BMT Cordah Limited
ENVIRONMENTAL CONSULTANCY
AND INFORMATION SYSTEMS

Maritime and Coastguard Agency

Emergency Response to Coastal Oil, Chemical and Inert Pollution from Shipping

Very Heavy Fuel Oil: UK Spill Risk Assessment

Final Report for the Maritime and Coastguard Agency

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ABBREVIATIONS

cSt	Centistokes, a unit of viscosity
CaMRA	Coastal and Marine Resource Atlas
ETV	Emergency Towing Vessel
HFO	Heavy Fuel Oil
IR	Infrared
MNR	Marine Nature Reserve
NNR	National Nature Resrve
RFO	Residual Fuel Oil
SAC	Special Area of Conservation
SSSI	Site of Special Scientific Interest
SLAR	Side Looking Airborne Radar
SPA	Special Protection Area
UKPCZ	UK Pollution Control Zone
UV	Ultraviolet
VHFO	Very Heavy Fuel Oil
VLCC	Very Large Crude Carrier
VTS	Vessel Traffic Services

1 EXECUTIVE SUMMARY

This is the final report of the Maritime and Coastguard Agency (MCA) Research Project 522 "Very Heavy Fuel Oil – UK Spill Risk Assessment". The study has been conducted by BMT Cordah Limited with the following objectives:

- To identify the quantities and routeings of Very Heavy Fuel Oils (VHFOs), both as cargoes and as bunkers, that are transported within and through the UK pollution control zone (UKPCZ)

- To assess the locations of environmental and economic resources vulnerable to pollution from VHFOs

- To evaluate the existing capacity to respond to VHFO spills in UK waters and make recommendations for additional measures

VHFO is not an industry-standard classification. The term has been applied to distinguish the 'heavier', higher viscosity grades of residual fuel oils from 'lighter', less viscous grades. In this study, VHFOs are defined as those fuel oils with a viscosity at 50ºC of 380 cSt or higher.

1.1 Production and characteristics of VHFO

VHFO, both as a cargo and as a bunker, is derived from Residual Fuel Oil (RFO), a by-product of the refining of crude oil. The characteristics of RFO vary according to the refining processes used but typically it has a viscosity of 500 to 600 cSt at 50°C.

Cargoes of VHFO are all comprised of RFO and almost all RFOs fall within the category of VHFO as defined by this study. The cargoes of *Erika* and *Prestige* were typical examples, which had viscosities of 555cSt and 615cSt at 50°C, respectively. Additionally these cargoes had very high asphaltene contents of 10 ~ 12 % leading to very high degree of emulsification giving very high residual product viscosities. These were created in particular by the high sea conditions, as often experienced in UK waters.

VHFO bunkers are derived by blending RFO with lighter oil products to produce a bunker fuel of the appropriate viscosity for the vessel requirements. Vessels with slower speed engines are able to use bunkers that fall within the category of RFO. These bunkers are often referred to by the industry classifications "IFO380", "IFO500" and "IFO700", which have viscosities at, or just below 380cSt, 500cSt and 700cSt at 50°C, respectively.

When spilled in seawater, the viscosity of VHFO can initially be expected to increase to 20,000 – 50,000 cSt and some will become almost solid. This viscosity will increase further over the following days through evaporation of light fractions and emulsification with seawater. VHFOs will not spread across the sea surface to the same degree as lighter oils and can remain thick, breaking into fragments after a few days. The density of the oil may cause it to sink, drop below waves or float just below the sea surface. In inshore areas incorporation into the oil of mineral fines can induce negative buoyancy.

Dispersant spraying, which can be an effective method of reducing the volume of spills of light and medium oils, is ineffective against VHFOs. They are best recovered using mechanical methods but even this can be difficult as viscosity increases. They can also be difficult to remove from storage tanks as a result of their viscosity and require heating coils or steam injection to enable meaningful pumping capability.

1.2 VHFO Traffic in the UK Pollution Control Zone

It was not possible to gain information directly from industry on the volumes of VHFO cargoes and bunkers passing along routes through the UK Pollution Control Zone (UKPCZ). Therefore, information on cargoes was determined using national, European and international statistical sources, and bunker volumes derived using indirect estimation techniques. 2002 and 2003 were used as base years for statistical data, and these were generally the latest years for which complete data was available at the time of the study.

1.2.1 Cargoes

The UK produced 11.5 million tonnes of RFO in 2003, of which 6.4 million tonnes were exported, 0.9 million tonnes supplied to international shipping as bunkers and 3.5 million tonnes were used in the UK industry and other sectors. 0.4 million tonnes was imported. Differences between figures arise from changes in stocks and statistical errors. It is estimated that 1.5 million tonnes were transferred domestically along coastal routes.

Within the EU, 6 countries produced over 10 million tonnes of RFO in 2003. In descending order these were Italy, Netherlands, Germany, Spain, France and the UK. The Netherlands and Belgium also act as trading hubs for RFO, importing and exporting large quantities of RFO. The Netherlands imported 15.5 million tonnes of RFO in 2003, exported 12 million tonnes (and supplied 13 million tonnes of RFO for international marine bunkers). Figures for recent years and newly available data for 2005 indicate that imports of RFO to the Netherlands are increasing and have doubled since 1998.

The main source of RFO imports to the Netherlands was from Russia, which has shown a large increase in exports of both crude oil and oil products in recent years. In 2002, Russia produced almost 60 million tonnes of RFO and exported over 29 million tonnes through the Baltic Sea. A recent development has involved North Sea transshipment of RFO cargoes into ships too large to enter the Baltic. In 2004, 22 of these ships carried an average of 276,000 tonnes of RFO each to destinations such as the Far East.

A network of routes through the UKPCZ was drawn up and the proportion of VHFO cargoes passing along each determined from the volumes of RFO traded between pairs of countries, proportioned according to the quantities of total oil products sent and received by individual ports within these countries.

1.2.2 Bunkers

Determining accurate information about the quantities of bunkers passing through the UKPCZ was not possible. A number of statistics were found but none gave information that could be easily used to determine VHFO bunker volumes or routeings. 27 million tonnes of

RFO bunkers were sold through NW European ports in 2002, of which 19 million tonnes are estimated to have been VHFO bunkers. This quantity can be expected to have passed through the UKPCZ but does not include Baltic Russian sales, domestic traffic or non-bunkering traffic which would have contributed to UKPCZ route volumes.

A rudimentary estimation has been made based upon a 'rule of thumb' those vessels greater than 20,000 deadweight (DWT) tonnes will tend to use IFO380 (or IFO500 or IFO700). The MCA provided vessel movement data for the Dover Strait, which included vessel types and DWT. Vessels greater than 20,000 tonnes DWT were separated and information regarding bunker capacities for different vessel classes used to determine the total bunker capacity of these vessels, which was 60 million tonnes. It was assumed that these vessels would, on average, be half full and therefore that 30 million tonnes of VHFO bunkers would pass through the Dover Strait. However, this does not account for traffic not passing through this route or the fact that vessels may not always completely fill their tanks when bunkering.

The determination of routeing volumes requires some estimation of the quantities of IFO380, IFO 500 and IFO700 bunker volumes annually passing through the UKPCZ. For this purpose a figure of 30 million tonnes has been applied as the current annual volume of VHFO bunkers passing through the UKPCZ (*not only the Dover Strait*). However, there are significant uncertainties underlying this figure for the reasons given above.

1.3 Trends in VHFO transport

The transport of VHFO cargoes through the UKPCZ almost doubled from approximately 26 million tonnes in 1998 to approximately 50 million tonnes in 2003. This has arisen from increases in imports and exports to EU countries and particularly the Netherlands. More significantly, and contributing to imports and exports from the Netherlands, is a rise in RFO exports through the Baltic Sea from Russia, which increased from 12.5 million tonnes in 1998 to 27.5 million tonnes in 2003.

It has not been possible to determine accurate figures for the increases transport of bunkers through the UKPCZ, which are believed to have been more gradual. It is estimated that these have increased from approximately 23 million tonnes in 1998 to 30 million tonnes in 2004.

Figure 1.1 presents the combined volumes of VHFO bunker and cargoes passing along routes through the UKPCZ.

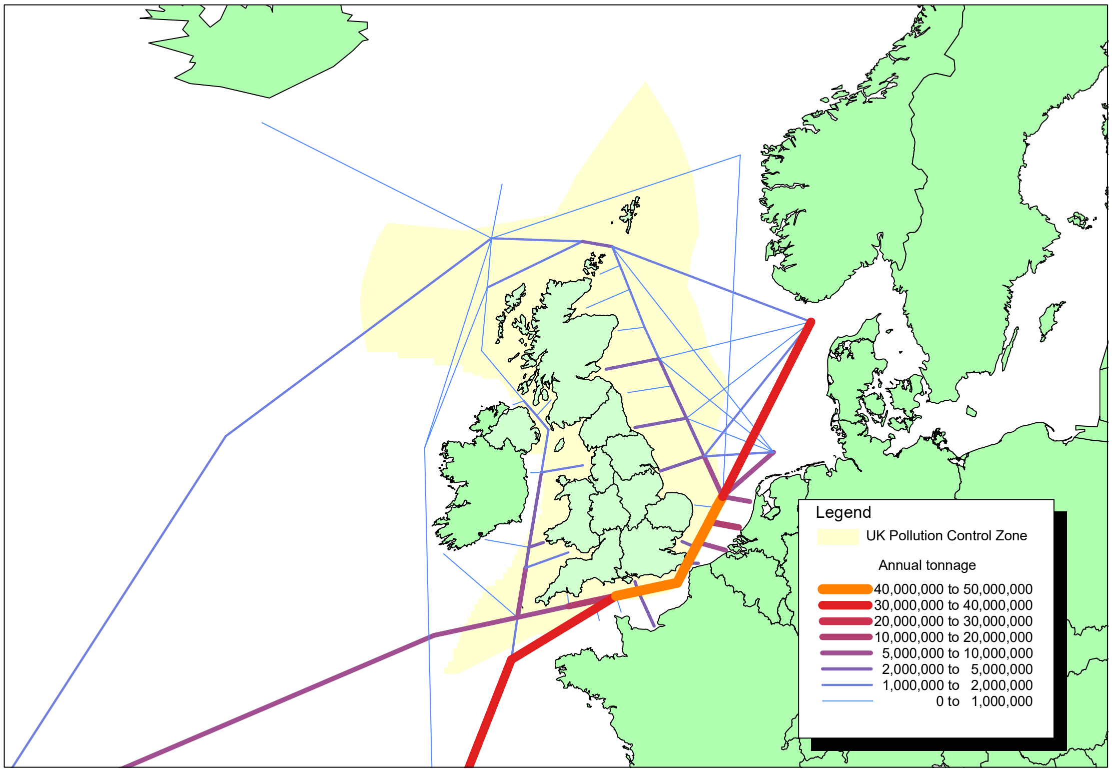

Figure 1.1 Combined VHFO bunkers and cargo volumes passing along routes through UKPCZ.

1.4 VHFO Spill Trajectory Assessment

Spill trajectory and weathering modelling was conducted for 5 locations around the UK to assess the volumes of VHFO that might come ashore in the event of a spill and the vulnerability of different shorelines to a VHFO spill. A spill of 16,000m^3 was modelled, based upon an extreme outflow data reported in the literature. Locations for the spill scenarios considered incident location probability assessments conducted in earlier UK pollution risk assessments, as well locations that covered a number of areas around the UK. The chosen locations were the Dover Strait, English Channel, St. George's Channel, the Minches and the central North Sea.

Both stochastic and deterministic modelling was conducted. The stochastic modelling, which modelled each scenario under a range of seasonal meteorological and oceanographic conditions, determined the areas that would most probably be affected by a spill from each location, as well as the probable time to shoreline oiling. Deterministic modelling assessed the changes in slick volume and trajectory for specific scenarios.

The modelling has determined that the coastlines most vulnerable to VHFO pollution within the UK are the southern English coast and, with a lower probability of spill incident occurrence, the western UK coast. The coasts of northern France, Belgium and the Netherlands are particularly vulnerable, although are not directly considered in this study. Under prevailing conditions, the eastern UK coast is less vulnerable, although the oil spill scenario considered here was offshore and in a near-shore incident or easterly winds, this coast would be vulnerable.

The stochastic modelling results indicated that even offshore scenarios show a high probability of some shoreline oiling within two weeks. The deterministic modelling results illustrated that only limited evaporation and dispersion occur. The 'at sea' volume increased by 50% as a result of emulsification. Significant shoreline oiling (>10,000 m^3, compared with the initial 16,000 m^3 spill) occurred in most of the deterministic scenarios modelled, even some time after the incident, although short to medium period beaching scenarios showed the highest volumes of shoreline oiling.

1.5 Ecological and economic sensitivity review

The sensitivity review assessed the impact of VHFO on typical UK coastline and marine habitats and economic activities. The sites most sensitive to VHFO pollution are the same as those generally vulnerable to oil contamination. However, VHFO spills present some specific threats to habitats compared with spills of lighter oils:

- They are more persistent at sea and can travel greater distances, presenting a risk of pollution to sites several hundred miles form the incident location.
- They may sink through the water column, presenting an increased risk to seabed communities.
- Whilst they tend to be less toxic than lighted oils, their viscosity increases the risk of smothering of habitats.
- They can adhere strongly to rocks or concrete and be difficult to wash off.

The most sensitive habitats to VHFO pollution are saltwater marshes, seagrass beds, sheltered mud flats, sheltered rocky shorelines and seabird sites, several of which are designated conservation sites. Sites of economic activity such as ports, harbours, marinas, fishers and aquaculture, resorts, beaches, power stations, offshore wind farms and ferries would also be sensitive to VHFO contamination.

The locations most at risk from a spill of VHFO are rocky shores, mudflats, saltmarshes and seabird sites along the southern and western UK coasts, northwest Scotland, Shetland and Orkney. Under easterly winds, which do not prevail in the UK, such sites on the east coast would also be at risk.

However, a wider consideration is the persistence of VHFO, which creates a potential risk of extensive shoreline oiling in the long term. The *Prestige* spill demonstrated that VHFO can affect shorelines over great distances (several hundreds of miles). The discussion and maps above show that almost all stretches of the UK coast contain sites sensitive to VHFO pollution and, whilst the coastlines mentioned above may require special consideration, other areas may also require protection in the weeks following a spill even some distance from the incident location.

1.6 VHFO Response Techniques

The response to VHFO spills requires consideration of its characteristics when spilled in seawater:

- Its density is either similar to or greater than seawater causing it to have neutral buoyancy, sometimes remaining just below the surface or to sink.
- It emulsifies to very viscous or near solid phases
- It can fragment into a number of smaller slicks floating either on the surface or sub-surface, and these are difficult to detect.
- It is highly persistent and does not readily disperse naturally or chemically.

As a result, not all counter-pollution equipment is suitable. A review of equipment was conducted to determine which was most effective in responding to VHFO spills. This included a review of the response to *Erika* and *Prestige*. This assessment considered only specialized counter-pollution equipment and not readily available response equipment such as construction plant.

In all oil spills from vessels, a primary consideration is the salvage of the vessel and the prevention of further oil leakage. A range of techniques can be applied to the recovery of heavy oils, but these are either techniques using standard salvage equipment or innovative techniques tailored to the specific situation.

Once a VHFO slick has formed, the most effective techniques for reducing its volume are containment and concentration using offshore/inshore booms and recovery using the following types of equipment:

- Cargo transfer/screw pumps (or a weir skimmer with suitable screw pump attached). Ideally, these should have large diameter tubes. Collection of water with the pump may aid the flow of viscous oil but should be decanted once on board the recovery vessel for optimum recovery.
- Toothed disk skimmers.
- Drum skimmers.
- Grab bucket (clam shell) skimmers.
- Vacuum system.
- Sweeping arm system.

An additional consideration in offshore spills is the availability of suitable vessels to deploy such equipment, and additional capabilities or vessels to collect VHFO. The sooner these vessels are able to attend the spill, the more oil they will be able to recover before weathering and slick fragmentation/sinking make this more difficult. The availability of large capacity transfer vessels with heated tanks will reduce the time spent returning to port and transferring oil.

If the VHFO slick threatens shorelines, these can be protected to a degree using shore sealing booms in the tidal zones of bays and estuaries and containment booms to deflect the oil from sensitive areas. VHFO shoreline cleanup techniques require the same equipment as those used in response to other spills: this is generally non-specialist equipment such as shovels, tractors and construction industry vehicles. VHFO's and their emulsions will not penetrate sediments as readily as lighter oils, so may not cause as much contamination of sediments on sandy and muddy shores. Storage may require more specialist equipment, for example, temporary oily waste tanks or lined pits.

Operationally, it is very difficult to monitor and track VHFO spills that are sub-surface and fragmented. Pollution response surveillance aircraft with SLAR, UV and IR tracking devices, have proven the most effective in being able to track the movement of the spill. Oil spill trajectory modelling software can be used to predict the path of the oil.

1.7 UK VHFO Response Equipment Review and Recommendations

An assessment of the UK's current capability to respond to spills of VHFO was conducted using data from the MCA stockpile inventory and through discussions, questionnaires and information gathering from other organisations. These organisations included partners from Bonn Agreement and other European neighbouring countries, which provide for mutual assistance in the event of a major spill.

The gathered information was reviewed to determine the stocks of equipment most effective against VHFOs:

- Inshore, offshore and shore-sealing booms
- Toothed disk, drum, weir, belt and grab skimmers.
- Cargo transfer and other pumps.
- Heated tanks and other storage.

In addition, an inventory of available oil pollution response vessels in the NW European region was compiled, based on information published by the European Maritime Safety Agency (EMSA).

This review determined that the current stocks of equipment were sufficient for a response to a spill of 16,000m^3 in relatively calm conditions, particularly when resources from Bonn Agreement partner countries were included. However, it was highlighted that spill incidents vary widely in their characteristics and therefore it is difficult to prescribe response resources that allow for every eventuality. There were a number of recommendations for ensuring that the UK's preparedness for a VHFO spill were optimised:

1. The MCA maintains a large stock of dispersants – these are a key counter-pollution resource outlined in the UK National Contingency Plan. However, they are ineffective against spills of VHFO. It is clear from the findings of this study that the quantities of VHFO passing through the UKPCZ, and hence the potential for a spill of VHFO, is increasing. It is recommended that the MCA review the National Contingency Plan, their advice and training to local authorities and other parties, to ensure that these have an appropriate balance between spills of light and heavy oils.

2. It is recommended that the MCA considers review of the availability of suitable vessels for the event of a VHFO spill. There are several vessels with capability to respond to VHFO spills available through EMSA and the Bonn Agreement partners, or that could be relatively quickly equipped through delivery of MCA equipment. They would need to be available on scene very quickly to efficiently respond to a VHFO spill. This review might involve the following actions:

    a. Review of the procedures for making ETVs available to regions away from their standby locations in the event of a major VHFO spill, and for ETVs to be made available and equipped to support the cleanup.

    b. Creation of container(s) of VHFO-specific response equipment – including high capacity recovery skimmers, screw pumps and offshore booms – to reduce delivery times to an ETV or other vessel.

    c. Review of the arrangements for assistance between Bonn Agreement countries to determine whether mutual assistance arrangements could be improved. Spills of VHFO are persistent and therefore an incident can present a threat to several countries. There is a high level of existing co-operation between Bonn Agreement partners, which has been demonstrated in several recent spills. However, as the frequency of spills – and hence, counter pollution stockpiling - decreases, a pooled VHFO response resource across Bonn Agreement countries could lower the individual costs on each country.

3. ETVs are currently placed at the four "corners" of the UK, with central areas on the eastern and western side covered by tugs and other vessels (e.g. through Liverpool or Aberdeen). However, as speed of vessel response is more critical in a VHFO spill, the MCA should review these locations. In particular, the North Sea could be considered to be well covered by other Bonn Agreement partners, so further consideration to coverage in the Irish Sea and western UK should be given.

4. The MCA should recognise that, as there has been a reduction in the number of spills over recent years, many commercial spill contractors are understood to have reduced their equipment holding and no longer retain equipment unnecessarily. Equipment may be held against a specific contract and not easily released for other operations. In addition, manufacturers build equipment to order and no longer hold stock for rapid sale. Therefore regular review of the commercial spill contractor

arrangements is recommended. It is also recommended that a database of equipment and vessel holdings should be reviewed annually.

5. It is recommended that the MCA investigates 3D oil spill trajectory and fate models to allow for prediction of the pathway of sunken oil, as well as the specific characteristics of VHFO. The persistence of VHFO can lead to it affecting shorelines several hundred miles from the initial spill site and prediction of regions potentially at risk will assist in their protection. Validated 3D hydrodynamic models exist for the UK continental shelf which could be used with these models.

6. The study has shown that VHFO trade, in particular from Russia, has increased significantly in recent years. The use of VLCCs in transporting this oil is increasing. These changes have happened relatively quickly and it is recommended that regular reviews of the changing conditions are conducted to ensure that the capacity of UK counter-pollution resources can continue to be assessed.

7. It is recommended that the MCA maintains awareness of developments in the detection of sunken high density spills, such as laser and sonar techniques, to allow them to assess whether such equipment would benefit to UK's response capabilities.

8. It was not possible in the study to assess the volume of traffic passing to the north of the UK, and it is recommended that the MCA assesses this traffic through its VTS stations in Stornoway and elsewhere, to determine whether additional traffic management, such as Traffic Separation Schemes, would reduce the risk of vessel incidents.

9. The study has identified wide geographical areas that are potentially at risk from VHFO pollution. Whilst it is believed that equipment resources are available to address such incidents, rapid transfer of equipment to remote or distant locations may be difficult. It is recommended that the MCA review the capability to airlift containerised equipment to ETVs or other vessels for response in remote locations. This might involve military, coastguard or other aircraft. A review of how such containers could be lowered onto and secured on vessels would also be required.

10. At sea recovery operations are able to continue more efficiently if recovered oil storage vessels are on site as long as possible. It is recommended that:

    a. A review of the capacity and transfer capabilities of ports and other reception/disposal facilities in the UK be conducted and a database compiled.

    b. The use of barges during (inshore) spill cleanup is considered. These would not necessarily require offloading as quickly and several could be used in rotation.

    c. The ability to airlift temporary storage tanks on to and off of vessels is considered.

11. Once other recommendations have been considered and acted upon, it is recommended that the MCA conduct an exercise to test from any new procedures and allow them to be amended if required.

12. During the assessment of VHFO vessel traffic through the UKPCZ, it proved difficult to determine the quantities of passing VHFO bunkers. If the MCA felt that it was important to have improved data for future assessment, it might consider methods by which this could be collected, e.g. through VTS stations.