The Removal of Oil from Sunken Vessels including SOLAR 1 - Some Technical Considerations

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PAJ International Oil Spill Symposium, 2007
"Oil Spill Risks, Old and New"

22nd & 23rd February 2007, Tokyo, Japan

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INTRODUCTION

Following the sinking of the tanker PRESTIGE in the Atlantic Ocean in 2002, a consortium headed by the Spanish oil company, REPSOL, designed and implemented a system for the removal of 13,000 tonnes of the vessel's remaining cargo of heavy fuel oil from a depth of some 3,650 metres, some 170 nautical miles off the Spanish coast. This was a remarkable engineering achievement, accomplished without further loss of oil and introduced the possibility that oil could be recovered from sunken wrecks in very deep water under most circumstances. Nevertheless, the IOPC Fund's Executive Committee judged that while the costs of some of the preparatory work should be met, the claim presented by the Spanish Government for the cost of the operation to remove the oil itself was inadmissible. This paper examines the criteria drawn upon by the Executive Committee to reach this decision and how, the circumstances of the SOLAR 1 sinking in the Philippines, allowed the Committee to reach a different conclusion.

RISK ASSESSMENT APPROACH

An "ecological time-bomb" is just one example of the emotive language that is typically used following the sinking of a loaded tanker and sentiments such as this have a strong influence on the political decision whether or not to remove oil from a sunken wreck. However, from a technical perspective the underlying principle is simply whether or not the wreck poses a significant pollution risk.

In assessing this risk the answers to two questions need to be analysed; first, the risk that oil will be released and second, the consequences of any such release. In evaluating the risk of release the key issues are the quantity of oil remaining on board and the rate at which that this oil is likely to be lost from the wreck. In a number of cases the outcome of such risk assessments has led to a decision to remove oil from sunken and examples are shown in Table 1. From this Table it can be seen that most of these were in relatively shallow water, close to coastal resources.

TABLE 1. Examples of sunken tankers from which cargo was extracted.

Vessel name	Date of Incident	Quantity of oil	Distance offshore	Water depth
		Tonnes	*Nautical miles*	*Metres*
TANIO (BOW)	1980	<5,000	26 N Brittany, France	90
YUIL NO.1	1995	670	5.5 Busan, Rep. Korea	70
OSUNG NO.3	1997	27	Kojedo, Busan	70
ERIKA	1999	11,100	60 W Brittany, France	100 – 130
SPABUNKER IV	2003	~1,000	Algericiras Bay, Spain	60

<u>i) Estimates of quantity of oil remaining in the wreck</u>

Establishing what volume of oil remains in the tanks of a sunken vessel is not straightforward and the reliability of such estimates is dependant on many factors. In the PRESTIGE incident a novel technique, a Reservoir Performance Monitoring tool, was used to locate the oil-water interface and so calculate the quantities remaining in each tank. This instrument is more commonly used in the oil exploration and production industry. The tool emits a cloud of high energy neutrons which interact with materials encountered releasing gamma ray radiation, the energy levels of which are indicative of the materials encountered. Electronic processing of the return signals allowed the oil–water interfaces to be located. In the SOLAR 1 incident this technology could not be applied because the vessel was substantially buried in mud and removal of the mud risked destabilising the wreck.

In many cases an underwater survey using video cameras mounted on Remotely Operated Vehicles (ROV surveys) is used to investigate the status of the wreck and damage to cargo tanks from which the likely quantity of oil remaining can sometimes be deduced. However, again in the case of the SOLAR 1 although such an examination was undertaken, it yielded little information on the quantity of oil remaining in the wreck. The ROV survey found that the vessel was upright, with a trim by the stern. The hatch cover to tank No.4 Port was found to have been displaced but otherwise there was very little evidence of damage at deck level and all the other tank tops were secure. The vessel had settled into soft mud so it was not possible to assess the extent of any bottom damage, however, there was substantial vertical creasing at various locations along the shell plating indicating that the vessel had suffered substantial hogging, possibly on impact with seabed. At the time of the survey there was little evidence of oil leakage and the leaks that were observed from a small number of locations were estimated to amount to only some 10 – 20 litres per hour.

One clear conclusion that could be drawn from the ROV survey was that the contents of Number 4 Port cargo tank, some 275 m^3, were no longer on board. There was also evidence that oil had leaked through the cargo tank vents. One possible hypothesis was that since the vent line to the cargo tanks was open and damage may have occurred that allowed water into the bottom of the tanks, a substantial quantity of oil may have been lost through these vents. It is also possible that internal structural damage allowed some oil from tanks adjacent to No.4 Port to escape.

A video recording made during an aerial survey conducted by the Philippines Coast Guard two days after the vessel sank indicated that a substantial quantity of oil was being lost from the wreck, perhaps as much as 10 – 20 tonnes per hour. Uncertainties in this estimate arose because the thickness of oil on the surface could only be judged by its appearance and the estimate was based on a snapshot in time. Nevertheless, the short video and the degree of contamination of the shoreline both pointed to a substantial loss of oil from the wreck in the early stages of the incident possibly more than half of its cargo. However, neither the Coast Guard video nor the ROV survey provided more than an indication of likely losses and indeed the lack of damage at deck level or to the upper hull strongly suggested that a considerable proportion of the cargo could still remain trapped within the hull.

In summary then, although techniques exist to determine how much oil remains in a sunken wreck, more often than not this is not known with any certainty.

ii) <u>Rate of release</u>

The concern often expressed in relation to sunken wrecks is that the total quantity of oil remaining in a wreck might be released at once due to a catastrophic failure of the ship structure. In reality there are very few situations when such a scenario could be imagined, firstly because usually the oil is held in a number of tanks and the failure of all tanks simultaneously is difficult to contemplate. The sort of situation which could lead to such an event might include a severe storm or tsunami for a wreck in shallow water or the vessel becoming crushed due to movement of the seabed as result of seismic activity. Under some circumstances serious damage to one or more tanks might be foreseen as a result of the passage of heavy fishing gear or a large vessel dragging its anchor.

In the case of PRESTIGE some seismic activity was reported in the vicinity of the wreck but a study conducted by Repsol considered the area to be geologically stable. On the other hand the area in which SOLAR 1 sank was in an area of considerable seismic activity (see Figure 1) which shows a major fault line running 25 nautical miles to the west of the sinking position. The most significant recorded seismic event took place in 1948, measuring 8.3 on the Richter Scale while the last major event in the vicinity was a tremor with a magnitude of 7 in 1990.

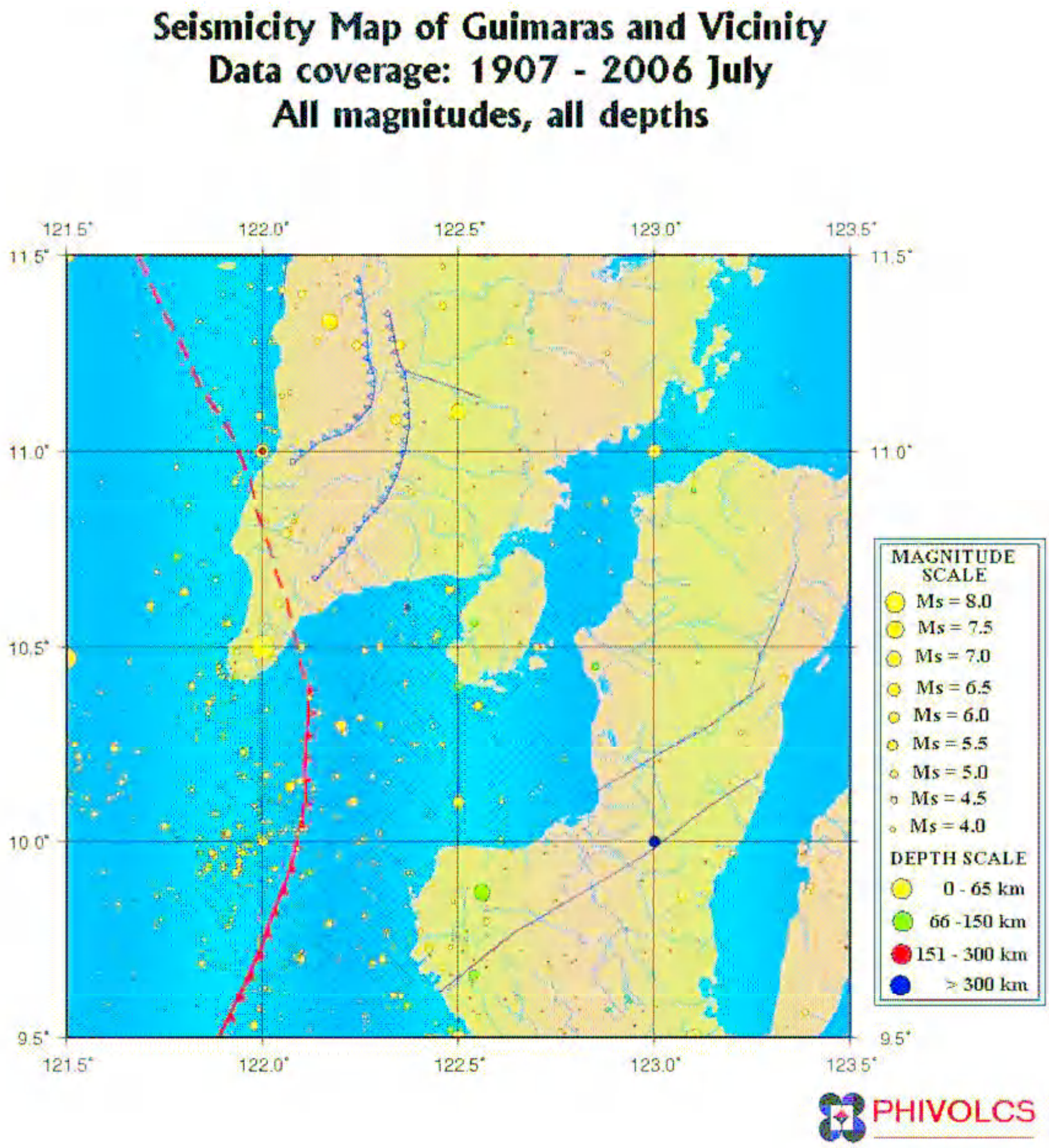
Seismicity Map of Guimaras and Vicinity
Data coverage: 1907 - 2006 July
All magnitudes, all depths
121.5°
122.0°
122.5°
123.0°
123.5°
11.5°
11.0°
10.5°
10.0°
9.5°
MAGNITUDE SCALE
Ms = 8.0
Ms = 7.5
Ms = 7.0
Ms = 6.5
Ms = 6.0
Ms = 5.5
Ms = 5.0
Ms = 4.5
Ms = 4.0
DEPTH SCALE
0 - 65 km
66 -150 km
151 - 300 km
> 300 km
PHIVOLCS

FIGURE 1

For any wreck it is very probable that in the longer term pin holes and fissure will result from corrosion of the steel and the tanks will start to leak oil. Drawing on the example of vessels sunk during hostilities in World War II, it may be fifty years or more before the effects of corrosion are apparent. These latter wrecks are generally found in shallower water than either PRESIGE or SOLAR 1 and where exposure to disturbance is likely to be greater and corrosion would be expected to be faster. Even in these cases it has not been the experience that oil loss has been catastrophic, but rather that oil has leaked slowly. Furthermore, there are numerous other examples of vessels with oil cargo on board which although sunk more recently, have not led to reports of further releases of oil after those associated with the initial sinking, see Table 2.

TABLE 2. Sunken tankers from which cargo recovery was not attempted.

Vessel name	Date of Incident	Quantity of oil*	Distance offshore	Water depth
		Tonnes	*Nautical miles*	*Metres*
ATLANTIC EMPRESS	1979	<270,000 crude	260 E Barbados & 350 ENE Trinidad	> 4,000
CASTILLO DE BELVER – BOW	1983	60,000 crude	136 W South Africa	> 3,000
– STERN		100,000 crude	24 W South Africa	420
ASSIMI	1983	~52,000 crude	170 E Oman	> 3,000
ABT SUMMER	1991	~260,000 crude	900 W Angola	~5,000
KATINA P	1992	~72,000 HFO	240 E Mozambique	~3,000
NAKHODKA	1997	10,000 HFO	75 N Japan	~2,500

* Quantities remaining on board are uncertain because in many cases losses were associated with fire and unknown amounts were spilled.

The rate at which oil leaks from tanks following the effects of corrosion is determined by the dimensions of the holes or cracks and the characteristics of the oil. Table 3 below compares the most significant oil properties of the PRESTIGE and SOLAR 1 cargoes. The pour point, as shown in Table 3, is the temperature below which, under the conditions of the test method, the oil no longer has a tendency to flow. In the case of PRESTIGE the seawater temperature at depth was at or below the oil’s pour point whereas for SOLAR 1, the water temperature was well above the oil’s pour point.

An oil below its pour point is not solid as such and is still buoyant as long as its density is less than that of seawater. There is therefore a force exerted on it, which if unconstrained would bring the oil to the surface. This force causes the oil to "creep" that is, while not fluid it does deform and will slowly move under the influence of buoyancy. If there are holes in the upper side of the wreck (such as, open sounding pipes, access points for tank cleaning machines and vent pipes) or damage to the tanks, the oil will find these and slowly leak out. A useful parallel can be drawn between oil below its pour point and toothpaste. With the lid off the tube, toothpaste will only slowly slump from the tube but with minimum force exerted on the tube it extrudes easily. In the case of oil in a sunken wreck the force is buoyancy rather than a squeezing force.

TABLE 3. Comparison of cargo properties

Cargo Properties	PRESTIGE Composite cargo	SOLAR 1
Quantity loaded tonnes	77,035	2,127
Density @15°C kg/m^3	993.0	965.3
Pour point °C	6	-6
Temperature °C @ depth (m)	~3 (3,650)	11 (630)
Viscosity @ 50°C mm^2.s^{-1}	615	217
Asphaltenes % by weight	6.8	3.2

Comparing the properties of the two oil cargoes it is clear that the SOLAR 1 cargo was a more fluid oil and as such is more likely to be lost more quickly through an orifice of given dimensions.

iii) Consequences of a release

The consequences of oil being released from a sunken wreck depend upon the quantity and rate of release, the oil's behaviour and fate and the economic and environmental resources that lie in the path of the oil as it moves over the sea surface under the influence of wind and currents. Although the PRESTIGE oil was more persistent, reaching as far as the UK and perhaps even the Netherlands, both oils were fuel oils with the potential to persist both as a whole oil or as a stable emulsion. However, the key considerations were the proximity and risk of damage to sensitive resources.

On the basis of observations made before the leaks from the wreck of PRESTIGE were sealed, when it was estimated releases amounted to some 1-2 tonnes per day, the risk to coastal resources in Spain, Portugal and France was judged to be minimal. Buoys intended to simulate drifting oil were released from the sinking position during 2003 and all those which were tracked travelled south towards the Atlantic islands of Madeira, the Canaries and the Azores. In fact the trajectories followed by the buoys during the year differed widely leading to the conclusion that tarballs resulting from any continuing releases were likely to be widely dispersed at very low concentrations across a million square kilometres of the surface of the Atlantic Ocean.

The seafood production industry along the Galician coast was by far the most valuable economic resource potentially at risk from oil pollution and the mussel cultivation industry concentrated in Rias Baixas was of particular significance - see Figure 2. Coastal fishing activity is of less importance by comparison. With such deep water and being far offshore, concentrations of sea birds were also likely to be low to nil in the vicinity of the wreck site. The soluble components of the oil were minimal and so hydrocarbon inputs to the environment would have been limited to the formation of tarballs as the oil weathered.

The most likely drift trajectory of oil from the sinking position was either to the north in winter and spring or to south in summer and autumn, but there was also a perceptible risk of oil surfacing from the wreck reaching seafood cultivation areas in Galicia (Rias Baixas) or the tourist beaches of the Atlantic islands in certain drift scenarios, depending on the season and the directions of winds and currents. However, a substantial release of oil would have been required to cause significant damage to the tourism industries of the Atlantic Islands or the Galician seafood industry, including damage to market confidence.

FIGURE 2. PRESTIGE sinking location off Galician coast, Spain.

In the case of SOLAR 1 the resources of Guimaras Island were particularly sensitive to oil pollution. In evaluating the threat of oil released from the wreck causing further damage to the economic and environmental resources of the island, a number of factors had to be taken into account. The sinking location is only some 10 nautical miles (18.5 km) from the shore - see Figure 3 - and depending upon the rate of release and weather conditions, oil could reach the shoreline.

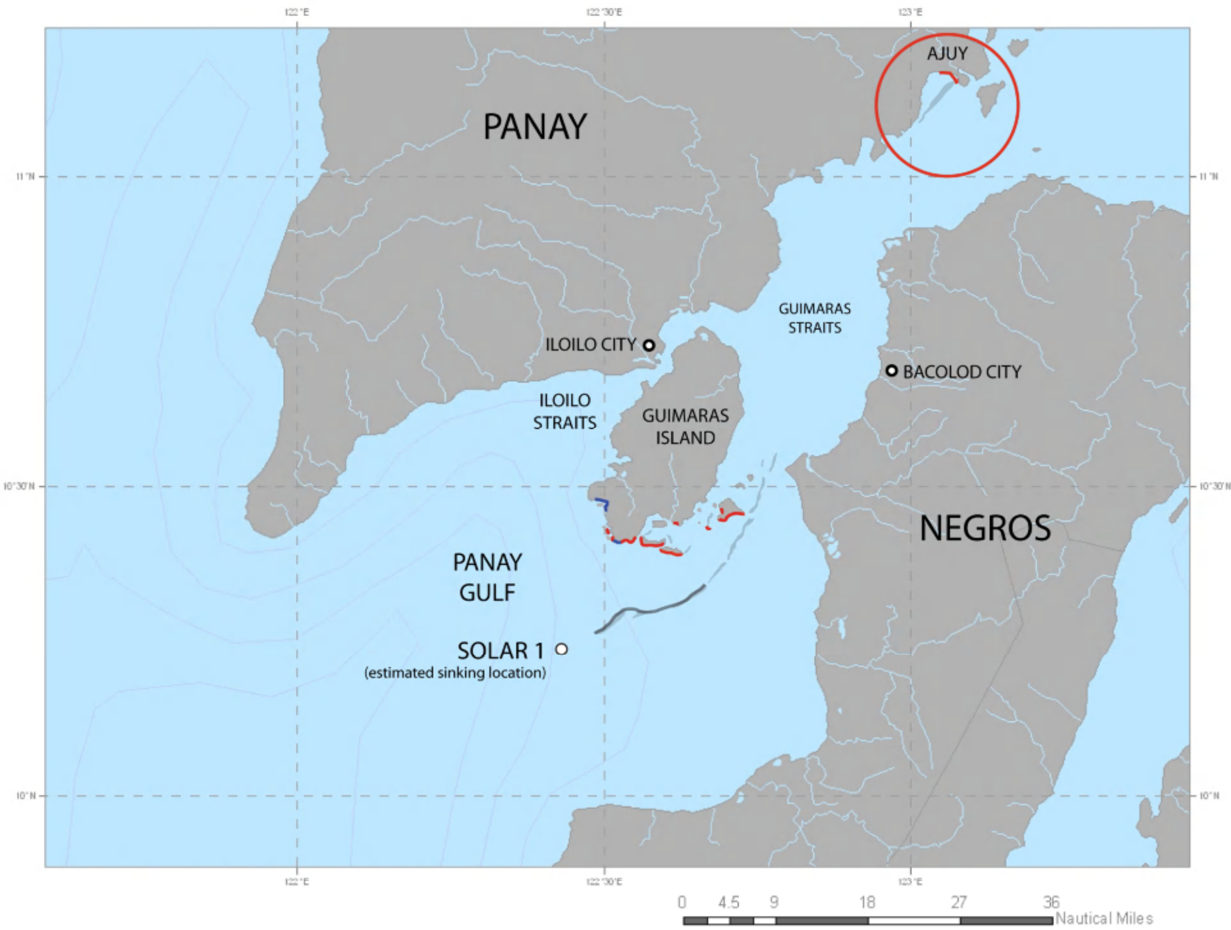

FIGURE 3. Oil spreading from SOLAR 1 sinking location, August 2006

Coastal fishing is practised within 15 km of the shore and the presence of oil and oily sheens on the water would interfere with fishing particularly at night. In addition, oil reaching the shoreline would disrupt the gathering of fish and shellfish from the fringing reef along the southern coast of the island. Some of these reefs dry out at certain states of the tide and so there is also the risk of contamination of the reefs themselves to consider. As far as it is possible to determine to date, the immediate impact of the oil on mangroves does not appear to have been severe. However, the experience of other incidents where similar habitats have been repeatedly oiled indicates that greater damage can be inflicted by chronic multiple oiling than by a single acute episode.

ADMISSIBILITY OF CLAIMS FOR THE REMOVAL OF OIL FROM SUNKEN WRECKS.

The Director of the IOPC Funds requested ITOPF to provide an opinion on the technical reasonableness of the operation to remove oil from PRESTIGE. We found that the only scenario capable of generating pollution damage of the same order of magnitude as the oil removal costs (~€100 million) would have had to involve a massive structural failure in the wreckage of PRESTIGE, leading to a sudden large oil release in excess of 1,000 tonnes capable of damaging sensitive coastal resources. From our review of past cases we could find no examples of such dramatic events involving wrecks lying in deep water. We therefore concluded that the costs of the PRESTIGE oil removal operation were disproportionate to the potential costs of the likely consequences of leaving the oil in place.

The Executive Committee of the IOPC Funds also considered a report prepared by other European experts at the request of the Spanish government, which gave an opposite opinion. However, although some of the costs involved in assessing the risks posed by the wreck and the costs of sealing the wreck were found to be admissible in principle, the Executive Committee noted in its report that costs relating to the actual oil removal operations were inadmissible in principle, since these costs were disproportionate to any potential economic and environmental consequences of leaving the oil in the wreck.

At the time the Executive Committee reached its decision that the oil extraction from the SOLAR 1 was admissible in principle, the information available indicated that the costs of operations to remove any remaining oil were expected to be between US$8-12 million depending on the amount of oil found on board. At that time the estimated level of the losses sustained due to pollution from SOLAR 1 was in the range in the range US$5-8 million but since that time further damage claims have become evident and costs of clean-up have escalated. The Committee agreed that in this case, the indicative costs for the oil removal operation were not disproportionate to the risks of pollution damage resulting from further releases of oil.

Following the Executive Committee debate in relation to the claim put forward by the Spanish government in the case of PRESTIGE, the Director of the IOPC Funds was instructed to consider criteria for admissibility of such claims. At the 1992 Fund's Assembly in October 2006 the Director put forward elements which would need to be taken into account when considering the admissibility of costs for measures to extract oil from sunken vessels. In due course text reflecting these factors will be included in the IOPC Funds' Claims Manual. The elements proposed by the Director are reproduced below:-

(a) The extent to which the shoreline which is most likely to be affected by a release of the oil from the vessel is vulnerable to oil pollution, and the economic damage which is likely to occur if the remainder of the oil were to be released from the vessel;

(b) The likely damage to the environment from a release of the oil from the vessel, including the potential costs of post-spill studies and measures of reinstatement;

(c) The likelihood that oil will be released from the vessel within the foreseeable future and will reach the shore or other natural or economic resources, the quantity, type and characteristics of the oil which could be released and the likely rate at which a release might take place;

(d) The extent to which alternative methods of containing the oil on board the vessel for an indefinite period, or of rendering the remaining oil harmless, are possible and adequate;

(e) The likely cost of the extraction operation and the likelihood that the operation would be successful, taking into account the location of the vessel and its condition, the type of the oil and the characteristics of the area where the ship is located and other relevant circumstances;

(f) The likelihood that significant quantities of oil would be released during the extraction operation and the likely amount of damage that would be caused as a result of such a release.

In Table 4 below these elements are applied to the two cases using the measures; high, moderate and low, and it can be seen that on this basis, the case for extraction of oil is stronger for SOLAR 1 than PRESTIGE. However, it is important to note that the deliberations of the Executive Committee when considering the admissibility of claims do not draw upon purely mathematical assessments but on the weight of argument, assigning different emphases to the different factors depending on the circumstances of the incident.

TABLE 4. Comparison of draft admissibility criteria applied to PRESTIGE & SOLAR 1

Factor	PRESTIGE	SOLAR 1
a) Risk of economic consequences	Low	Moderate
b) Risk of environmental consequences	Low	Moderate
c) i] Likelihood of oil release, and ii] risk of oil reaching sensitive resources	Low Low	Unknown High
d) Alternative approaches	Considered	-
e) i] Costs and ii] likelihood of success	High High	Moderate High
f) Risks of release during extraction	Low	Low

In reaching their decision on the admissibility of costs to extract oil from SOLAR 1, the Executive Committee weighed the proximity of economic and environmental resources vulnerable to oil pollution, the uncertainty over the quantity of oil remaining and the unknown consequences of frequent seismic activity against the moderate projected costs of oil removal from a lesser depth.

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