likely	**Low**	**Low**
Socio-Economic Resources	4A: Water Column Resources	High	Moderate area of water column could be impacted in an area with minimal fishing, although much of that impact would be in an enclosed harbor area	**Med**	**Low**
	4B: Water Surface Resources	High	Although a moderate area of water surface could be impacted, much of that impact would be in an enclosed harbor area	**High**	**Med**
	4C: Shore Resources	High	Very small length of shoreline could be impacted	**Low**	**Low**
Summary Risk Scores				**12**	**9**