Identification of Marine Environmental High Risk Areas (MEHRA's) in the UK

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P 8639	A. MacDonald, C. McGeechan, M. Cain, J. Beattie, H. Holt, R Zhou, D. Farquhar

Abstract:

This document presents the assessment carried out by Safetec UK Ltd to assist the UK Department of the Environment, Transport and the Regions identify potential Marine Environmental High Risk Areas (MEHRA's) in UK waters. The MEHRA's concept was put forward by Lord Donaldson in the inquiry and subsequent report (Safer Ships Cleaner Seas) which followed the Braer oil tanker incident. The concept of MEHRA's is to identify comparatively limited areas of high environmental sensitivity, which are also at risk from shipping (i.e. marine pollution). Once MEHRA's have been formally identified, the location of these sites will be brought to the attention of ship owners and insurers to encourage shipping to plan routeing to avoid these sites and hence reduce the risk of pollution.

The assessment has been carried out by identifying the environmental sensitivity of the UK coastline and coastal waters based on a number of different sensitivity features (e.g. wildlife, landscape, amenity/economy, geology and fishing). The different sensitive features have been mapped on a Geographical Information System (GIS) and a scoring methodology applied to rank sensitivity of both coastal and sea areas.

The marine pollution risks have been estimated using the most up to date shipping traffic data in the UK (COAST database) as well as recognised accident models which have been calibrated against historical incidents in UK Waters. As with the environmental sensitivity, the risk results generated have been mapped on a GIS system that presents a transparent means for the assessment process.

The pollution and environmental sensitivity results were combined to identify potential MEHRA's.

Keywords:

MEHRAS, COAST, DETR, JNCC, Pollution Risk, Environmental Sensitivity, Marine, Donaldson, Frequency.

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Dovre Safetec AS
P.O.Box 4163, Valentinlyst
N-7450 Trondheim
Norway
+47 73900500

Dovre Safetec AS
P.O.Box 813
N-4004 Stavanger
Norway
+47 51939220

Dovre Safetec AS
P.O.Box 521, Sentrum
N-0105 Oslo
Norway
+47 22404440

Safetec UK Ltd
36 Upperkirkgate
Aberdeen AB1 1BA
UK Scotland
+44 1224 648651

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1 INTRODUCTION

1.1 Introduction

Safetec UK Ltd have been commissioned by the Department of the Environment, Transport and the Regions (DETR) to identify potential Marine Environmental High Risk Areas (MEHRA's) around the UK. Following the Braer disaster, the Donaldson Inquiry (Ref. 1) provided an overview of the use of routeing measures which are aimed at accident prevention and subsequently dangers of pollution and loss of life.

Routeing measures are primarily focused on encouraging ships to follow routes where they are less likely to collide with each other, run ashore or get into difficulties. Their second aim is to reduce the scope for disaster if a ship does get into difficulties and thirdly to ensure that, so far as reasonably practicable, ships are kept outwith areas where pollution would cause particular damage to the environment.

With respect to the third aim of environmental protection, the Donaldson Inquiry did not accept a suggestion to place a blanket ban on all large, potentially polluting vessels by requesting they keep a fixed distance from shore during transit: 10 and 50 nm were proposed. This rejection was based on a number of issues including:

- Some channels are too narrow to be able to maintain a set distance.
- Bunching may occur at a fixed distance and increase the likelihood of an accident.
- In some circumstances it may be safest to seek shelter closer to shore.
- By their nature vessels would have to pass within blanket ban distances as they enter/exit ports.
- Although not specifically mentioned by the Inquiry, a blanket ban would not be consistent with International law.

Hence the Donaldson Inquiry proposed an alternative to blanket banning by recommending that Marine Environmental High Risk Areas be established, which are comparatively limited areas of high environmental sensitivity and also at risk from shipping. The basis of the MEHRA's recommendation was that their identification and publication will give ship Masters additional information relevant to passage planning that would be more likely to result in the usage of the recommended routeing. It was additionally hoped that ship owners and insurers would, in their own self-interest, regard a MEHRA as an area from which their ships should keep clear and would therefore result in reduction in pollution risk at these sites.

This report has been prepared to document the approach adopted by the DETR for identifying MEHRA's and proposes sites which should be classed within this scheme.

1.2 Background to MEHRA's

Within the Donaldson Inquiry it was envisaged that MEHRA's should have both an environmental and shipping concept, and that even the most environmentally sensitive areas would only become MEHRA's if there is a realistic risk of pollution from shipping.

As a result, the two main factors suggested for consideration when identifying MEHRA's are:

- The risk of pollution from shipping incidents; and
- The environmental sensitivity of the coastal waters around the UK.

Lord Donaldson identified approaches for assessing these issues fully to ensure that the MEHRA's initiative effectively reduces the risk of pollution in environmentally sensitive areas. Outlines of the main considerations are presented within the following subsections. It should be borne in mind that the Inquiry acknowledged that the listed outline considerations were likely to require some refinement.

1.2.1 Risk of Pollution from Shipping

The Donaldson Inquiry recommended that when assessing the risk of pollution, regard should be given to the following maritime considerations:

a) the number, type and size of vessels passing and the nature of their cargoes;

b) the distance of the usual shipping lanes from the shore;

c) any circumstances giving risk to an increased risk of collision such as a significant amount of traffic going across normal flow;

d) hydrographical conditions relevant to safe navigation, such as lack of safe anchorage;

e) prevailing meteorological and tidal characteristics;

1.2.2 Environmental Sensitivity

When assessing environmental sensitivity, it was recommended that regard be given to the following environmental considerations:

a) existence of wildlife feeding or breeding sites of international significance or the presence of biological communities of either flora or fauna or both or particular interest or rarity: designation as a Special Protection Area under the EC Birds Directive or any area of special conservation under the Habitats Directive will normally be regarded as evidence of this.

b) the existence of commercially exploitable biological resources and mariculture sites; and

c) the extent to which the area provides a public recreational amenity.

1.3 Methodology for Assessing MEHRA's

Within the Inquiry it was recognised that whilst subjective decisions on the areas to qualify were probably unavoidable, they should be minimised as far as possible by setting "points" for each criteria. Any particular area would need to "score" a minimum, based on both environmental sensitivity and pollution risk. It is noted that the Inquiry suggested that a maximum 10% of the UK coastline be used as a starting point for MEHRA's coverage as beyond this it was considered that the effectiveness of the concept would be reduced.

There is no doubt that the choice of areas will be controversial, therefore a transparent methodology was chosen which established criteria, based on both shipping risks and on environmental importance.

Whilst a certain amount of subjective assessment is unavoidable, an attempt has been made to keep this to a minimum by setting points for the different criteria.

1.4 Overview of Study Objectives

The two main factors to be considered in the process of identifying MEHRA's are the risk of pollution and the environmental sensitivity of the coastline and sea areas. The objectives of this project were to collect data on the environmental sensitivity of the UK coastline and surrounding waters as well as carrying out a risk assessment using the most up-to-date ship routeing information to estimate the pollution risks in UK waters.

By combining the environmental sensitivity data with the pollution risk data, contour maps of the UKCS have been plotted which form the basis for the identification of MEHRA's.

The secondary objectives of this study are to provide a transparent means of re-assessing MEHRA's at regular intervals. This will allow performance to be measured and any subsequent revision to be made to improve the potential benefits of this initiative.

1.5 Overview of Study Methodology

The methodology adopted within this study involved identifying the main marine hazards presenting the greatest risk of pollution to the UK Continental Shelf (UKCS) and the causes of such incidents. The routeing of the different vessels around the UK was then identified and the risks of different types of incidents and of spills resulting from different incidents calculated. This allowed the generation of risk estimates on a geographical basis.

Data was collated simultaneously on different types of sensitivities for the UK Coastline and surrounding waters, taking into account a number of different criteria such as ecological, social, cultural, economic, scientific and educational importance. This included information such as Internationally recognised environmentally sensitive areas such as St Kilda which is a World Heritage Site as well as biosphere reserves, blue flag beaches, fish farms, shellfish harvesting areas, Sites of Special Scientific Interest (SSSI), Areas of Outstanding Natural Beauty (AONB), etc. Based on the number of different sites and their sensitivity to marine pollution, within each area, a score was given to each coastal and sea area to rank on sensitivity.

The results of this study (pollution risk and environmental sensitivity) have been incorporated into a Geographical Information System (GIS) for ease of display and further evaluation. The two sets of data have been combined in order to rank the coastline and sea areas to identify potential MEHRA's.

Finally, conclusions are drawn and recommendations are made as to how this work can be used as input to the overall MEHRA's initiative to ensure it satisfies the requirements of the Donaldson Inquiry.

1.6 Assumptions & Limitations

This section presents a list of the assumptions and limitations associated with this work.

1.6.1 Assumptions

The following assumptions have been made during this project:

- Risks will vary during different times of the year. The results generated in this study assume an annual average, taking into account seasonal variations with respect to environmental conditions as well as traffic patterns.

- For spills occurring offshore affecting the coastline, a limit of 30nm has been applied in the assessment, i.e. for the purposes of this study it is assumed spills occurring at greater than 30nm will do not infringe on the coastal cells.

1.6.2 Limitations

The following list presents the main limitations, which are associated with this work:

- Whilst the shipping traffic database used is considered the most reliable and up to date for the UKCS, there still exist some areas where traffic surveys have not been carried out to validate the routeing pattern.

- With regard to tanker routes, there are a number of offshore fields which use shuttle tankers for oil export which have come onstream in the last year and are yet to be included within the COAST database.

- Limitations exist with regard to ship routeing when vessels enter harbours and estuaries, as within the COAST database, the routes generally start and stop at the entrance to harbours and estuaries e.g. Humber, Forth, Clyde, Bristol Channel, Mersey and Thames.

- The models do not consider the possibility of tug assistance for vessels in trouble.

- The oil spill drift model used in the study is simplistic.

- The coastlines of the Channel Islands and the Isle of Man have not been assessed.

- No consideration has been given to the possibility of safe anchorages in the different areas for vessels in trouble.

- It is noted that whilst the shipping movement data is based on data from 1998, the shipping incident data is from 1989-1998 (inclusive). Therefore there is some uncertainty, when apply 1998 movement data to validate accident frequencies for this 10 year period.

- The potential for oil spills from pipelines has not been included in the assessment.

- Marine benthic communities have not been considered in the evaluation of sea areas. This could lead to an underestimate of the sensitivities of some sea areas.

- Limited consideration has been given to prevailing tidal conditions within the analysis.

- The study does not include any assessment of operational spills or any spills associated with offshore installations.

- No data on routeing of fishing, naval or pleasure craft has been included in the assessment.

- The effects of tidal currents have not been accounted for in the assessment.
- For a number of the protected sites identified, area data was not presented, and therefore point (geographical position) data was used. This could present some limitations if a site identified only by point data extends outwith the cell in which the point lies.
- No consideration has been given in the sensitivity modelling to the effect or potential for a spill to affect industry such as power stations and desalination plants which require a continual supply of clean seawater, as well as the safe operation of coastal industries and ports.

1.7 Report Overview

The following presents an overview of the content of the different sections of this report:

Section 1	Provides an introduction explaining the background to the work, the study objectives, brief details of the methodology, an overview of the report contents and abbreviations used throughout the documentation.
Section 2	Presents details of the study methodology.
Section 3	Provides details on the different causes of marine pollution and identifies from a hazard perspective where this project will focus.
Section 4	Presents details of the ship routeing information used in the project.
Section 5	Presents details of the assessment into shipping accidents with frequencies presented for each type of casualty.
Section 6	Examines the likely consequences of a shipping casualty in terms of spill probability and spill size.
Section 7	Presents the risk of pollution from shipping in UK waters.
Section 8	Presents details of the coastal sensitivities which have been arrived at through the ranking of different environmental, social, cultural and economic factors.
Section 9	Presents the identification of the Marine Environmental High Risk Areas (MEHRA's) based on combining the results of the pollution risk and environmental sensitivity assessments.
Section 10	Presents the conclusions and recommendations arising from the study.
Section 11	Presents references used during the course of the study.
Appendix 1	Presents an overview of the routeing of shipping within UK waters.
Appendix 2	Presents an assessment of the different factors that have an influence on the risks associated with shipping in UK waters. The basis of this assessment is 10 years of vessel incidents in UK waters (1989 to 1998 inclusive).

Appendix 3	Presents the historical oil spill statistics that have occurred in UK waters over a 10-year period (ACOPS data for 1989-1998 inclusive).
Appendix 4	Provides an overview of the different protected and environmentally sensitive sites identified around the UK coastline.
Appendix 5	Presents the coastline characteristics around the UK, in terms of different types of coastline as well as coastline exposure in terms of wind and wave severity.
Appendix 6	Presents an overview of the risk models which have been used to estimate the risks of pollution occurring in UK waters.
Appendix 7	Provides details of the environmental data which has been used in the assessment.
Appendix 8	Presents plots of the different risk results, incident frequencies and pollution risks which have been generated during the risk assessment work.

1.8 Abbreviations

The following abbreviations are used within this report:

ACOPS	Advisory Committee on Protection of the Seas
AGLV	Areas of Great Landscape Value
AONB	Areas of Outstanding Natural Beauty
AoSP	Areas of Special Protection
ARLS	Highland Areas of Regional Landscape Significance
ASI (NI)	Areas of Scientific Interest (Northern Ireland)
ASSI (NI)	Area of Special Scientific Interest (Northern Ireland)
ASV	Areas of Scenic Value
ATBA	Area to be Avoided
CFAS	Centre for Environmental Fisheries & Aquaculture Science
COAST	COmputer Assisted Shipping Traffic (Database)
CP	Country Parks
cSAC	Candidate Special Area of Conservation
CWT	County Wildlife Trust
DETR	Department of the Environment, Transport and the Regions
dwt	Dead Weight Tonnage
EC	European Community
ESA	Environmentally Sensitive Areas
ESCR (NI)	Earth Science Conservation Review sites (Northern Ireland)
EU	European Union
FEEE	Foundation for Environmental Education in Europe
FRS	Fisheries Research Services
FSA	Formal Safety Assessment
GCR	Geological Conservation Review Site
GIS	Geographical Information System
GRT	Gross Registered Tonnage
IMO	International Maritime Organisation
ITOPF	International Tanker Owners Pollution Federation

JMT	John Muir Trust
JNCC	Joint Nature Conservation Committee
LANR (NI)	Local Authority Nature Reserves (Northern Ireland)
LLP	Lloyd's of London Press (formerly)
LMIS	Lloyd's Maritime Information Services
LNG	Liquefied Natural Gas
LNR	Local Nature Reserves
LPG	Liquefied Petroleum Gas
LPO	Limestone Pavement Orders
MAIB	Marine Accident Investigation Branch
MARPOL	Marine Pollution
MCA	Maritime and Coastguard Agency and Marine Consultation Areas
MEHRA's	Marine Environmental High Risk Area
MNR	Marine Nature Reserves
MSAC	Marine Special Area of Conservation
NCR	Nature Conservation Review Site
NCR (NI)	Nature Conservation Review sites (Northern Ireland)
nm	Nautical Miles
NNR	National Nature Reserve
NP	National Park
NT	National Trust
PCZ	Preferred Conservation Zones
PSSA	Particularly Sensitive Sea Area
RLD	Regional Landscape Designations
RSA	Regional Scenic Areas
RSC	Regional Scenic Coasts
RSPB	Royal Society for the Protection of Birds
SAC	Special Areas of Conservation
SMA	Sensitive Marine Area
SPA	Special Protection Area
SSSI	Sites of Special Scientific Interest
UK	United Kingdom
UKDMAP	United Kingdom Digital Map
UKCS	United Kingdom Continental Shelf
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational Scientific & Cultural Organisation
VMNR	Voluntary Marine Nature Reserve
VTS	Vessel Traffic Services
WHS	World Heritage Site
WR	Wildlife Refuges (Northern Ireland)
WT	County Wildlife Trust
WT2	Woodland Trust
WWT	Wildfowl and Wetlands Trust

2 METHODOLOGY

2.1 Introduction

The methodology used within this study is based on Formal Safety Assessment (FSA) which has the following main stages:

- Description of intention
- Hazard identification
- Detailed risk assessment - pollutant release
- Consequence analysis - environmental sensitivity
- Risk evaluation
- Risk reduction strategy
- Strategy implementation
- Monitoring

The philosophy of Formal Safety Assessment is aimed at continual assessment and improvement, and therefore the above tasks are best represented by the following illustration, which highlights the need for continual review and revision. When considering this figure it should be noted that the latter three stages do not fall within the scope of this study and that these are likely to be addressed following public consultation and finalisation of MEHRA's sties.

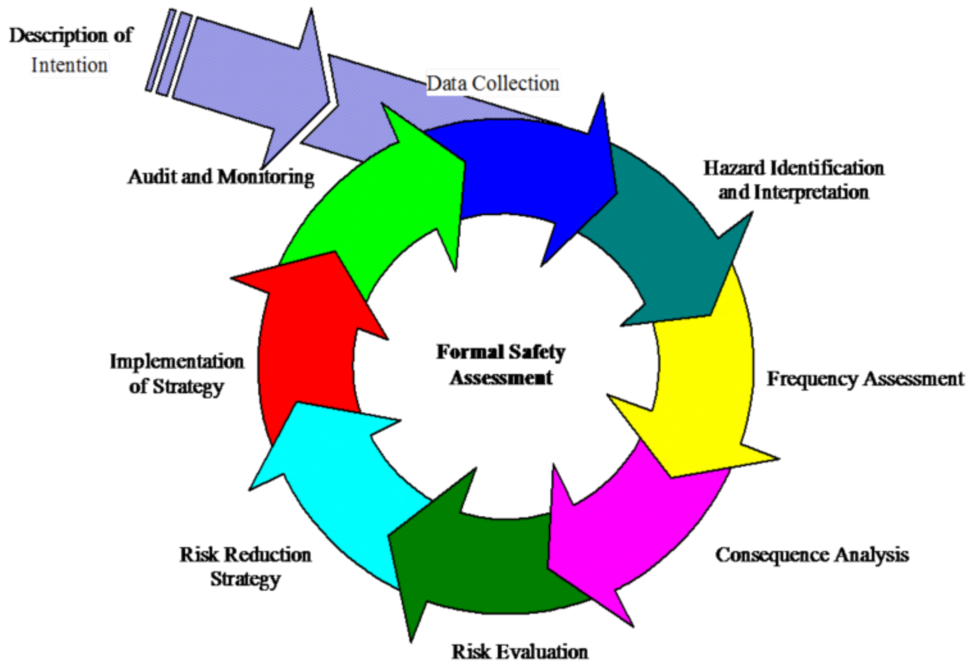

Figure 2.1 Formal Safety Assessment Approach Overview

The following figure presents a more detailed overview of the steps undertaken in this particular project:

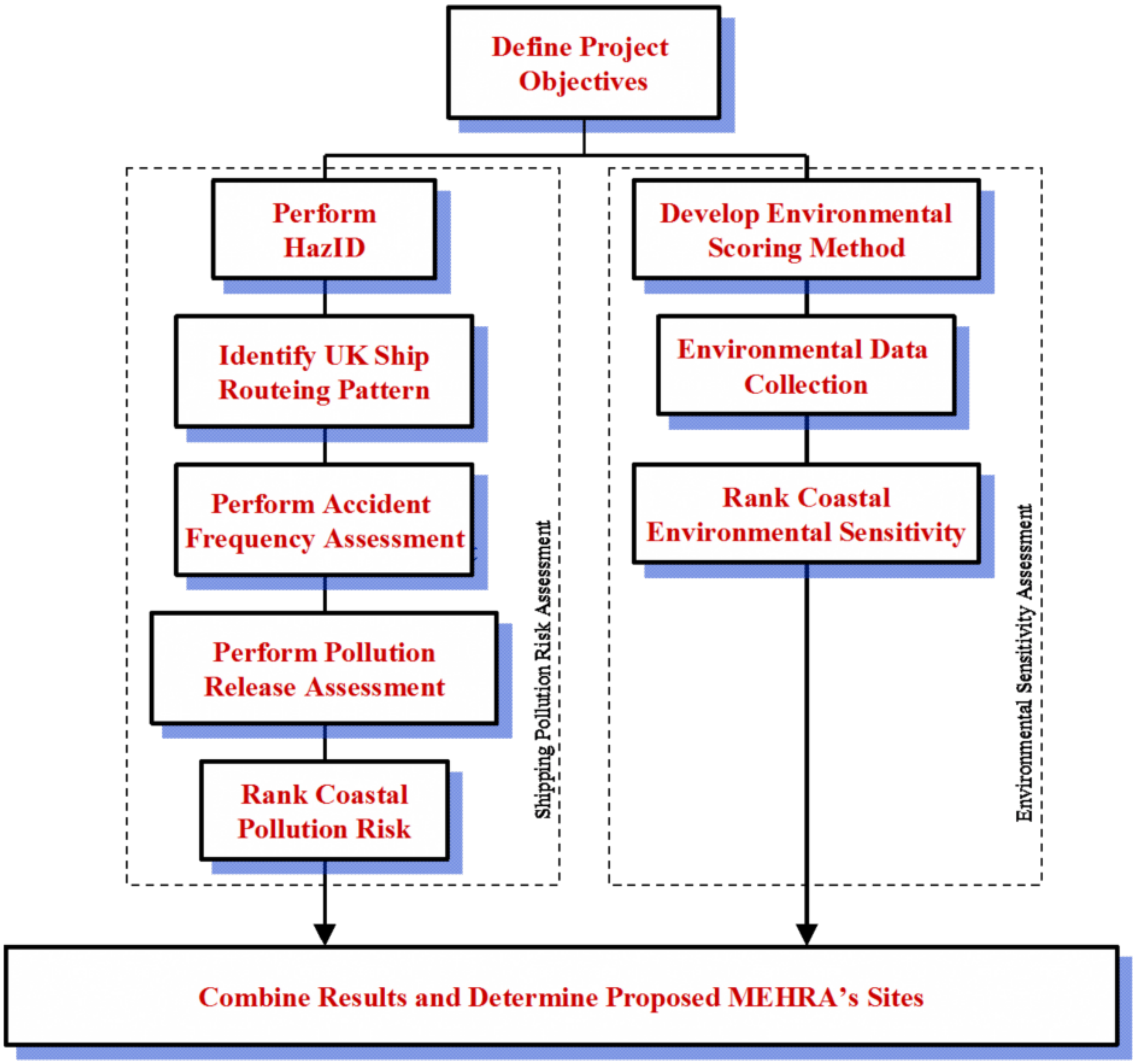

Figure 2.2 Detailed Overview of Methodology Applied to Identify MEHRA's

A brief outline of the main tasks is presented in the following sections:

2.2 Define Project Objectives

Within any risk assessment it is necessary to document clearly the objectives of the assessment to provide an overview of the scope of the study and the intentions of the work. Documenting the aim of the study in this manner also assists in measuring the effectiveness of the MEHRA's project. Section 1 provides an overview of the background and intentions of this work which are effectively to identify the Marine Environmental High Risk Areas (MEHRA's) for the UK, based on shipping pollution risks and environmental sensitivity.

2.3 Shipping Pollution Risk Assessment

Within this section of the study, the hazards presented by shipping are considered in terms of damage to the marine environment and direct relevance is placed on issues that can be benefited from alternative routeing, which is the essence of the MEHRA's initiative. Following identification of the main pollutants from shipping that present the greatest threat to the UK coastline, a detailed review of ship routeing will be documented prior to performing a risk assessment to determine the likelihood of different types of incidents and spills taking place in UK waters. As recommended by Lord Donaldson, this assessment will be based on standardised methodologies to ensure traceability and repeatability. The methodologies used are those common to work currently being undertaken by the Maritime and Coastguard Agency for assessing the risk of chemical spills within UK waters (Ref. 2.). The outcome of this assessment will be a range of accident frequencies and spill sizes for UK waters, which are calibrated against historical data to ensure they are in line with experiences within UK waters.

2.4 Sensitivity of UK Waters (Coastline & Sea Areas)

This task looks at the sensitivity of the UK coastline and sea areas to pollution in terms of the environment and socio-economic factors. In a similar manner to that outlined within the previous section this will adopt a scoring system to rank the different areas based on a range of criteria. This will aid traceability and repeatability, so that clear reasoning can be given as to why different areas have greater sensitivities than others, which in turn will facilitate the public consultation phase of this initiative.

2.5 Identification of Proposed MEHRA's

This task involves combining the results of the incidents and spill frequency data with the environmental sensitivity data to establish the basis for the MEHRA's. Once the final scorings sites have been determined, the highest will be highlighted as MEHRA's candidates. As recommended by Lord Donaldson, approximately 10% of the UK coastline is the target for MEHRA's allocation.

3 HAZARD IDENTIFICATION & OVERVIEW

3.1 Introduction

The waters around the UK coastline include some of the world's busiest sea lanes. At any one time there are in the order of 5,000 ships operating in the North Sea. There are very few areas of the UK's coastal waters without significant shipping traffic. It is noted that despite this, shipping is responsible for a relatively small proportion of all marine pollution in the UK, compared to that from land-based sources that can be traced back to centres of population and to industrial and agricultural operations. It is however acknowledged that marine accidents generally result in much greater consequences than pollution from land based sources.

Data from UNEP (Ref. 3) estimates the following distribution of pollution sources to the seas:

Waterbourne land-source pollution	44%
Airbourne land-source pollution	33%
Marine transportation	12%
Marine dumping (of mainly land source waste)	10%
Offshore oil production	1%

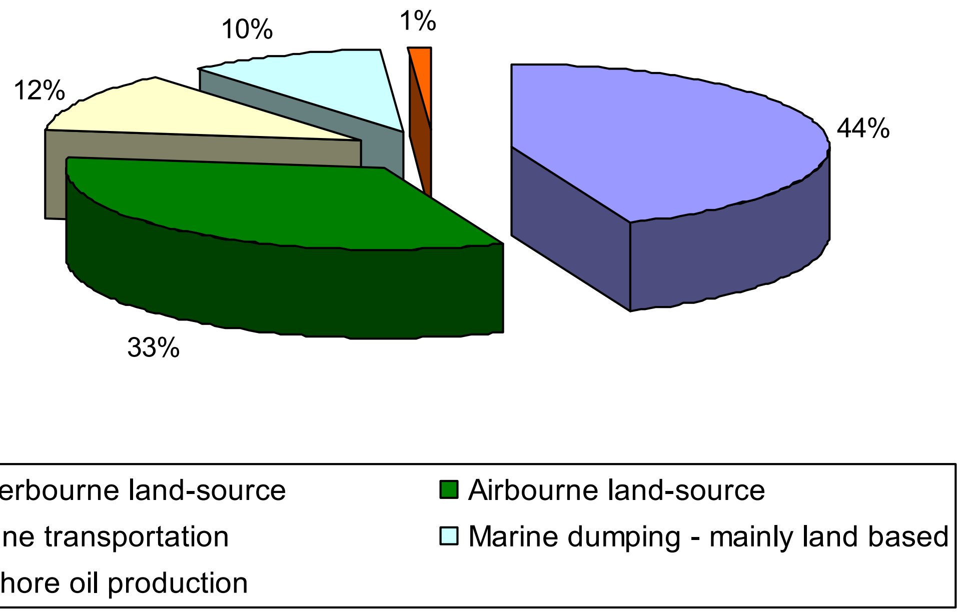

Figure 3.1 Sources of Pollution to the Seas

This study is aimed at marine transportation and the likely releases of pollutant to the sea resulting from this activity.

3.2 Pollution from Ships

Within marine transportation, ships can constitute an environmental hazard to the marine environment through:

- Operational pollution,
- Accidental pollution,
- Physical damage.

Each of these different types of pollution is discussed within the following subsections, which also provide an overview of the International Maritime Organisation (IMO) instruments relating to each.

3.2.1 Operational Pollution

Operational pollution of the marine environment can occur via a variety of pathways. These include oil and oily wastes, noxious liquid substances, sewage, garbage, anti-fouling paints, foreign organisms and even noise. The majority of these discharges are governed by the MARPOL regulations annex I, II and V (Ref. 4).

MARPOL sets international standards for the discharge of ships' wastes. It also provides for the designation by the IMO of special areas, within which tighter standards apply. All waters around the UK coast are part of a special area designated under Annex I of MARPOL. The North Sea and English Channel are part of a special area under Annex V. Therefore, there are already strict rules governing discharges of oil and garbage that might affect the UK coastline. While the IMO has not designated a special area under Annex II covering UK waters, the International standards already prohibit most discharges of noxious liquid substances.

3.2.2 Accidental Pollution

Accidents such as collision, and grounding can result in large quantities of pollutant being released into the marine environment. The types of pollutant released following an accident tends to be similar to those associated with operational discharge but as they are more highly concentrated and larger in volume they have a much greater potential to harm the marine environment.

From information reviewed on accidents resulting in pollution within UK waters (Ref. 5), it was observed that the most common release to the marine environment is oil. From Lloyd's casualty data recorded over a 10 year period (1989-1998 inclusive) there is only one recorded chemical pollution incident at sea which occurred when two vessels collided in the English Channel and three containers carrying packaged chemicals were lost overboard.

3.2.3 Physical Damage

Grounding vessels, anchors and propellers have the potential to physically damage and disturb reefs, banks, coastline, marine habitats and animals. An example of this in another part of the world is the alleged removal of kelp by fast ferries in the Cook Sound in New Zealand.

It is difficult to ascertain the level of damage resulting from this characteristic of shipping. However, for the purpose of this assessment it is considered that following designation of MEHRA's any reduction in physical damage resulting from the increased awareness of coastal sensitivities amongst the marine world will be focused around the most environmentally sensitive sites.

3.3 Causes & Sizes of Spills

From the data reviewed within this assessment it was ascertained that most pollution to the sea from shipping is associated with oil. This occurs due to operational release as well as accidents. An assessment of the likely level of pollution from the different causes was undertaken using data obtained from the International Tanker Owners Pollution Federation (ITOPF). Using this information the following distribution was obtained.

Table 3.1 Distribution of Oil Pollution Incidents by Cause

Cause	Description	Spill Size Category			Total
		< 7 tonnes	7-700 tonnes	>700 tonnes	
Operations	Loading/discharging	2757	288	15	3060
	Bunkering	541	24	0	565
	Other operations	1162	47	0	1209
Accidents	Collisions	144	225	85	454
	Groundings	217	186	101	504
	Hull Failures	547	67	39	653
	Fire and Explosions	149	16	20	185
Other	Not Specified	2213	157	34	2404
Total No. of Spills		7730	1010	294	9034

The above information is presented graphically in the following figure:

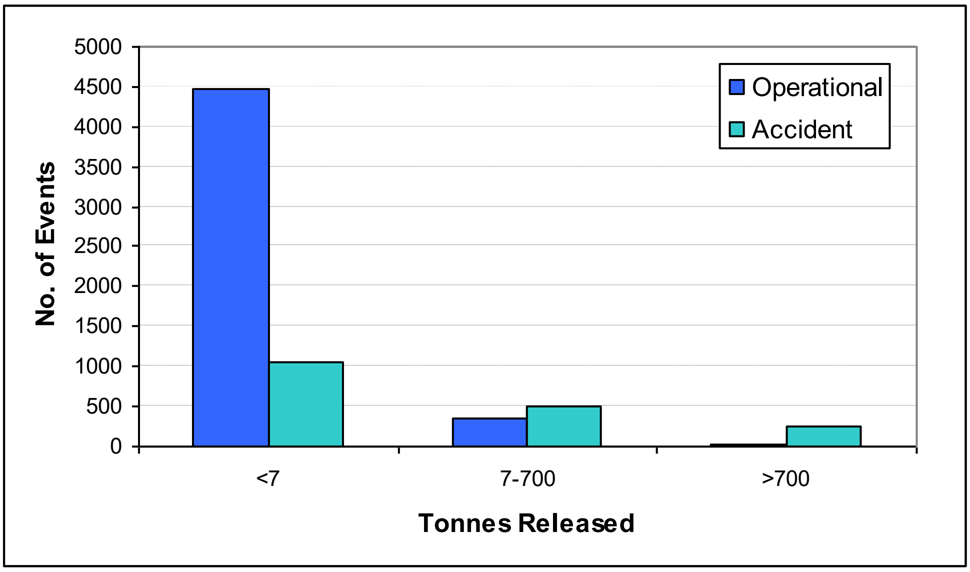

Figure 3.2 Distribution of Oil Spills (Operational vs Accidents)

Figure 3.2 shows that the vast majority of oil spills are relatively small and result from vessel operations such as cargo transfer, bunkering etc. Large spills are far less common, and tend to result from an accident, which causes physical damage to the vessel and release of fuel and/or cargo.

3.4 Summary Discussion

From this review, it is observed that the vast majority of ship related pollution to the sea, which is likely to have most influence on the selection of MEHRA's sites, is oil cargo and fuel oil (bunker) releases which occur as a result of an accidental event. Therefore, the detailed risk assessment work undertaken within this study will focus on this scenario. Operational pollution has not been considered further as this tends to result in smaller releases which are already governed by the IMO through MARPOL annex I, II and V.

4 SHIP ROUTEING IN UK WATERS

4.1 Introduction

As the main focus of this work is on shipping accidents, a detailed risk analysis was required to assess the risks of these events. Within the Donaldson Inquiry it was emphasised that there were a number of factors required to assess the pollution risk associated with a vessel such as:

- the number, type and size of vessels passing and the nature of their cargoes;
- the distance of the usual shipping lanes from the shore;
- any circumstances giving rise to an increased risk of collision such as a significant amount of traffic going across normal flow;
- hydrographical conditions relevant to safe navigation, such as lack of safe anchorages;
- prevailing meteorological and tidal characteristics

Therefore each of these parameters along with other factors found to influence the likelihood of an accident were accounted for within the risk assessment. From the first three bullet points presented within the above list it can be seen that the ship routeing pattern within UK waters will form a major input to any analysis work.

The following sections present an outline of the shipping route data utilise within this study.

4.2 COAST Database

4.2.1 Introduction

Lord Donaldson's recommendation of establishing a UK shipping database has already been responded to by the DETR by contributing to the development of the COAST database on ship routeing in UK waters (Ref. 6). COAST improved upon the reliability of existing traffic databases by utilising a large number of data sources. The main data sources used included:

- Port Callings Data provided by LMIS
- Offshore Traffic Surveys carried out by Standby Vessels (> 200 surveys)
- Platform and Coastal based Radar Systems
- Information from Offshore Operators (Standby/Supply/Shuttle Tanker details)
- Information from Ferry Operators
- Vessel Passage Plans
- Deep Sea Pilot Route Details

The following figure presents an example of some of the shipping survey data that have been used to compile the COAST database.

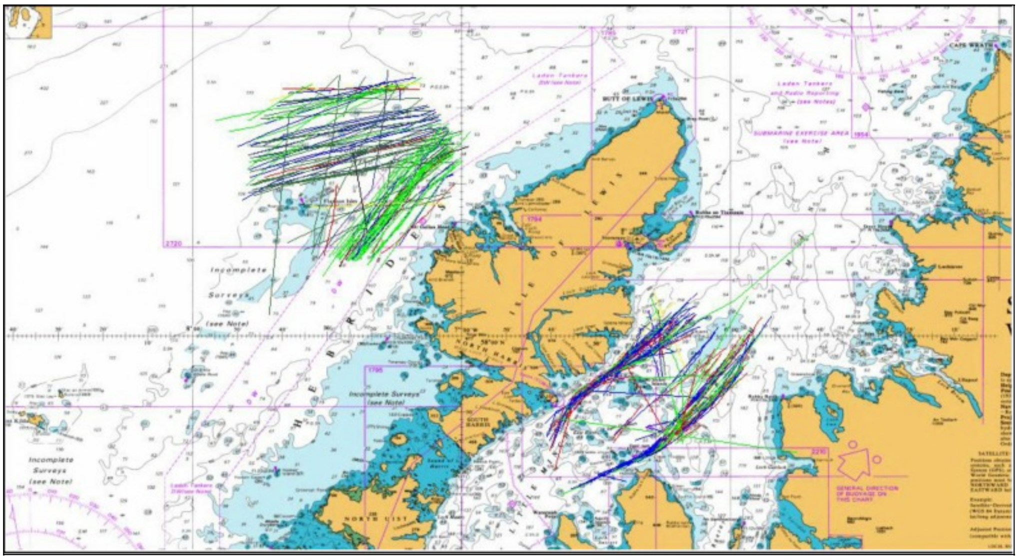

Figure 4.1 Shipping Data from MCA Survey West of Lewis and in the Minches

The COAST database was released as a new product in March 1996. The main information contained in the system for each route is as follows:

- Port of Departure/Destination
- Route Waypoints
- Number of Vessels per year
- Vessel Type Distribution
- Vessel Size Distribution
- Flag Distribution
- Age Distribution
- Speed Distribution

On completion of COAST it was recognised that the system could potentially become dated unless maintained regularly. As the developers of the system, Safetec now maintain COAST and produce annual updates of the database to reflect changes to shipping routes (e.g. due to the installation of new offshore platforms, port competition). For this project, the most up-to-date version of COAST available has been used which is based on port log data from 1998 and survey data up to 1999.

It should be noted that the database does not include "non-routine" traffic, such as naval vessels, fishing vessels, pleasure craft and offshore traffic to mobile drilling units.

4.2.2 Vessel Type Classification

Initially COAST was developed to provide information on shipping in 5 general vessel type bands, namely:

- Merchant
- Shuttle Tanker
- Ferry
- Standby
- Supply

However, it was identified that for this study which is focused on oil spill risks, further breakdown of vessel type was required. Hence, COAST was updated for this project in order to increase the vessel type breakdown. The ten vessel types and five size distributions in the most up to date version of the database are presented in the following tables.

Table 4.1 Vessel Types included in the Updated COAST

Code	Type	Subtypes included
1	Bulk	Bulk Carrier
		Bulk/Containership
		Cement Carrier
		Ore Carrier
		Wood-chip Carrier
		Bulk/Oil Carrier
		Ore/Oil Carrier
2	Cargo	Cargo/Training
		General Cargoship
		Multipurpose Cargoship
		Refrigerated Cargoship
		Livestock Carrier
		Containership
		Refrigerated Containership
3	Ferry	--
4	Liquefied Gas Tanker	LPG Carrier
		LNG Carrier
		LNG/LPG Carrier
5	Ro-Ro	Ro-Ro Ship
		Ro-Ro/Containership
		Vehicle Carrier
		Passenger Ro-Ro
6	Standby Vessel	--
7	Supply Vessel	--
8	Chemical Tanker	--
9	Oil Tanker	--
10	Shuttle Tanker	-

Table 4.2 Vessel Size Categories in Dead Weight Tonnage (dwt)

Code	Size Category (dwt)
1	Under 2,000
2	2,000 to 5,000
3	5,000 to 20,000
4	20,000 to 50,000
5	Over 50,000

An overview of the routes contained with COAST is presented in Figure 4.2.

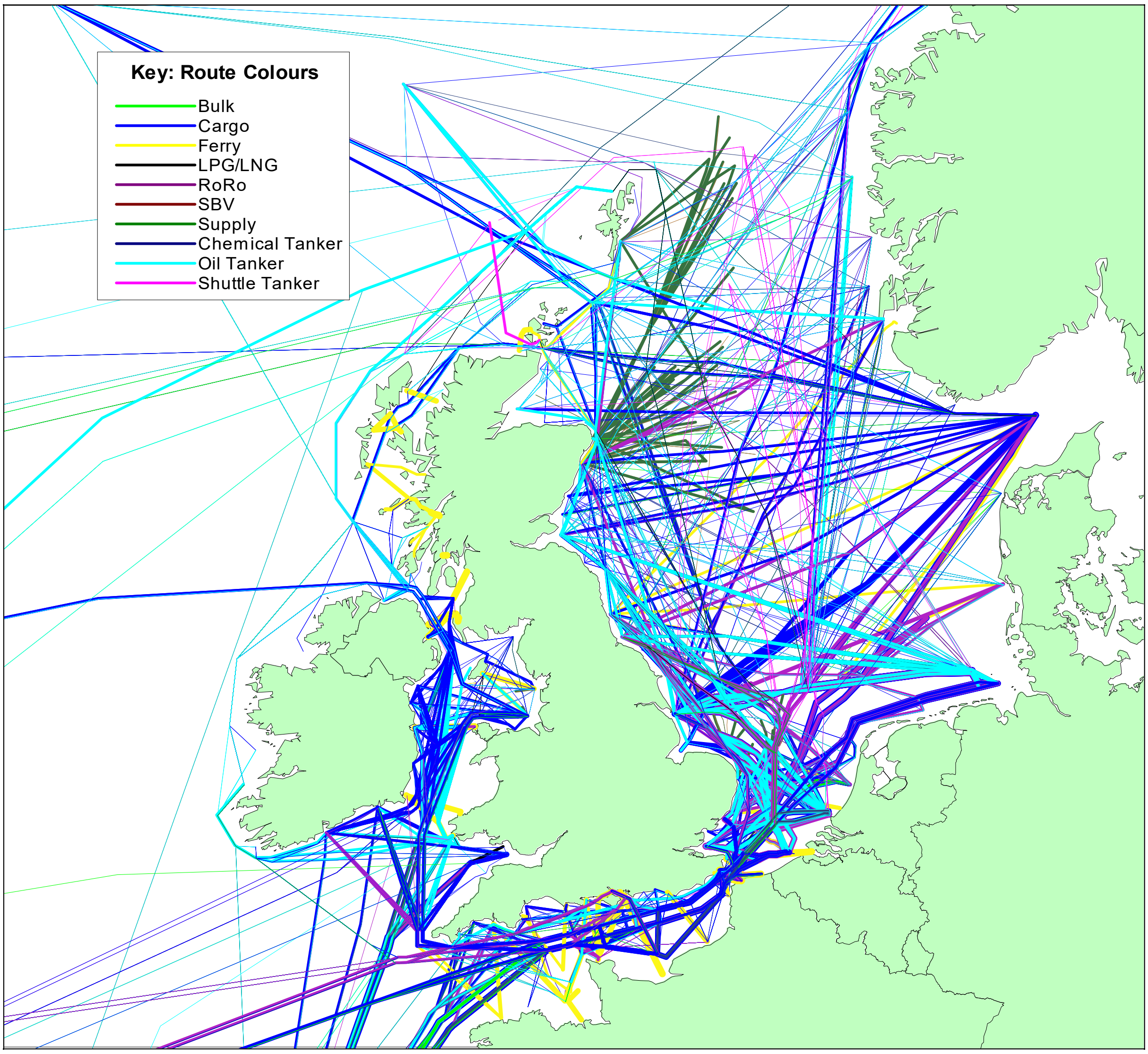

Figure 4.2 Overview of COAST Database 1999

Further details on the ship routeing are presented within Appendix 1.

5 SHIPPING ACCIDENT FREQUENCY ASSESSMENT

5.1 Introduction

Once the ship routeing has been identified, the next stage of the assessment is to determine the frequency of different incidents taking place within UK waters which would be proceeded by the consequence evaluation. These tasks involve the application of several predictive models, which can be categorised as either

Frequency models - which determine the likely frequency of accidents within UK waters
Consequence models - which determined the likelihood of a spill and the volume of the release

Within each of the models developed, it was considered of paramount importance that the results were validated against the best available historical data to ensure an accurate representation of the pollution risks within UK waters. The following sections provide an overview of the frequency assessment carried out for this study.

5.2 Frequency Assessment

5.2.1 HazID Review

In the initial stages of this study a review of historical casualty data (see Appendix 2) was undertaken to determine which major marine incidents have the potential to result in a detrimental effect to the coastal environment. From this review it was established that there were five main categories which are listed as follows:

Ship to Ship Collision	Striking or being struck by any self propelled ship whilst at sea whether the ship is in transit or anchored and excluding collisions with any underwater vessel/wreck and self propelled oil installations.
Fire and Explosion	Accidents where fire and/or explosion is the first event reported. Casualties involving fires and/or explosions after collision stranding etc. are categorised under "Collision", "Stranding" etc.
Foundering and Structural Failure	Includes ships which sank or were damaged as a result of hull failure, heavy weather damage, springing leaks, breaking in two etc., and not as a consequence of the other defined casualties.
Powered Grounding	Includes grounding, bumping over sandbars, striking underwater wrecks and ships, reported hard and fast for an appreciable period of time, and cases reported as touching bottom when the reporting ship is under power.

Drifting Grounding	Includes grounding, bumping over sandbars, striking underwater wrecks and ships, reported hard and fast for an appreciable period of time and cases reported as touching bottom when the reporting ship is adrift due to loss of power, steering or due to adverse weather conditions which cause a moored vessel to drag anchor.

Initial analysis of 10 years casualty data (1989-1998 inclusive for UK Waters) identified a total of 341 reported incidents (i.e. an average of 34.1 incidents per annum). Figure 5.1 presents a breakdown of these incidents into the five major accident groups identified above.

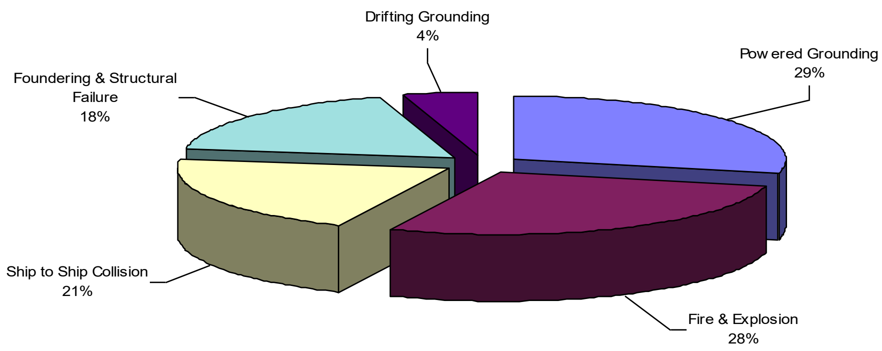

Figure 5.1 Breakdown of Serious Casualties by Accident Group (1989 to 1998 Inclusive)

These major accident groups were isolated within the database to allow further, more in-depth analysis to be carried out. Within this analysis various factors such as ship age, size and type were assessed as well as the environmental conditions at the time of each incident to establish if any underlying trends exist which influence the likelihood of each incident type occurring. The findings of the analysis were then incorporated into the predictive models for the different types of incident.

The following graphs provide a brief overview of the findings of this review. Figure 5.2 presents a breakdown of the weather conditions that were reported at the time of each ship collision incident.

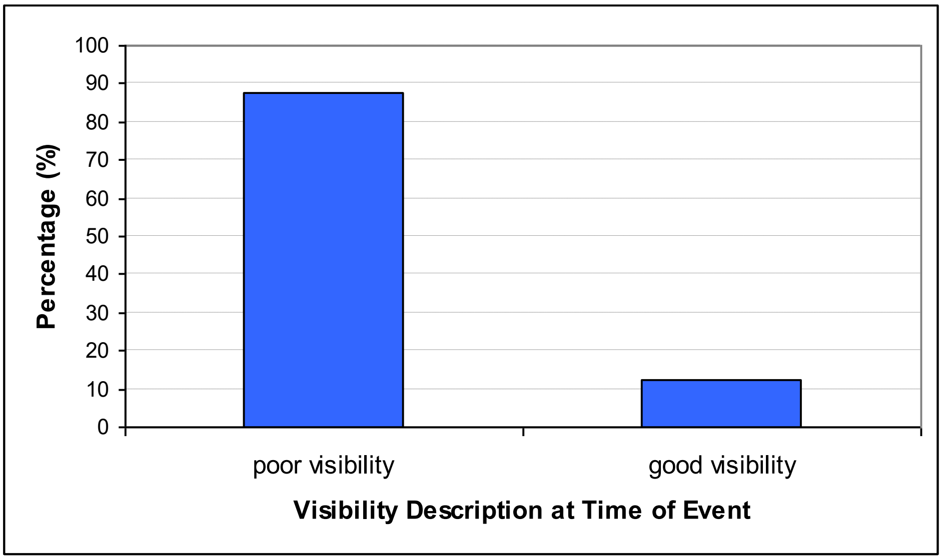

Figure 5.2 Breakdown of Visibility Conditions during Ship to Ship Collision Incidents

From Figure 5.2 it can be seen that the likelihood of ship to ship collision is much higher in poor visibility which supports previous analysis work performed during the COLLIDE model development.

Figure 5.3 presents the ratio of incidents by vessel age against the industry average for foundering and structural failure giving due consideration to the number of vessels in each age category.

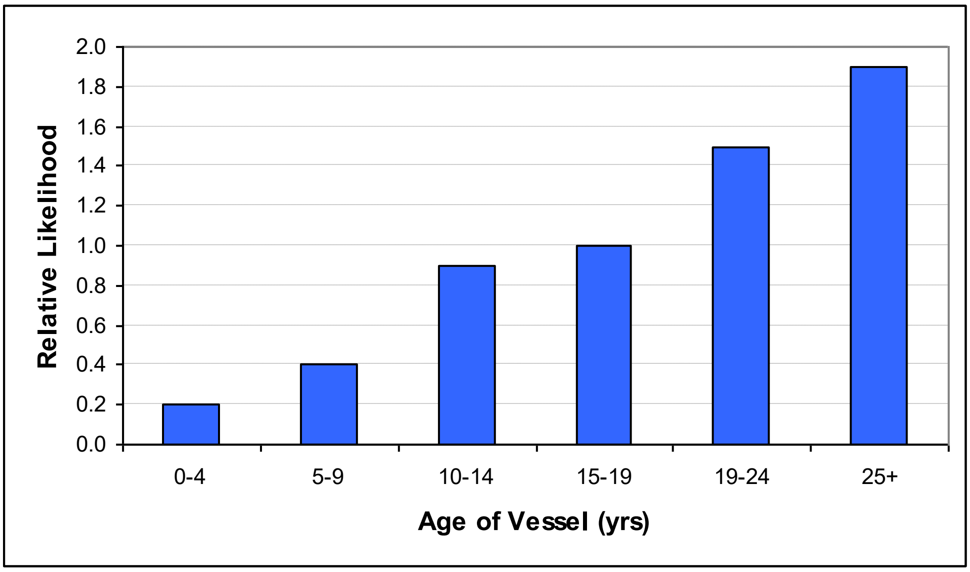

Figure 5.3 Ratio of Incidents by Vessel Age for Foundering and Structural Failure

From Figure 5.3 it can be seen that there is a relationship between the age of vessels and the likelihood of foundering or structural failure. This is as expected and is considered to be a result of deterioration of hull due to corrosion stresses and fractures.

A more detailed discussion of the factors identified to have an influence on the likelihood of a shipping accident is documented for different vessel types and sizes within Appendix 2.

5.2.2 Predictive Modelling

Having identified the routeing pattern and assessed the factors which have an influence on the likelihood of different shipping incidents taking place, several models were run to determine the geographical distribution of incidents. The five different models applied were:

- Ship to ship collision model
- Fire and explosion model
- Foundering model
- Powered grounding model
- Drifting grounding model

The models used were those to be applied to a recent analysis commissioned by the Maritime and Coastguard Agency for a UK Chemical Spills assessment (Ref. 2). The following table presents the factors considered within each of these models. Further details on each of the models are presented within Appendix 6.

Table 5.1 Factors Considered within Different Frequency Models

Models	Parameters Used Within Models
Ship to ship collision	Route positions, visibility, encounter angle, VTS areas, vessel type and size, vessel speed, and number of vessels on route.
Powered grounding	No of vessels on route, proximity of route to coastline, coastal rockiness, vessel size, VTS areas, sea state, vessel type, geometrical probabilities, navigational error probabilities.
Drifting grounding	Vessel type and size, wind strength & direction, sea-conditions, self-repair probabilities, mechanical failure probabilities, drift speeds.
Fire and explosion	Vessel type and size, traffic densities.
Foundering	Vessel type and size, traffic densities and probability of severe weather in different geographical locations.

In order to present the collision frequency results in a manner that could be viewed alongside the UK coastline, a GIS system was developed with different sized cells generated depending on proximity to the shore. The different cell sizes applied are as follows:

- 7.5 nm x 4 nm (shoreline cells)
- 15 nm x 8nm (sea cells)
- 30 nm x 16 nm (sea cells)
- 60 nm x 32 nm (sea areas remote from UK coastline)

Figure 5.4 and Figure 5.5 presents the shoreline and sea area cells used by the models.

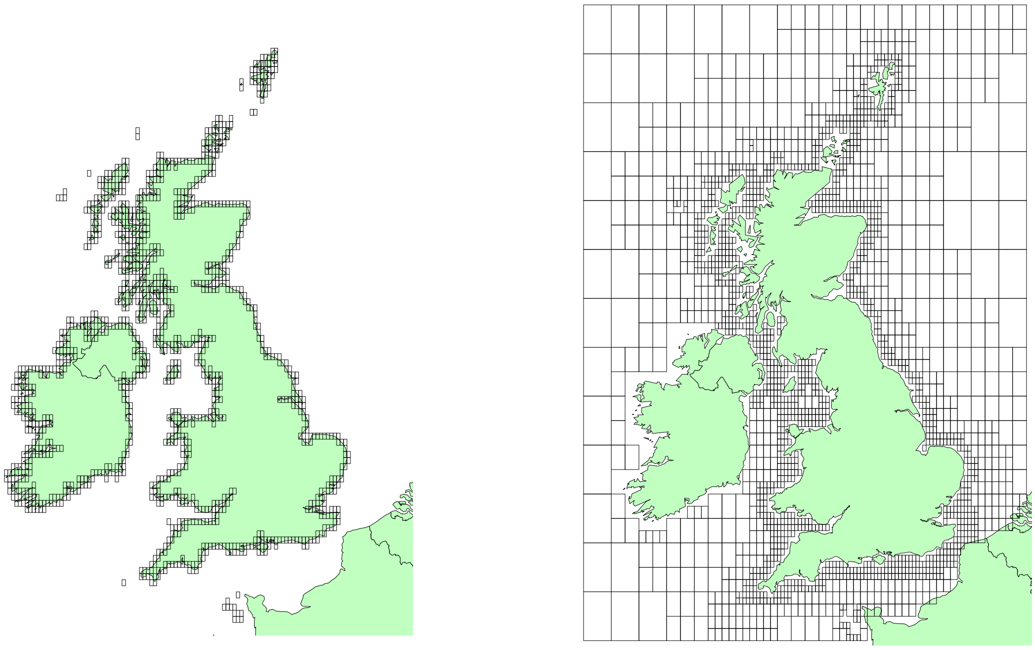

Figure 5.4 Shoreline And Sea Area Cells Used In Pollution Risk Models

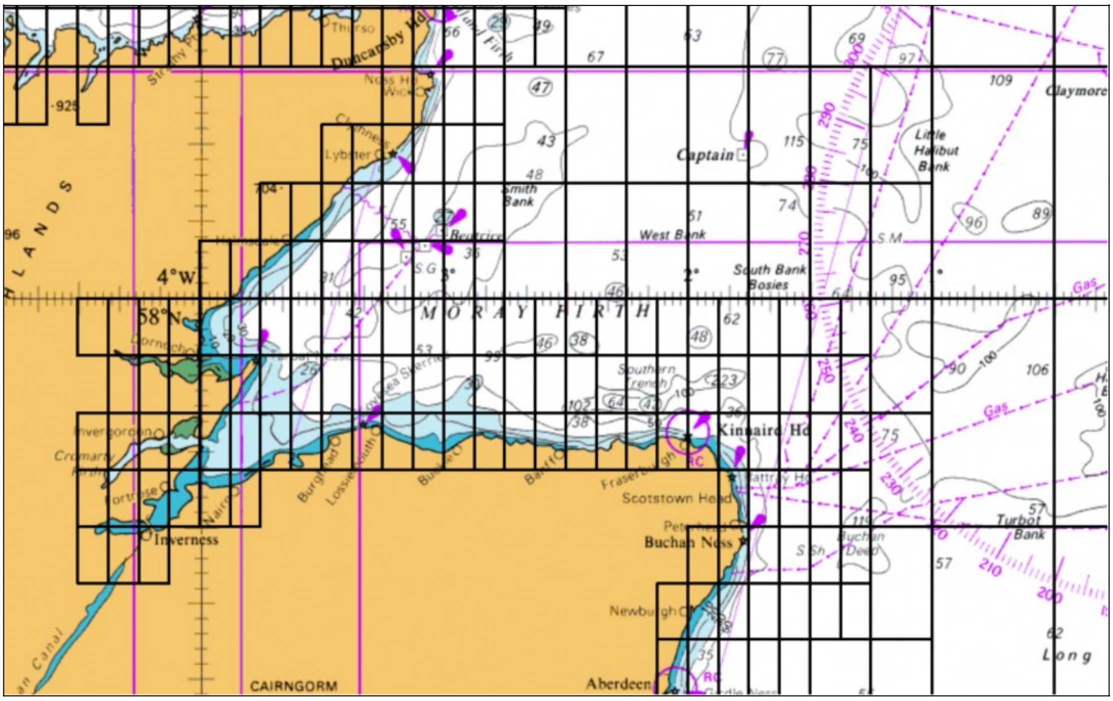

Figure 5.5 Examples of Coastal Cells and Sea Cells

5.2.3 Accident Frequency Results

Using the different models, the following estimates were made for different types of incidents occurring in UK waters on a per annum basis.

Table 5.2 Model Predictions for Different Types of Incidents Taking Place in UK Waters (Per Annum)

Model	Frequency of Incidents Predicted Per Annum
Ship to Ship Collisions	7.0
Foundering	7.3
Fire and Explosion	9.5
Drifting Grounding	1.5
Powered Grounding	9.8
TOTAL	35.1

The above results are presented graphically in Figure 5.6.

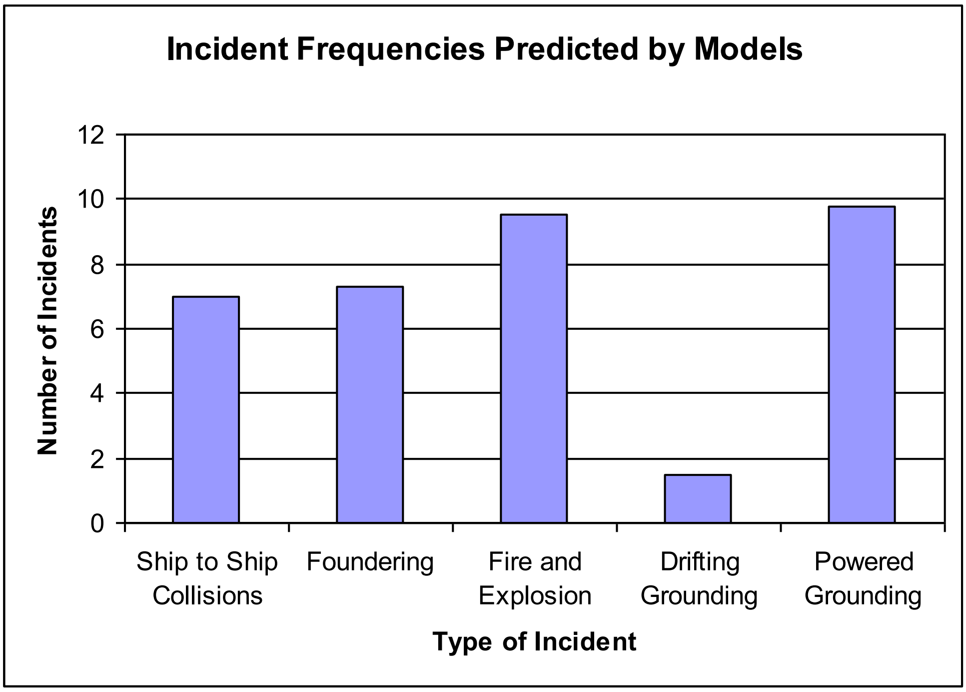

Figure 5.6 Incident Frequencies Per Annum in UK Waters Predicted by Modelling

Different frequencies have been calculated for different vessel types and size categories. The following figures present the geographical distributions of risk levels for all vessel types. As tankers form a significant proportion of the threat of major pollution incidents for UK waters, separate plots are presented for tankers. Detailed plots for each accident type are presented in Appendix 8.

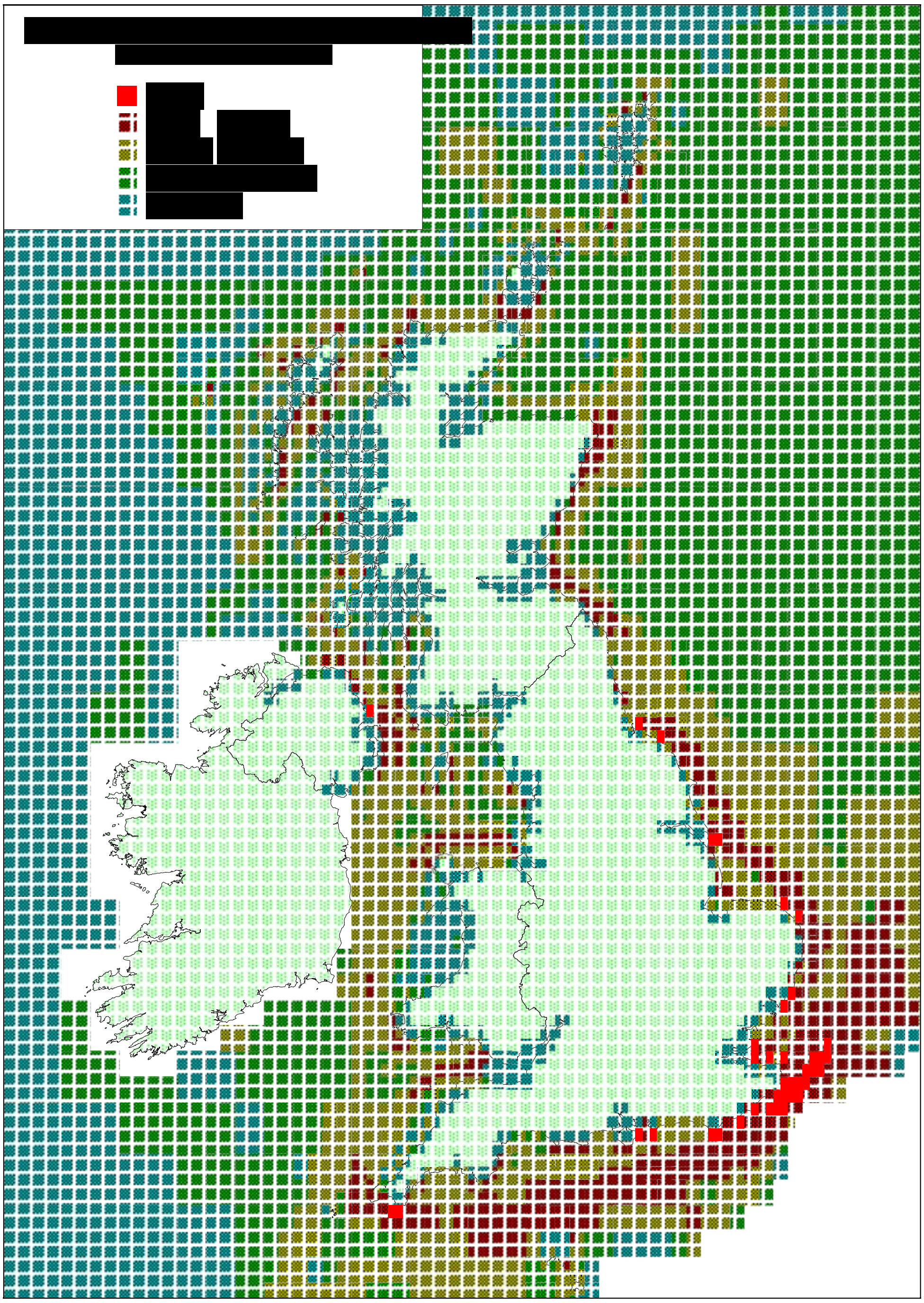

Figure 5.7 Geographical Distribution of All Scenarios for All Vessel Types

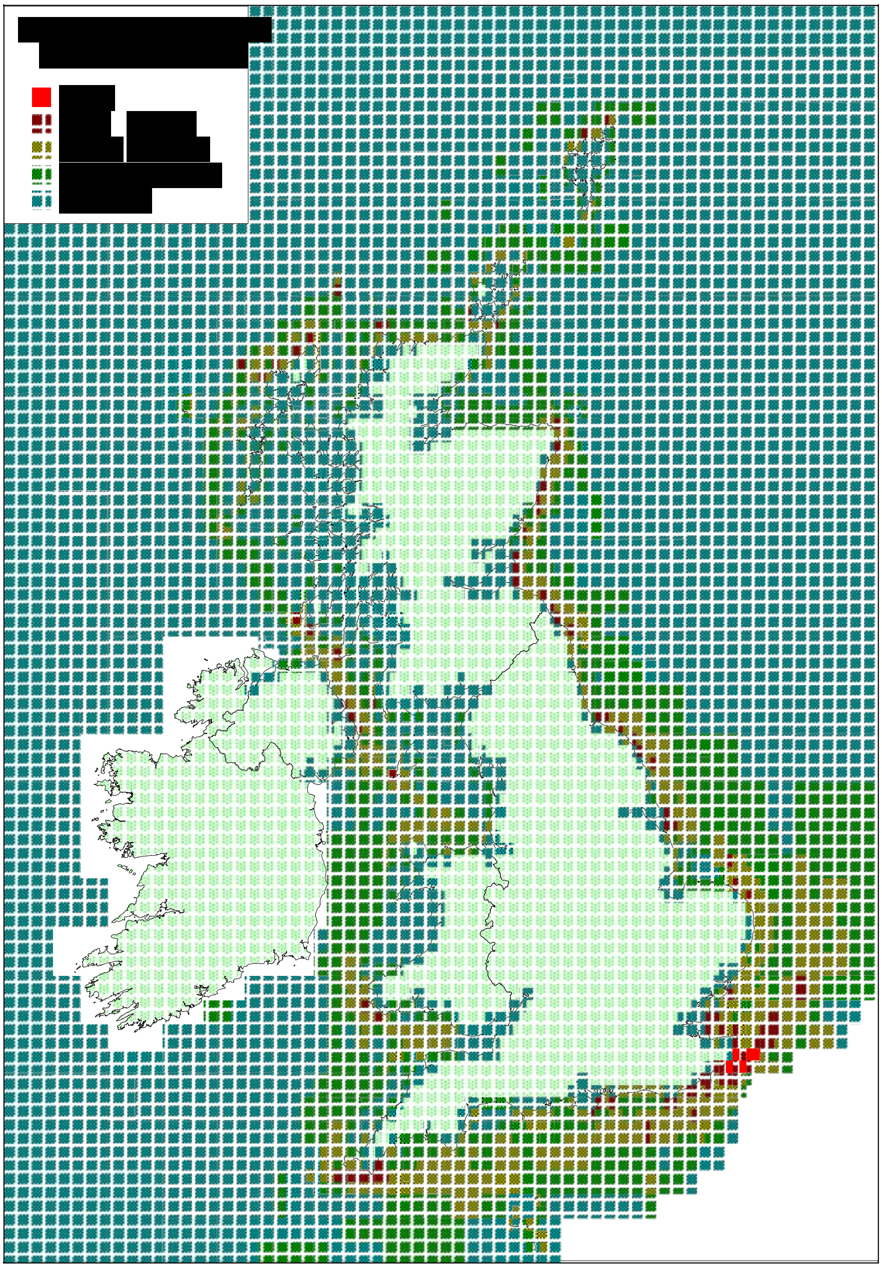

Figure 5.8 Geographical Distribution of All Scenarios for Tankers

From this analysis it was observed that as expected some of the highest incident levels are predicted around the areas with high shipping densities. However on further investigation it was observed that the contribution of each scenario varied for each depending on factors such as distance from coastline, proximity to other shipping lanes, age of vessels, etc. Table 5.3 presents the different incident frequency breakdowns for a sample of locations around the UK coastline.

Table 5.3 Contributions to Incident Frequencies at Different Locations in UK Waters

Cell No. Identifier	Location	Incident Category	Frequency
962	In vicinity of Humber estuary (Non- coastal cell)	Ship to ship collision	0.053
		Fire & explosion	0.03
		Powered grounding	Not applicable
		Drifting grounding	Not applicable
		Foundering	0.02
		Total	0.105
615	Dover Strait (Non- coastal cell)	Ship to ship collision	0.15
		Fire & explosion	0.06
		Powered grounding	Not applicable
		Drifting grounding	Not applicable
		Foundering	0.04
		Total	0. 25
2,235	West Coast of Lewis (Coastal cell)	Ship to ship collision	Not applicable
		Fire & explosion	Not applicable
		Powered grounding	0.0075
		Drifting grounding	0.0106
		Foundering	Not applicable
		Total	0.018

5.2.4 Validation of Incident Results

At the onset of this study it was agreed that any models developed should be calibrated using the most up-to-date and reliable data available. Full details of this calibration process are presented within Appendix 8. The following figures provide a sample of the comparisons of historical versus predicted frequencies for some of the incidents covered by the modelling.

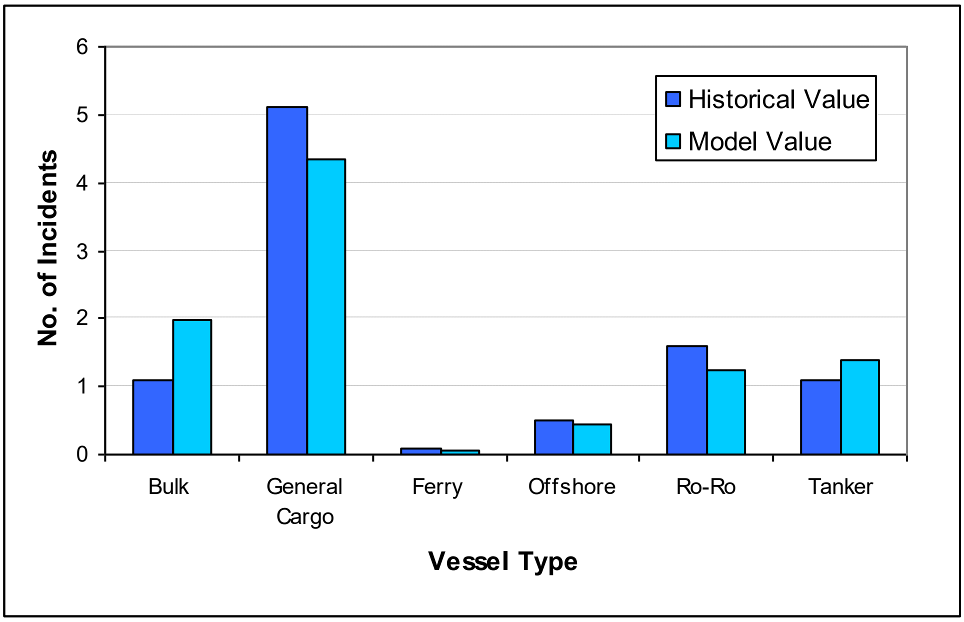

Figure 5.9 Model Predictions vs Historical Data for Fire & Explosion Incidents in UK Waters

The above graph shows that there is a good comparison between model predictions and the actual number of historical occurrences for fires and explosions. Figure 5.10 presents the model versus historical frequencies for foundering incidents for different vessel types.

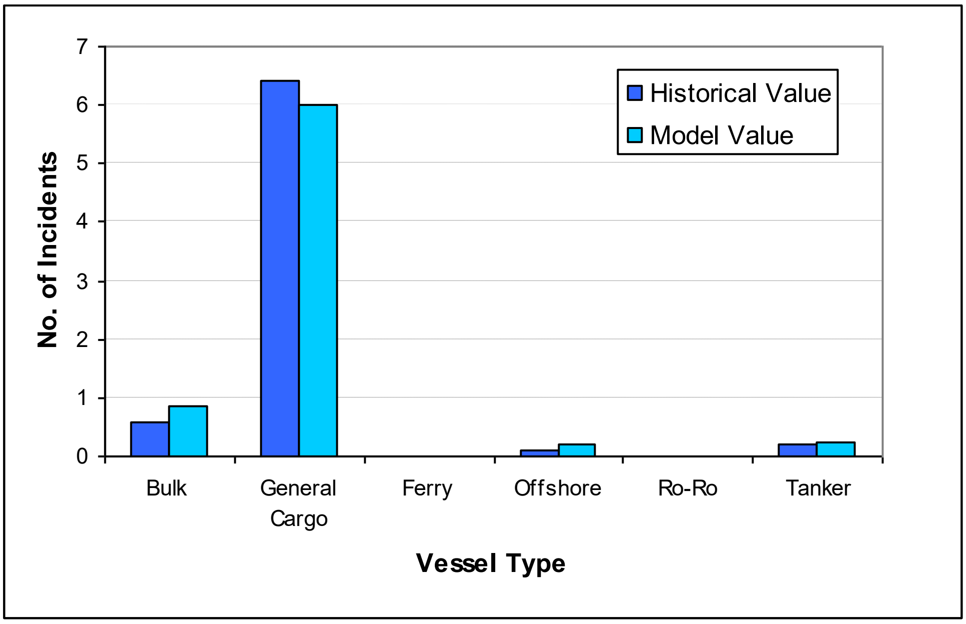

Figure 5.10 Model Predictions vs Historical Data for Foundering Incidents in UK Waters

As with fire and explosion, the frequencies generated from the model and from the historical data compare well. The following figure presents the same comparison for different vessel sizes.

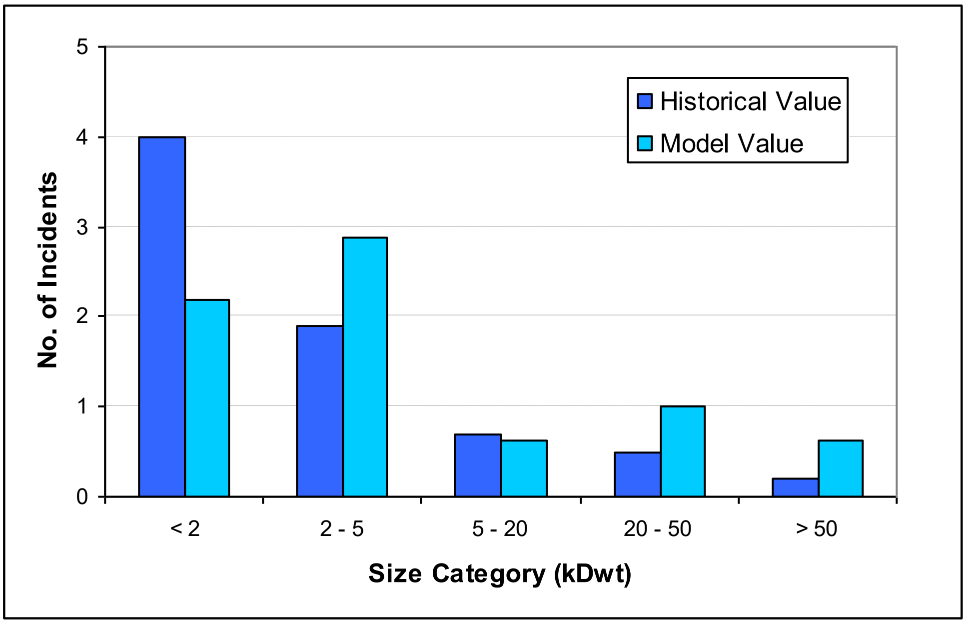

Figure 5.11 Model Predictions vs Historical Data for Foundering Incidents on Vessels of Different Sizes in UK Waters

As stated previously, further graphical comparisons between the model predictions and historical data for each of the incident types are presented in Appendix 8. The overall conclusion of this exercise is that the model predictions and the historical experience are in close agreement.

6 CONSEQUENCE MODELLING – RELEASE OF POLLUTANT

6.1 Introduction

From the review of historical data on marine pollution from shipping (Section 3) it was observed that the main cause was cargo and fuel release following an accident. The type and frequency of various accident scenarios has been investigated (Section 5). This section proceeds to investigate the probability of the accident resulting in pollution and the likely spill size, which may result.

6.2 Methodology

The pollution consequences of a serious shipping casualty depend on the following:

- Probability of a spill following an accident
- Size of spill

In order to assess each of these, predictive models were developed based on historical spill data from the following data sources:

- Lloyd's Casualties
- ITOPF (International Tanker Owners Pollution Federation)
- Worldwide Tanker Spill Database

Full details of the methodology are presented in Appendix 6.

6.3 Spill Probability

Spills were divided into two categories; fuel oil spills from bunkers (all vessel types) and spills of oil carried as cargo (laden tankers). The probability of a spill per casualty was calculated based on historical accident data for each casualty type as presented in Figure 6.1.

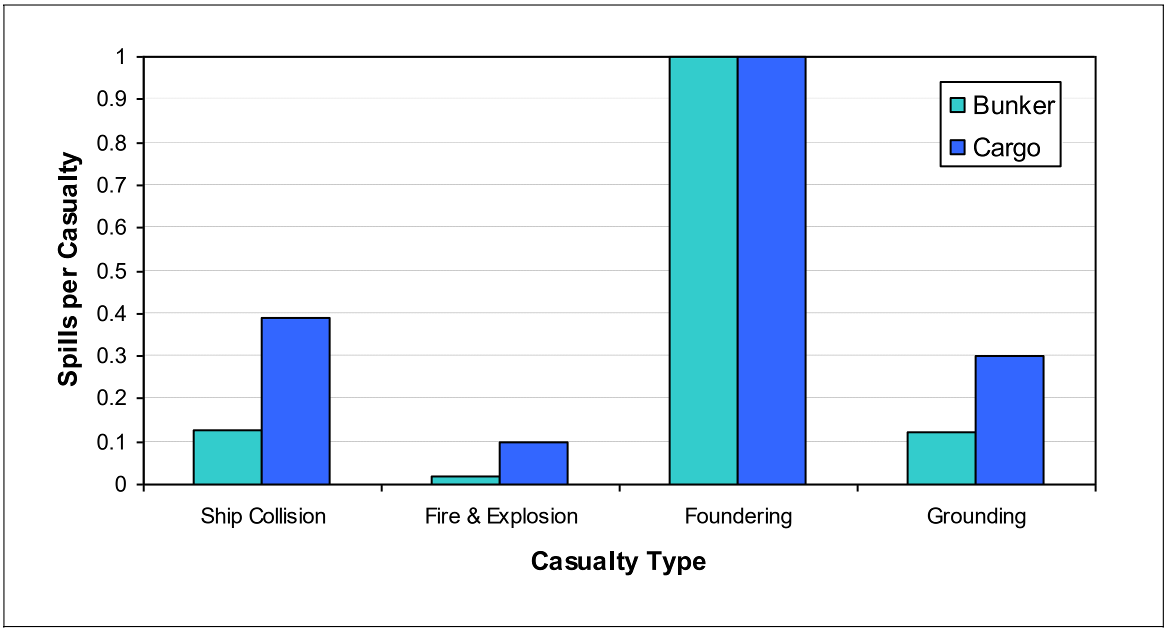

Figure 6.1 Probability of an Oil Spill resulting from a Casualty

For foundering, it was assumed that all sunken ships will release some oil, although it may only be a small amount.

6.4 Spill Size

Using the spill frequencies, the estimated spill size for each casualty type and ship size was calculated using historical data and distributed into the following five size categories:

Table 6.1 Spill Size Categories Applied in Assessment

Spill Size Category	Spill Size (tonnes)
1	0 to 1,000
2	1,000 to 10,000
3	10,000 to 50,000
4	50,000 to 100,000
5	Over 100,000

For spills of fuel oil from bunkers, the vast majority of historical spills are minor (category 1), with only larger vessels having sufficient bunker capacity to spill more than 1,000 tonnes of oil.

To estimate the amount of oil spilled in a release from a vessel carrying oil as cargo, historical data indicated that the model must account for both a relatively large number of small spills and infrequent large ones. The main factors influencing spill size are:

- Casualty Type
- Ship Size & Type (double hull/single hull)

Worldwide data on releases of oil from tankers was used to estimate the spill size distribution for each casualty type and ship size. Samples of the data for grounding incidents are presented in Figure 6.2 and Figure 6.3.

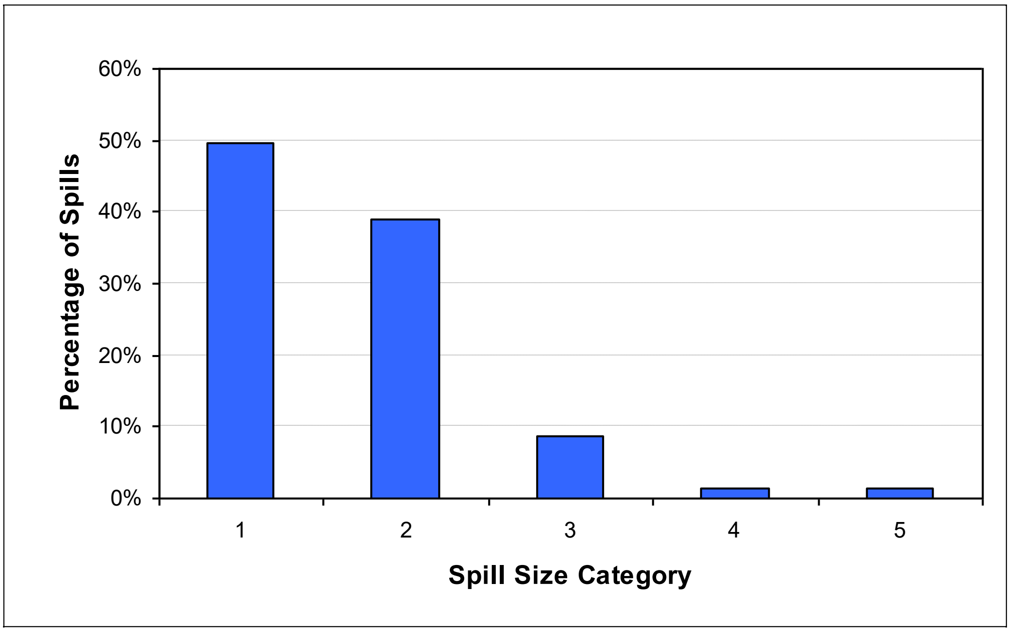

Figure 6.2 Distribution of Grounding Spills involving Tankers into Spill Size Categories

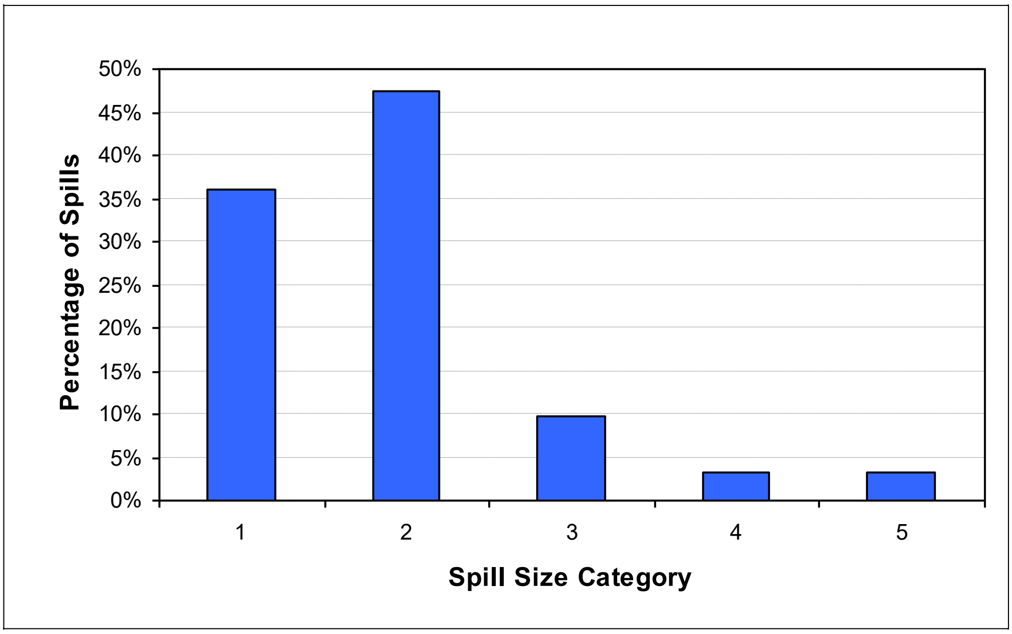

Figure 6.3 Distribution of Grounding Spills involving Tankers above 50,000 DWT into Spill Size Categories

However, the Worldwide data only reports spills of oil over 1,000 barrels (approximately 136 tonnes), therefore, supplementary information from ITOPF was used to estimate the proportion of smaller spills.

6.5 Results – Frequencies of Different Sizes of Spills in UK Waters

Using the incident frequencies, spill probabilities and spill size distributions, the frequencies of different sizes of spills occurring in UK Waters have been estimated. The following figures present the cumulative frequency of spills in exceedence of each spill size category.

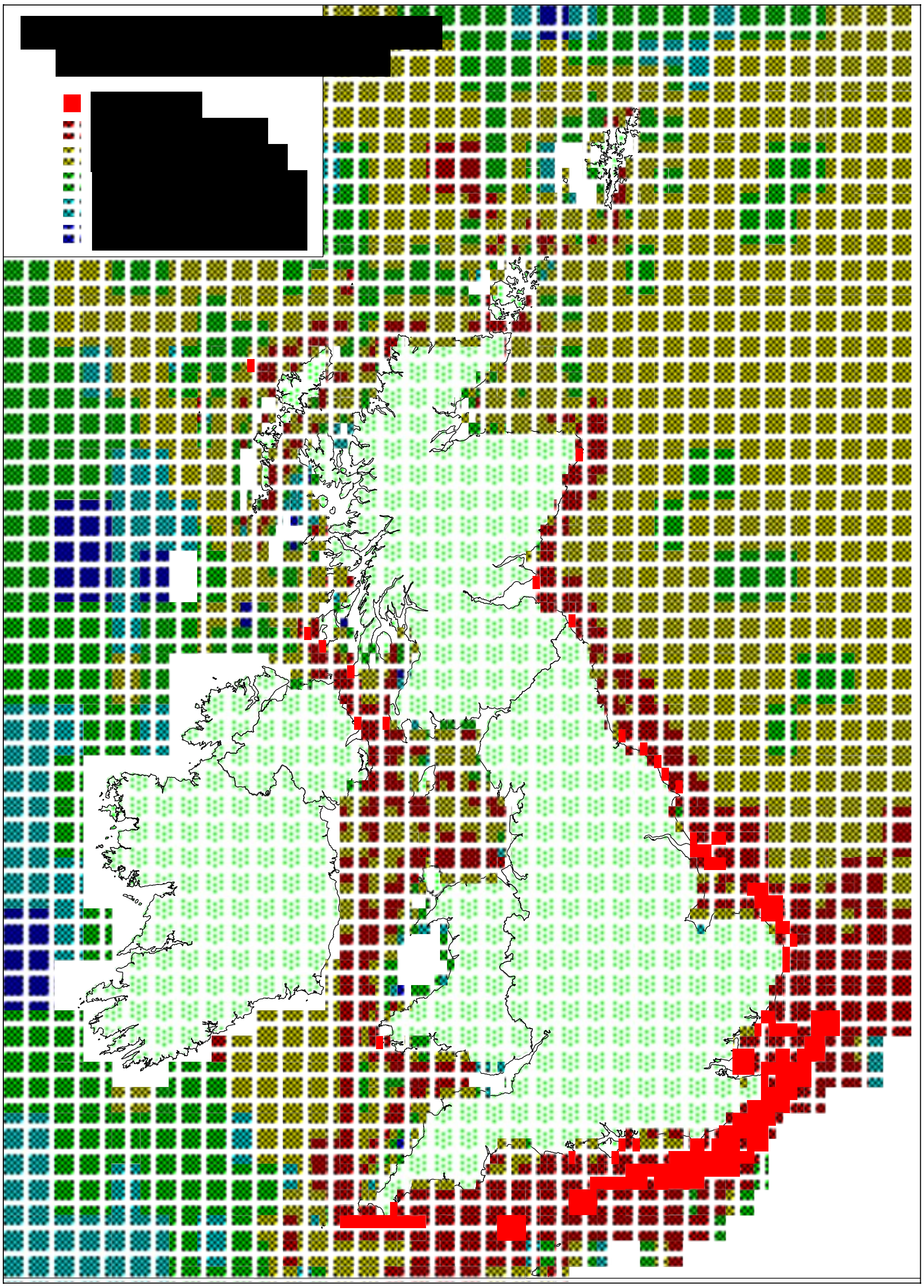

Figure 6.4 Overview of Spills From All Vessels in UK Waters >0 Tonnes Per Annum

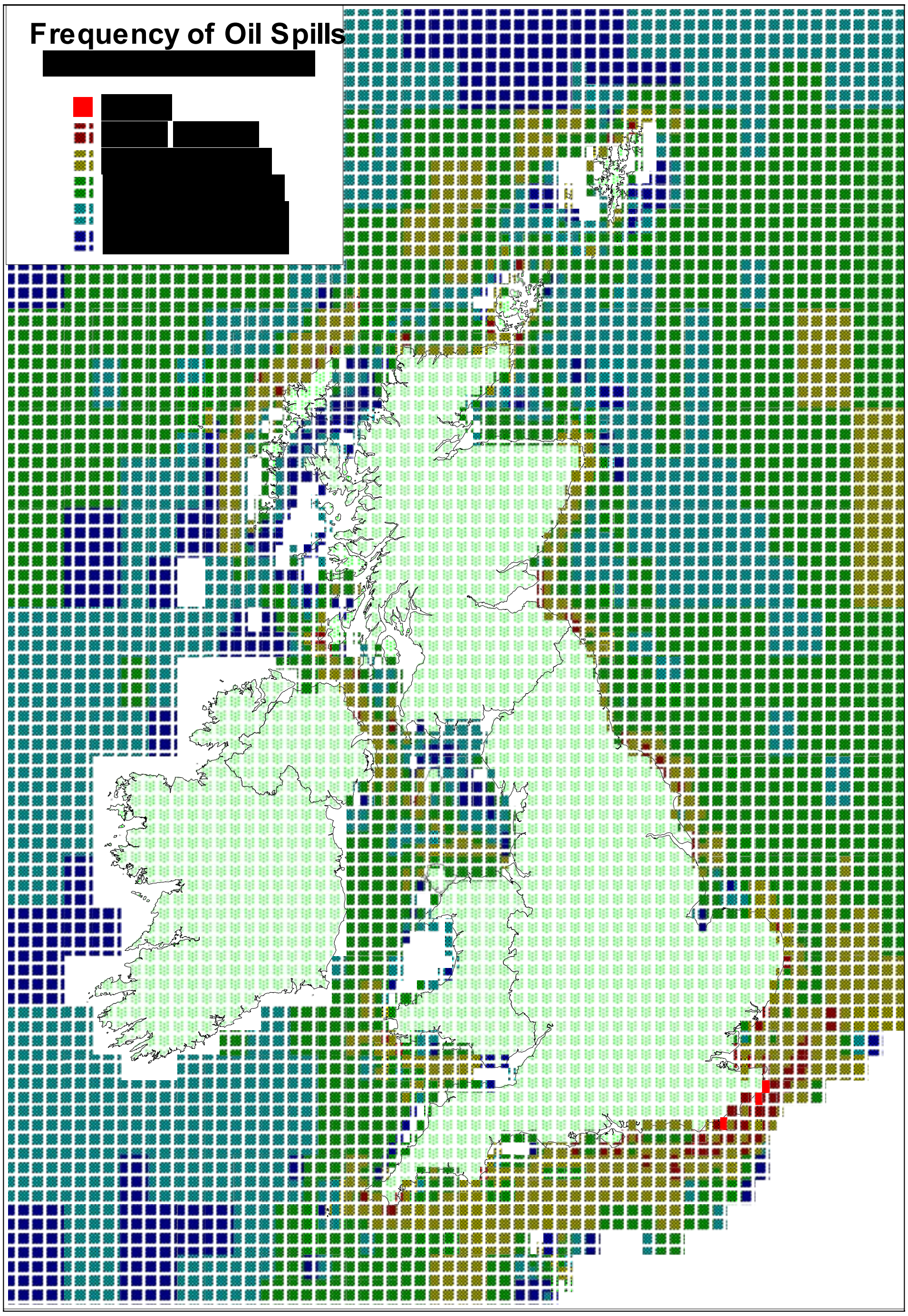

Figure 6.5 Overview of Spills From All Vessels in UK Waters >1,000 Tonnes Per Annum

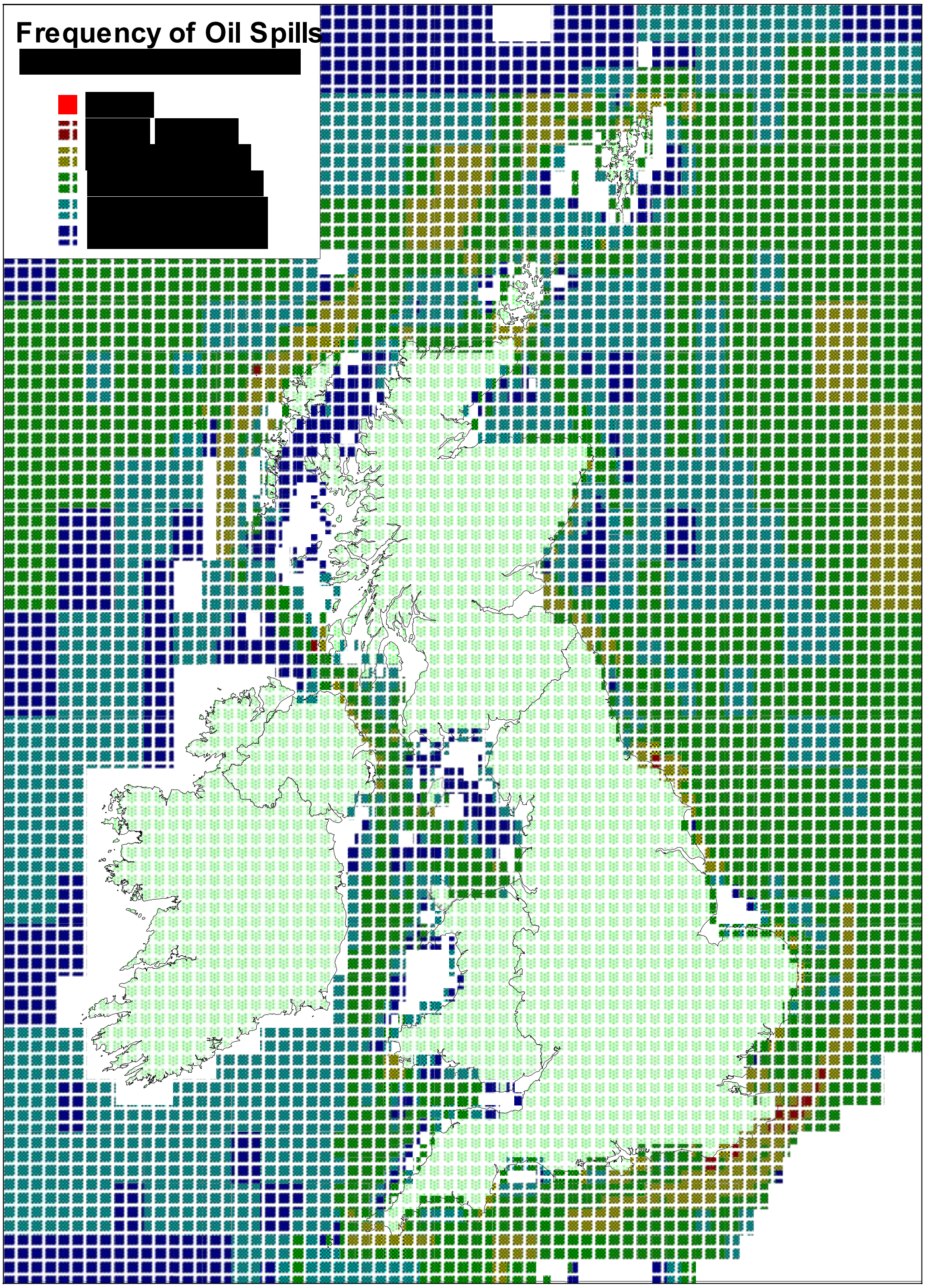

Figure 6.6 Overview of Spills From All Vessels in UK Waters >10,000 Tonnes Per Annum

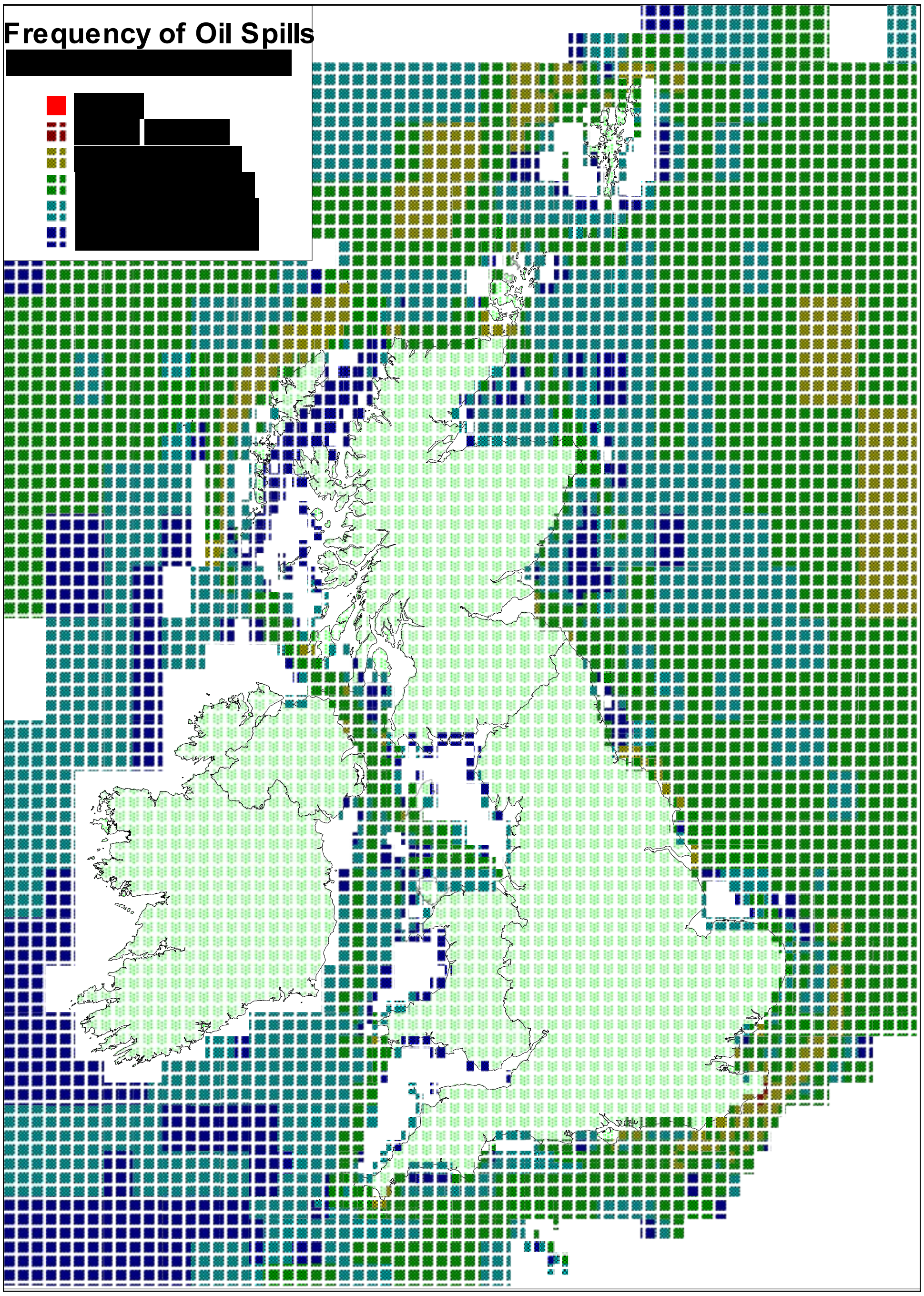

Figure 6.7 Overview of Spills From All Vessels in UK Waters >50,000 Tonnes Per Annum

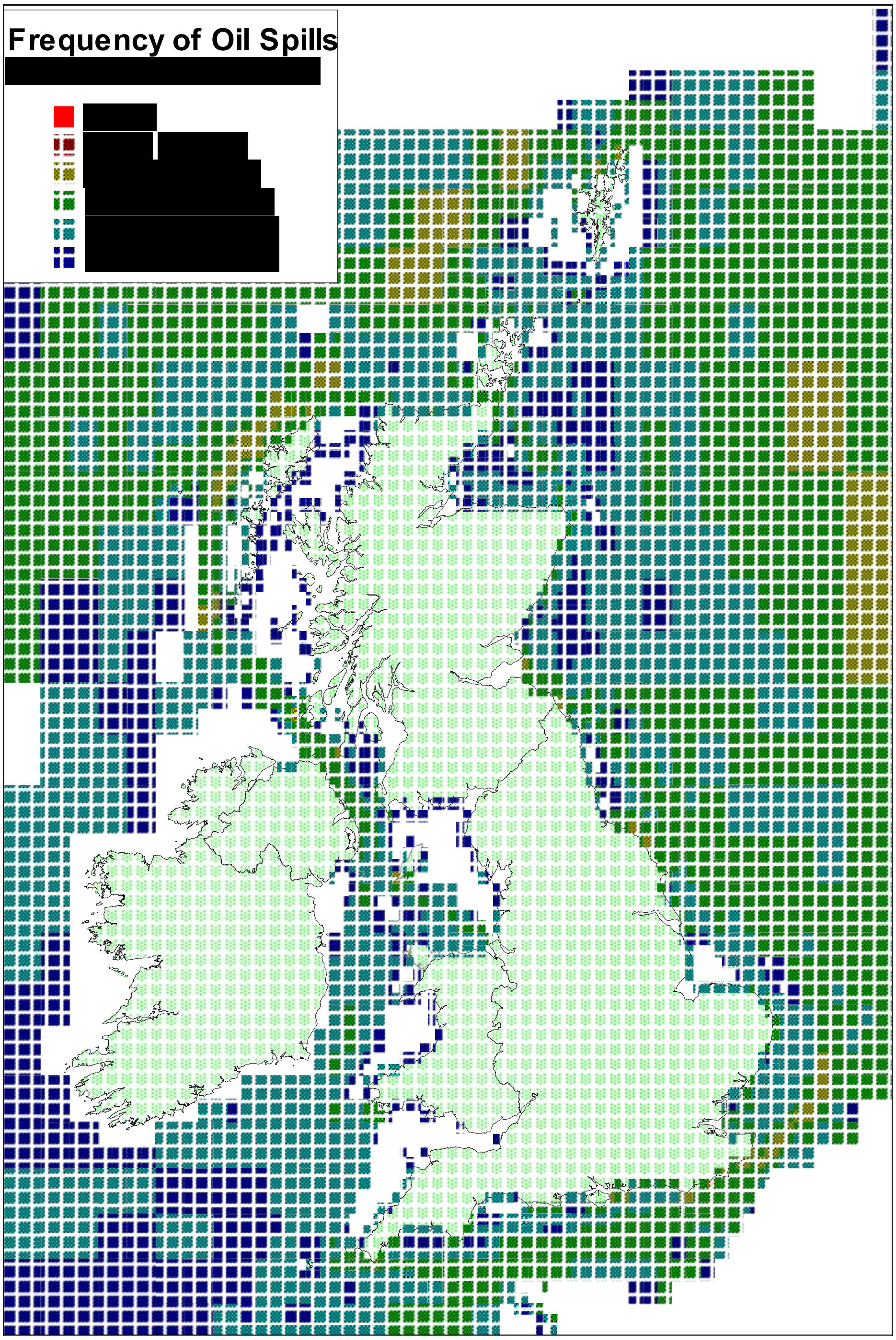

Figure 6.8 Overview of Spills From All Vessels in UK Waters >100,000 Tonnes Per Annum

7 POLLUTION RISK RESULTS

7.1 Introduction

To rank areas of the UK coastline in terms of pollution risk, each coastal cell has been allocated a score based on the tonnes of oil per annum either being spilt directly within the cell following an accident, or drifting into the cell following a spill at sea.

The average quantity of spill within each spill size category was estimated from historical data and multiplied by the annual frequency of spills for that category to give the total oil spilled per year for all cells in UK waters.

A simple oil spill drift model was developed to add the potential contribution of oil spilled at sea to oil pollution within coastal cells.

7.2 Average Spill Quantity

Using historical data, the average tonnes of oil released for all spills within each size category was calculated. The results are presented in Table 7.1

Table 7.1 Average Size of Oil Spills per Size Category

Size Category (Tonnes)	Average Spill Size (Tonnes)
< 1,000	25
1,000 – 10,000	3,000
10,000 – 50,000	30,000
50,000 – 100,000	75,000
> 100,000	150,000

7.3 Quantity of Oil Spilled Per Cell (Direct)

To predict the tonnes of oil spilled per annum directly within a cell, the frequency of each spill category has been multiplied by the average spill size for the category. An example of the methodology is outlined in Table 7.2.

Table 7.2 Methodology for Determining Ranking of Pollution Risk in UK Waters

Spill Size Category	Representative Spill Size (tonnes)	Frequency of Spill (Per Annum)	Tonnes Spilled (Per Annum)
1 (0-1000 tonnes)	25	$1x10^{-2}$	0.25
2 (1-10,000 tonnes)	3,000	$1x10^{-3}$	3
3 (10-50,000 tonnes)	25,000	$1x10^{-4}$	2.5
4 (50-100,000 tonnes)	75,000	$1x10^{-5}$	0.75
5 (>100,000 tonnes)	150,000	$1x10^{-6}$	0.15
Totals	N/A	N/A	6.65

The following figure presents the results of this assessment.

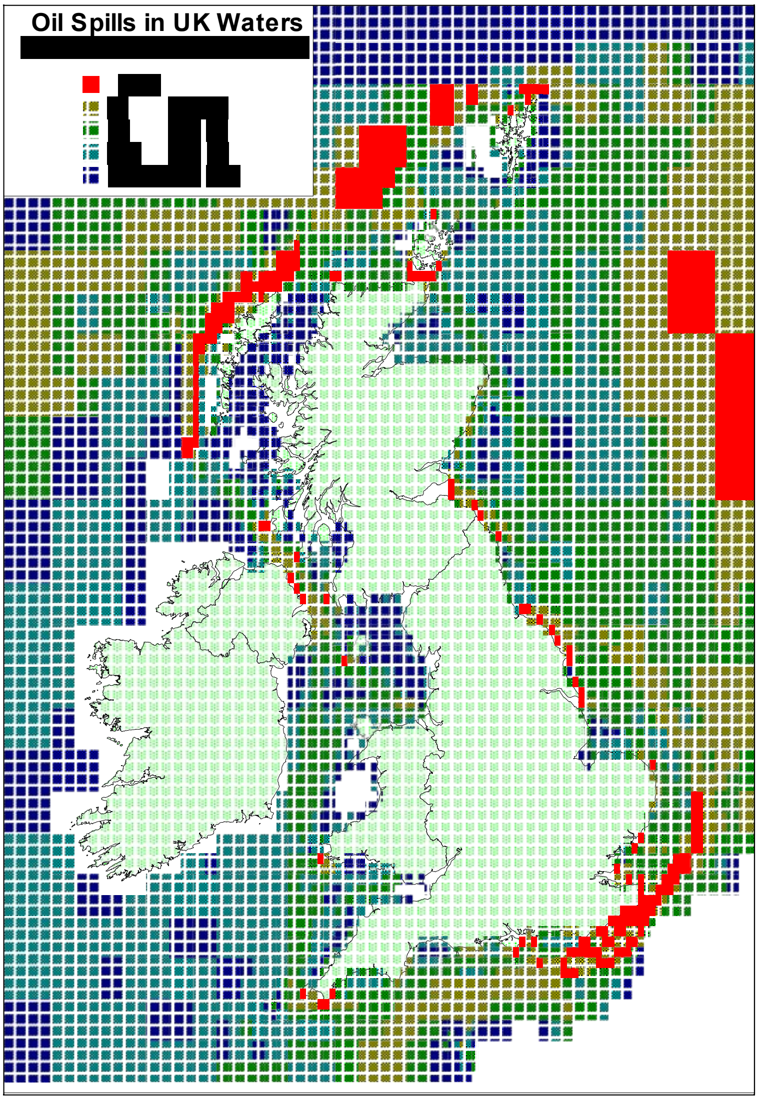

Figure 7.1 Ranking of Potential Spills in UK Waters

Based on the model predictions, the highest score of 232.7 (tonnes per annum) is for a cell off the coast of Dover (i.e. in the Dover Strait). Details of the top 10 largest potential pollution spill sites in UK waters are presented in the following table.

Table 7.3 Top Pollution Likelihood Scores for UK

Cell No. Identifier	Location	Score
3189	Dover Strait	232.7
3191	Dover Strait	216.2
3155	English Channel (near Hastings)	178.7
973	Dover Strait TSS off S. Foreland	110.6
3145	English Channel Inshore TSS (Off Beachy Head)	110.4
1387	Dover Strait TSS	101.4
970	Dover Strait TSS	98.6
2278	West Coast of Scotland (Off Rhinns of Islay)	97.2
2160	West Coast of Scotland (Flannan Isles)	89
1407	Approaches to Dover Strait (Due East of Ramsgate)	83.4

The breakdown of the highest score into spill categories is presented in the following table:

Table 7.4 Pollution Risk for Cell No. 3189 Off Dover

Spill Category	Tonnes Per Annum
1 (0-1000 tonnes)	3.3
2 (1-10,000 tonnes)	54
3 (10-50,000 tonnes)	44.7
4 (50-100,000 tonnes)	43.6
5 (>100,000 tonnes)	87.1
Totals	232.7

7.4 Contribution from Oil Spills at Sea (Indirect)

The main limitation associated with using the above output combined with environmental sensitivity to determine MEHRA's is that spills which occur away from the coastline (e.g. in sea cells) are not included in the contribution to the pollution risk on the coast.

As oil spill modelling in itself has a high degree of uncertainty associated with it and would be an enormous task with respect to the areas covered within this study, a simple model was developed to take into account the potential for spills which occur at sea reaching the coastline. The model takes into account the following factors:

- Quantity of oil spilled in sea cells
- Distance and angle of sea cells from coastal cells
- Wind direction

Each of these parameters is discussed below.

Quantity of Oil Spilled in Sea Cells
The tonnage of oil spilled in each sea cell per year within UK waters was predicted (see Figure 7.1).

Distance and Angle of Sea Cell from Coastal Cell
The model assumes that the amount of oil reaching the shore (given the correct wind direction) will vary with distance as follows:

Table 7.5 Fraction of an Oil Spill at Sea Reaching the Coast

Distance from Sea Cell to Coastal Cell	Fraction of Oil Reaching Shore
0 - 10 nm	1.00
10 - 20 nm	0.50
20 - 30 nm	0.25
Over 30 nm	0.00

Wind Direction
Each cell holds wind direction data corresponding to 12 points of the compass (i.e., 30° intervals). This was broken down further to give the probability of wind direction at each 1° interval (0 to 360°).

Methodology
For each sea cell, all wind directions which would "hit" the shoreline were identified. The probability of oil reaching a specific coastal cell was then calculated by finding all the angles which would intersect with the cell (see Figure 7.2), summing the wind probability for these directions and multiplying by the annual tonnage of oil spilled in the sea cell and the fraction of oil reaching the shore (based on distance).

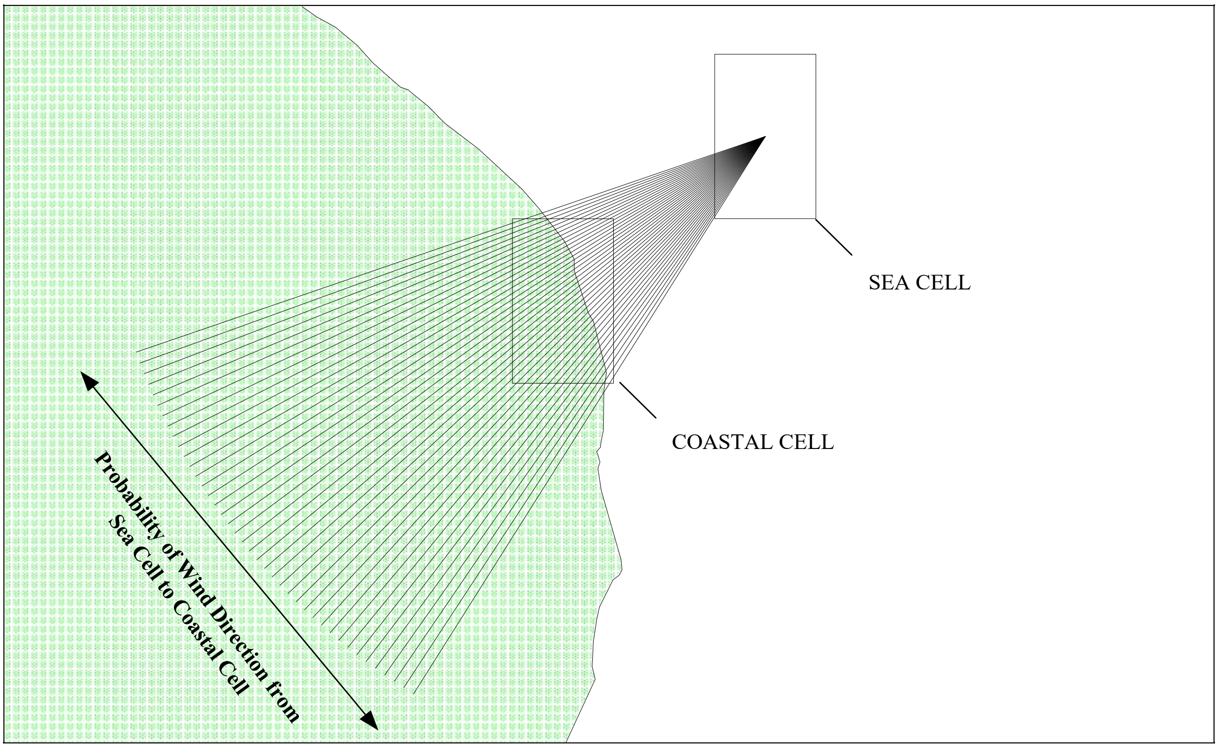

Figure 7.2 Probability of Wind Blowing Oil from Sea Cell to Coastal Cell

This is calculated for all combinations of sea to shore cells as follows:

$$T_{drift} = T_{oil} \cdot D_{fr} \cdot W_{prob}$$

where T_{drift} = Annual tonnage of oil reaching the coastal cell.
T_{oil} = Annual tonnage of oil spilled in a sea cell.
D_{fr} = Fraction of oil reaching shore based on distance from sea cell to coastal cell (from Table 7.5).
W_{prob} = Probability of wind direction from sea cell to coastal cell.

For each coastal cell, the quantity of oil contributed from all the sea cells was summed to give the total amount of oil spilled at sea which is estimated to drift into the coastal cell per annum.

The results of this model are presented in Figure 7.3.

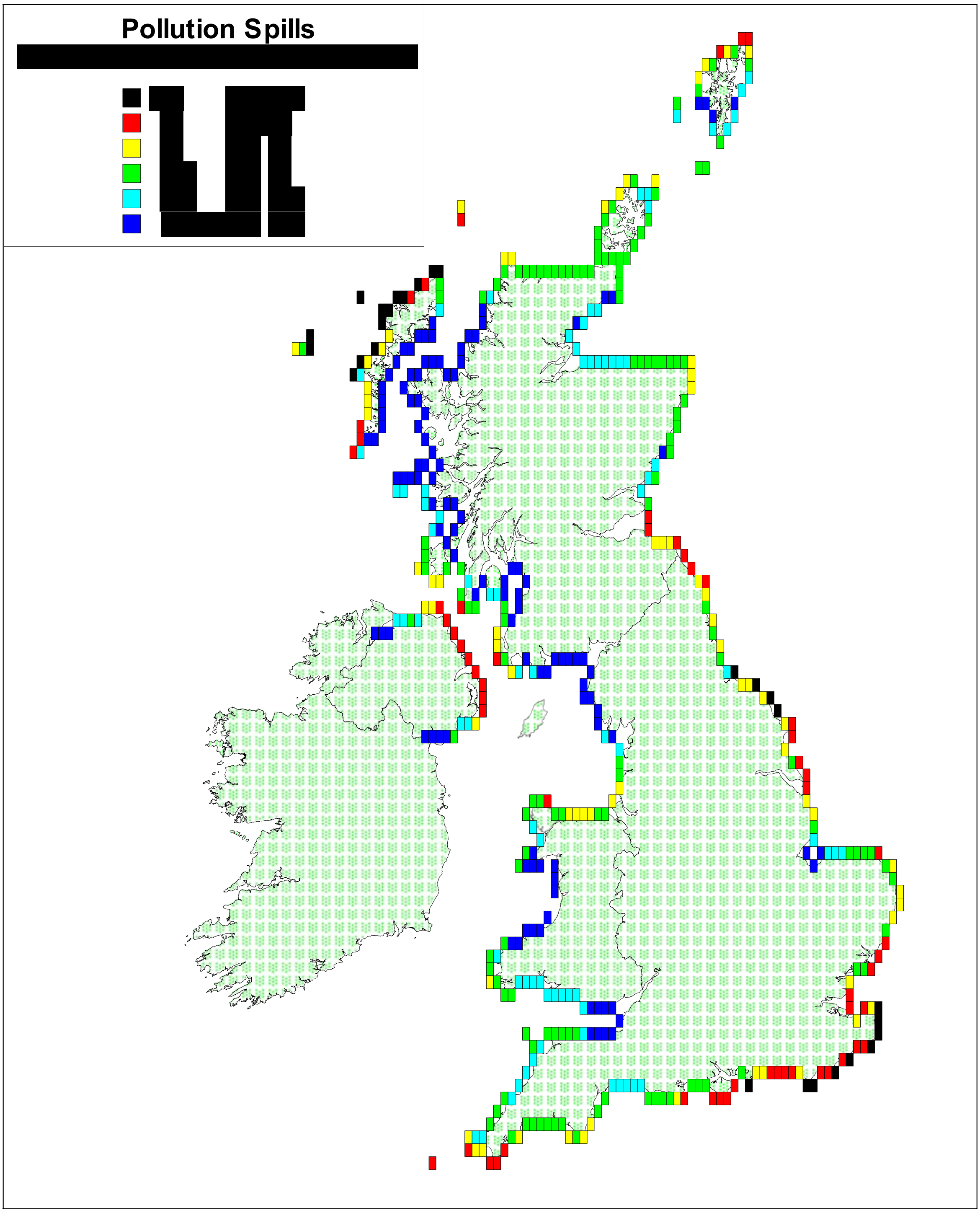

Figure 7.3 Spills from Sea Reaching the UK Coastline

It can be seen from this figure that a high proportion of the spills which occur off the North West Coast of Scotland will reach the shore on the West Coast of Lewis. Applying this model also shows an increase in the pollution risk for St Kilda.

7.5 Coastal Pollution Risk Results (All Spills)

Combining the coastal spill data with spills from sea which could reach the coast, the overall pollution sensitivity of the coastline was estimated. The following figure presents the results of this assessment.

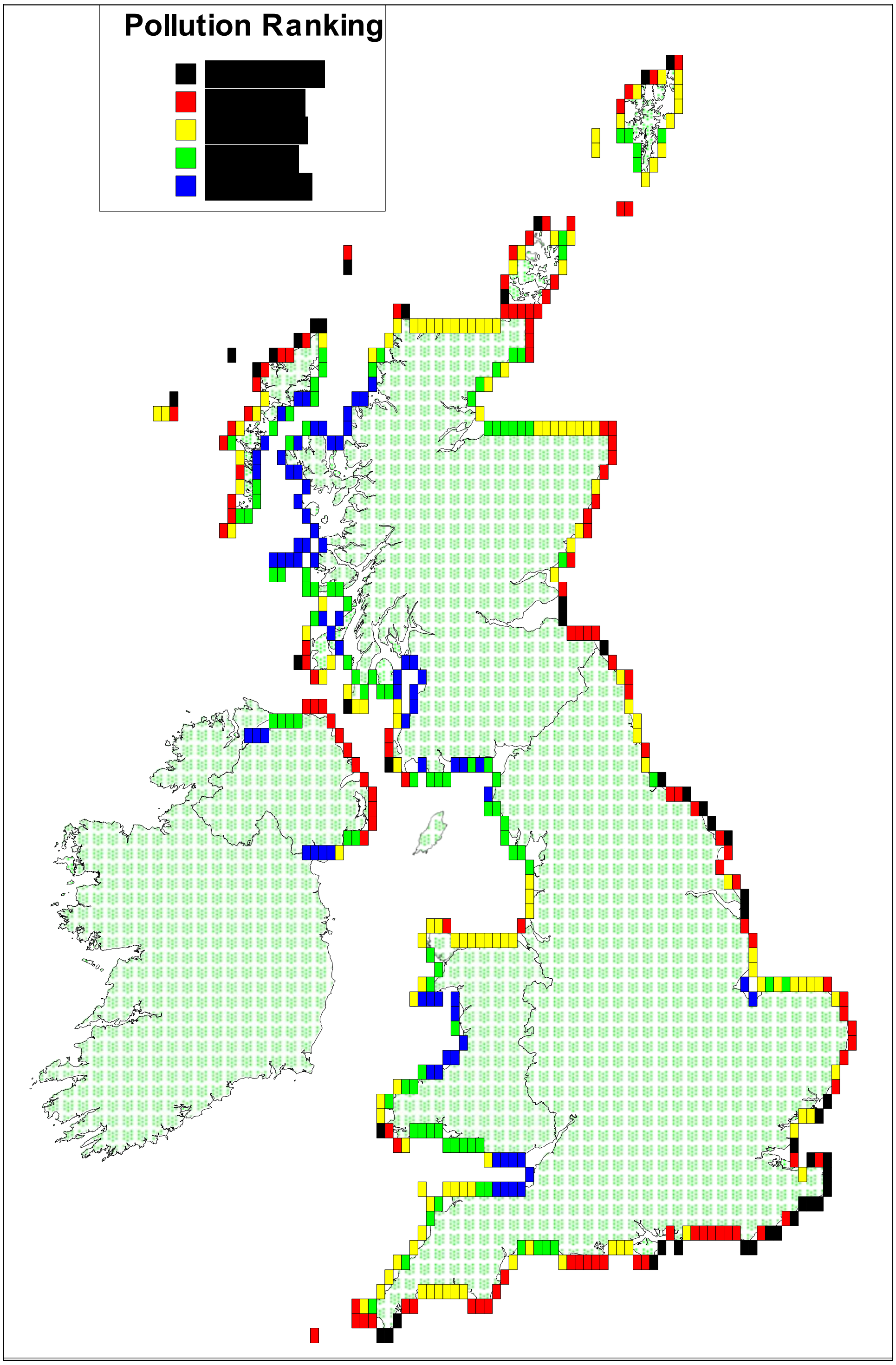

Figure 7.4 Estimated Pollution Sensitivity of the UK Coastline

From the results used to generate Figure 7.4, the following table documents the top ten coastal cell scores on pollution for the UK Coastline.

Table 7.6 Top 10 Coastal Pollution Cells on the UK Coastline

Cell No. Identifier	Location	Score
1284	Dover	295.2
1286	South Foreland	294.3
1250	Hastings	204.5
255	Flannan Isles (West Coast of Lewis)	136.2
1240	Beachy Head	131.8
373	Islay (West Coast of Scotland)	100.9
1253	Dungeness	95.8
1191	Near Whitby	90.8
1239	Beachy Head	90.5
321	Uig (West Coast of Lewis)	78.7

7.6 Validation of Results

Overall, the average amount of oil spilled in UK waters per annum predicted by the model and reported by ACOPS is presented in Table 7.7.

Table 7.7 Comparison of Annual Oil Spill Amount in UK Waters

Source	Average Annual Oil Spilled (Tonnes)
Model	12,500
ACOPS	16,200

Therefore, the model underestimates the average quantity of oil spilled from marine accidents per annum within UK waters by 20% compared to the ACOPS data for 1989-1998 (full details of the ACOPS data is presented in Appendix 3). However, this is mainly due to two large spills during this period from Braer (84,000 tonnes in 1993) and Sea Empress (72,000 tonnes in 1996). These two large spills dominate the ACOPS figure, hence, it is considered that the model predictions are a reasonable estimate.

The geographical distribution of spills from the ACOPS data is presented in Figure 7.5. It can be seen that historically the highest density of spills have occurred in the English Channel, The Wash and Humber Estuary, Liverpool Bay and Shetland Islands. The model predictions in Figure 7.4 compare well with the ACOPS plot, although spills in the waters to the South of the Shetland Islands are underestimated.

Overall, it is considered that the model provides a good representation of the historical geographical distribution of oil spills, although it is acknowledged that 10 years data is insufficient for a detailed comparison, based on the low frequency of the events which are being predicted.

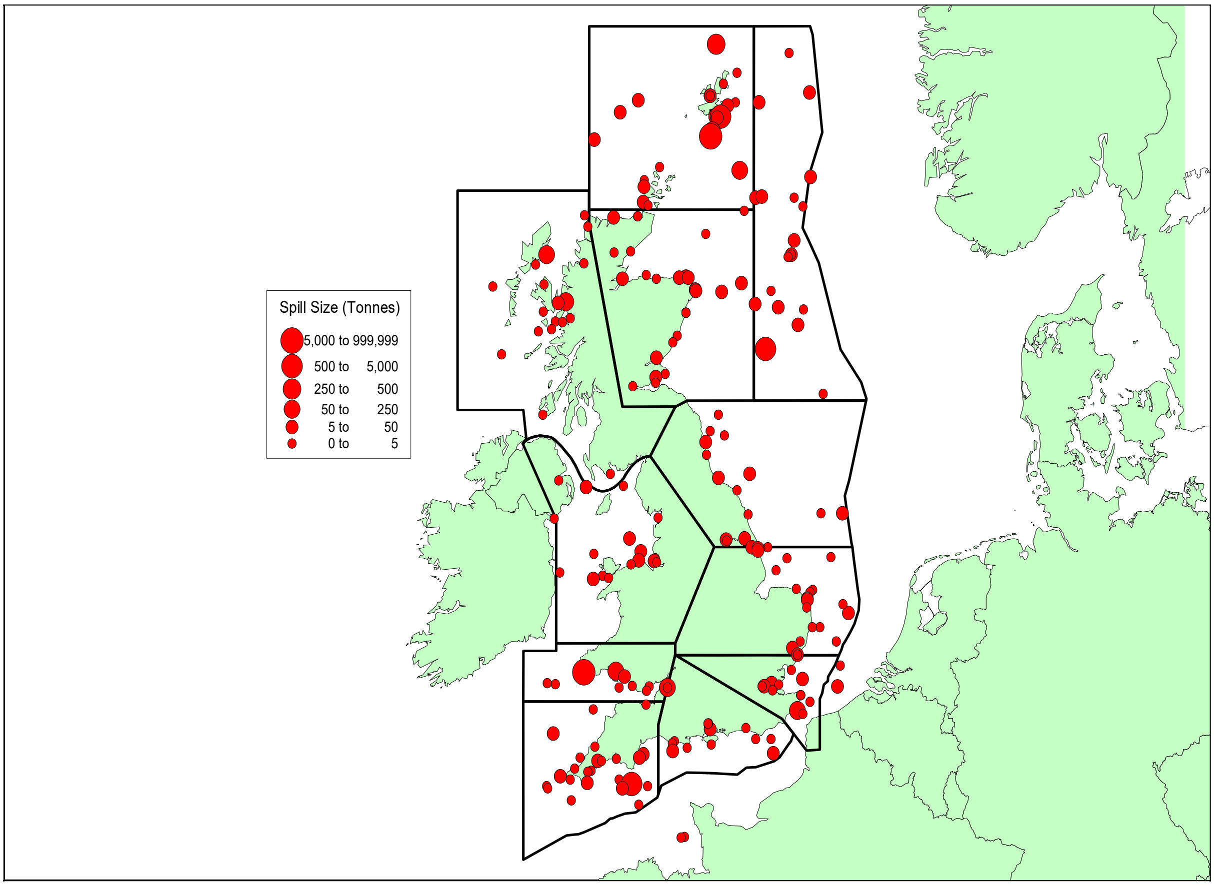

Figure 7.5 Plot of the Reported Oil Spills within UK Waters (ACOPS, 1989 – 1998)

8 ENVIRONMENTAL SENSITIVITY

8.1 Introduction

Following assessment of the likelihood of an accident leading to pollution in UK waters or in the vicinity of the coastline, the MEHRA's initiative requires the identification of the sensitivity of both the UK coastline and surrounding waters to a spill, taking into account environmental, social, cultural, economic as well as scientific and educational factors. This section describes the methodology applied as well as the results generated in terms of the sensitivity of both the coastline and sea areas.

8.2 Methodology

This section describes the methodology used to identify and rank environmentally sensitive areas around the UK. The system which was devised with the assistance of JNCC and the DETR was designed to be as objective as possible, with a scoring system used to allocate "points" to different sites based on a number of different criteria.

When assessing sensitivity, the Donaldson report (cfr Section 1) recommended that regard be given to the following environmental considerations:

a) existence of wildlife feeding or breeding sites of international significance or the presence of biological communities of either flora or fauna or both or particular interest or rarity: designation as a Special Protection Area under the EC Birds Directive or any area of special conservation under the Habitats Directive will normally be regarded as evidence of this.

b) the existence of commercially exploitable biological resources and mariculture sites; and

c) the extent to which the area provides a public recreational amenity.

These general considerations were expanded upon using guidelines devised by IMO for identifying Particularly Sensitive Sea Areas (PSSA) (Ref. 7). These are marine areas that require special protection because of their vulnerability to environmental damage by maritime activities. The current guidelines allow areas to be designated a PSSA if they qualify in any one of three categories which include ecological characteristics, social-cultural-economic and scientific-educational criteria. There are currently two designated PSSA's in the World:

- Great Barrier Reef, Australia
- Sabana-Camaguey Archipelago, Cuba

When an area is approved as a PSSA, specific measures can be used to control maritime activities in that area, such as ship routeing measures and installation of Vessel Traffic Services (VTS). Although the Marine Environmental Protection Committee of IMO are currently reviewing the guidelines for PSSA designation to further consider the relationship between environmental, ship safety and navigational aspects it is apparent that there are clear similarities with the UK concept of MEHRA's. Therefore, the criteria used to identify PSSAs were considered to provide a useful and objective measurement of environmental sensitivity for the UK coastline.

To be identified as a PSSA, at least one of the following criteria must be met.

Table 8.1 Description of PSSA Criteria

PSSA Criteria	Description
	Ecological Criteria
Uniqueness	An area is unique if it is "the only one of its kind", e.g., habitats of endangered species.
Dependency	Ecological processes of such areas are highly dependent on biologically structured systems, e.g., coral reefs, mangrove forests. Such biotically structured ecosystems often have high diversity, which is dependent on the structuring organisms. Dependency also includes areas representing the migratory routes of marine fish, reptiles, birds and mammals.
Representativeness	These areas have highly representative ecological processes, or community or habitat types or other natural characteristics. Representativeness is the degree to which an area represents habitat type, ecological processes, biological community, physiographic feature or other natural characteristics.
Diversity	These areas have a high variety of species or include highly varied ecosystems, habitats, communities and species.
Productivity	The area has high natural productivity. Production is the net result of biological processes which result in an increase in biomass in areas of high natural productivity such as oceanic fronts and upwelling areas.
Naturalness	The area has a high degree of naturalness, as a result of the lack of human-induced disturbance or degradation.
Integrity	The area is a biologically functioning unit, an effective, self-sustaining ecological entity.
Vulnerability	The area is susceptible to degradation by natural events or the activities of people.
Social-Cultural-Economic Criteria	
Economic Benefit	The area is of particular importance to utilisation of living marine resources.
Recreation	The area has special significance for recreation and tourism.
Human Dependency	The area is of particular importance for the support of traditional subsistence and/or cultural needs of the local human population.
Scientific-Educational Criteria	
Research	The area has high scientific interest.
Baseline and Monitoring Studies	The area provides suitable baseline conditions with regard to biota or environmental characteristics.
Education	The area offers opportunity to demonstrate particular natural phenomena.
Historical Value	The area has historical and/or archaeological significance.

The methodology chosen was to identify sites in the UK and surrounding waters which have been designated under International, National and statutory legislation after having undergone a rigorous assessment process and as such include all of the criteria outlined in Table 8.1. A further evaluation of a large number of the designations selected was carried out by JNCC, where they reviewed sites to assess if they were sensitive to marine pollution. This evaluation considered factors such as:

- Whether a site is inter-tidal or sub tidal,
- If a site has been selected for coastal lagoon, shellfish, other benthic species, marine birds mammals or fish, and;
- Terrestrial sites designated for marine birds and/or seals.

To assist in the identification and ranking of the UK coastline environmental sensitivities, a GIS database of environmentally sensitive protected sites within coastal areas of the UK was compiled.

A sample of the data held within the GIS system is presented in Figure 8.1 to Figure 8.3. A full description of the types of sites considered in the assessment and their locations on the UK coast and in UK waters is provided in Appendix 4.

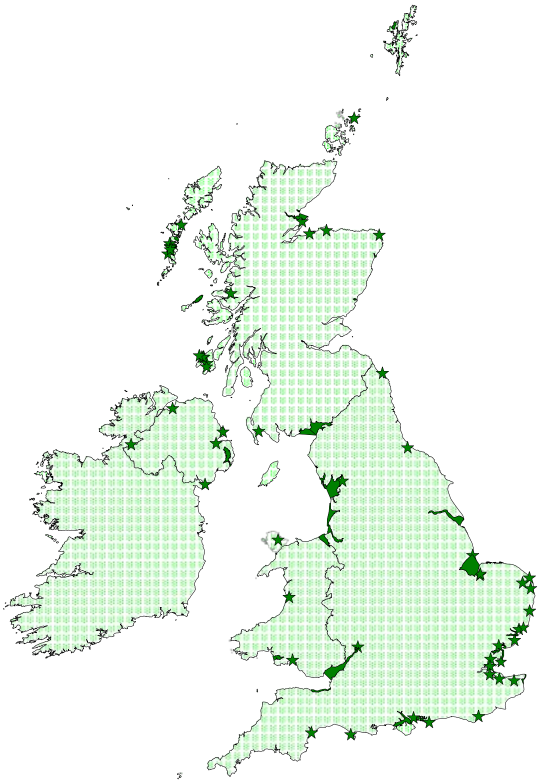

Figure 8.1 Ramsar Sites (Source: Scottish Natural Heritage (1998), JNCC (1999), World Conservation Monitoring Centre (1999))

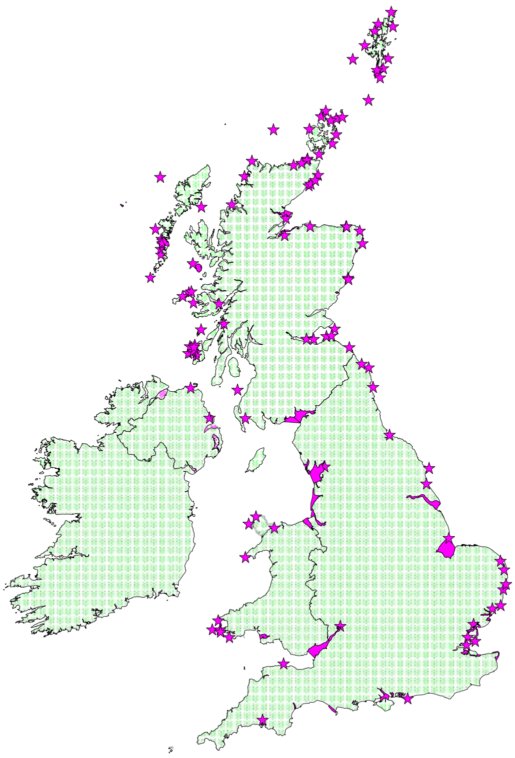

Figure 8.2 Special Protection Areas (Source: JNCC (1998))

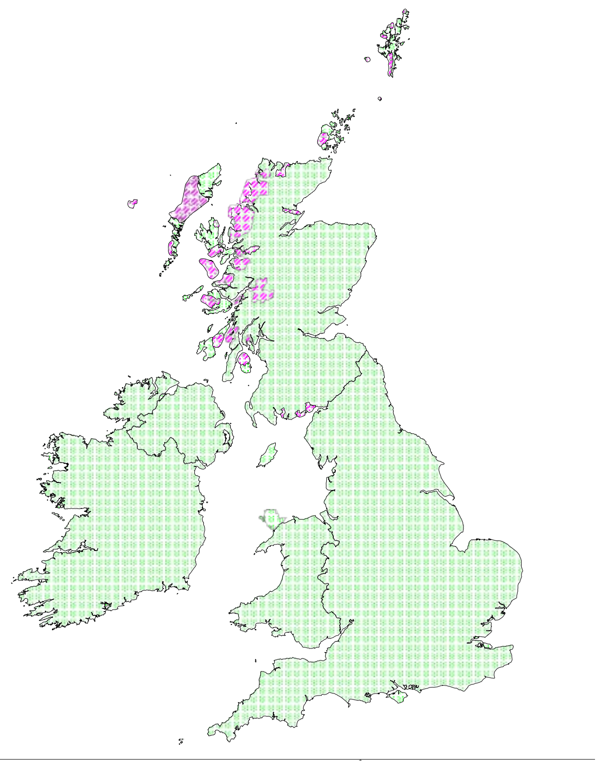

Figure 8.3 National Scenic Areas (Source: Scottish Natural Heritage (1998), World Conservation Monitoring Centre (1999))

To rank the sites in terms of environmental significance, a points system has been applied. The scoring system was developed through discussions with JNCC, with higher points being allocated to designations with a higher sensitivity to marine pollution.

A full list of the scores for protected sites in the UK is presented in the following table.

Table 8.2 Scores for Different Designations

Nature of Importance	Designation	Score
Wildlife	World Heritage Site (Biological)	5
	Biosphere Reserve	5
	Ramsar Site	5
	Special Protection Area (SPA)	5
	Special Area of Conservation (SAC)	5
	Site of Special Scientific Interest (SSSI)	3
	Area of Special Scientific Interest (ASSI NI) & ASIs	3
	National Nature Reserve (NNR)	3
	Marine Nature Reserve (MNR)	3
	Local Authority Nature Reserve (LANR NI)	1
	Local Nature Reserve (LNR)	1
	Sensitive Marine Area (SMA)	1
Seabird Vulnerability	Vulnerability of Offshore Seabirds (*)	5, 3 or 1
Fishing	Fish Farms (**)	3, 2 or 1
	Shrimp/Nephrops Fishing Areas	3
	Shell Fish Production Areas	1
	Shellfish Waters	1
Amenity/Economy	Country Park (CP)	1
	Blue Flag Beach	1
	Blue Flag Marina	1
	Preferred Conservation Zone (PCZ)	1
Landscape	National Park (NP)	3
	Area of Outstanding Natural Beauty (AONB)	3
	National Scenic Area (NSA)	3
	Environmentally Sensitive Area (ESA)	1
	Heritage Coast	1
	Regional Landscape Designation (RLD)	1
Geological	World Heritage Site (Geological)	3
	Geological Conservation Review (GCR)	1
	Earth Science Conservation Review (ESCR NI)	1

(*) Seabird vulnerability to oil pollution scores are weighted based on sensitivity scoring from JNCC:

High	5
Medium	3
Low	1

(**) Fish farm scores are weighted based on density as follows:

High	3
Medium	2
Low	1

The GIS programme calculates scores for each cell around the UK coastline and all sea cells in UK waters based on the methodology outlined in the following table:

Table 8.3 Scoring Methodology for Environmental Sensitivity of UK Coastline & Sea Areas

Nature of Importance	Methodology	Example Sites Within a Cell	Cell Score
Wildlife	Only the highest scoring site located within a cell scores.	1 WHS (ecological), 1 SPA, 1 SSSI, 1 LNR.	5
Seabird Vulnerability	One score per cell.	High ranking	5
Fishing	Each criteria identified within a cell scores and scores are added.	High density fish farming, and shellfish waters.	4
Amenity/Economy	Each criteria identified within a cell scores and scores are added.	2 blue flag beaches, 1 blue flag marina and 1 country park	3
Landscape	Only the highest scoring site located within a cell scores.	1 AONB, 1 NP and 1 ESA.	3
Geological	Only the highest scoring site located within a cell scores.	1 WHS (geological) & 1 ESCR site.	3
Total	N/A	N/A	23

It is noted that if a coastal cell has more than one of a given type of protected site, e.g., Biosphere Reserve, the points are only added once. This is based on the fact that the sites vary in terms of size, therefore, a large site in one cell may be equivalent in area to three smaller sites in another cell. The only exception to this was for fish farms where the points are weighted based on the number of fish farms within a cell. Using this methodology, all cells around the UK coast and in sea areas have been awarded a points score to represent sensitivity based on the types of designated sites within their geographical boundaries. Applying the methodology outlined in Table 8.3, theoretically the maximum score which any cell can have will be 28.

8.3 Results of Sensitivity Assessment

Based on the methodology outlined in the previous section, each cell on the UK coastline and in the sea areas has been given a score, following which the cells were colour-coded based on environmental sensitivity. The results of the sensitivity ranking for the coastal cells and the sea areas are presented in the following sub-sections.

8.3.1 Sensitivity of Coastal Cells

Based on the methodology outlined in Section 8.2, sensitivity scores have been generated for coastal cells. Table 8.4 presents the ranking which has been carried out for the coastal cells.

Table 8.4 Outline of Sensitivity Ranking of UK Coastline

Ranking	Colour Code	No. of Points	Percentage of Cells
Very High (HH)	Black	>16	9%
High (H)	Red	13-16	21%
Medium (M)	Yellow	11-13	21%
Low (L)	Green	8-11	27%
Very Low (LL)	Blue	1-8	19%

Therefore, the top 9% most environmentally sensitive areas around the UK coastline have been identified and are coloured black in Figure 8.4.

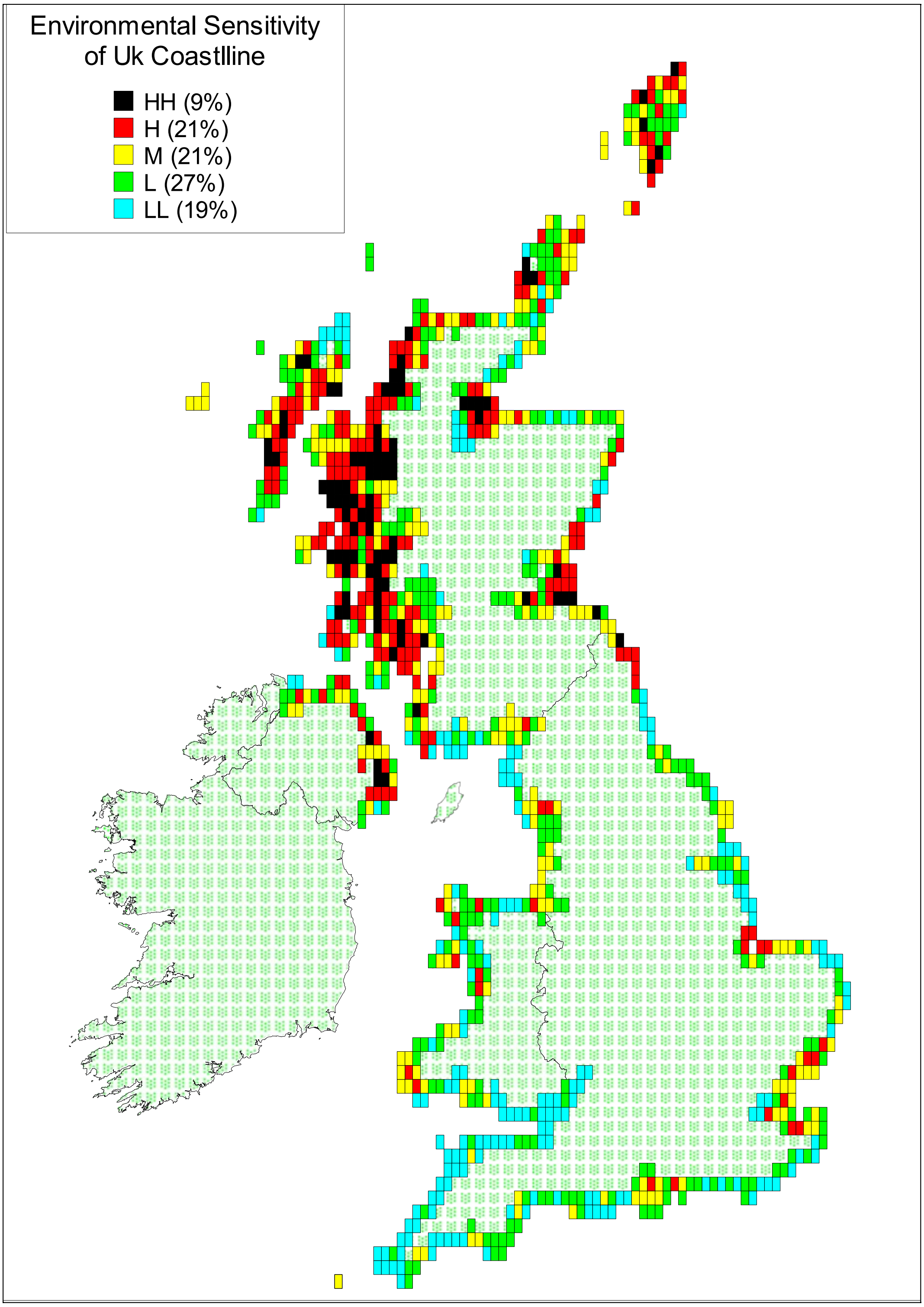

Figure 8.4 Environmental Sensitivity Ranking of UK Coastline

From the figure it can be seen that the main areas of very high environmental sensitivity around the UK coastline are around the West Coast of Scotland. Details of the top 10 coastal sensitivity sites in the UK are presented in the following table.

Table 8.5 Top Coastal Sensitivity Scores for UK

Cell No. Identifier	Location	Score
7603	East Coast of Isle of Mull (adjacent to Firth of Lorn & Loch Linnhe)	22
9655	Near Kinlochbervie on West Coast of Scotland	21
8498	Adjacent to Loch Kishorn & Kyle of Lochalsh (West Coast of Scotland)	20
8499	Adjacent to Loch Kishorn & Kyle of Lochalsh (West Coast of Scotland)	20
9140	Priest Island near Ullapool (West Coast of Scotland)	20
8743	Lochmaddy in North Uist (Western Isles)	20
7985	Sound of Arisaig (West Coast of Scotland)	19
7600	Loch na Keal on the West Coast of Mull	19
7599	Ulva off West Coast of Mull	19
7604	Lismore & Kerrera near Mull	19

The highest score of 22 is for a shore cell on the East Coast of the Isle of Mull adjacent to the Firth of Lorn and Loch Linnhe. The following table presents details of the different factors that contribute to the sensitivity of this area.

Table 8.6 Coastal Sensitivity For Cell No. 7603 Near Mull on West Coast of Scotland

Category	Sites Within Category or Ranking	Score
Wildlife	1 Special Protection Area (SPA)	5
	1 Site of Special Scientific Interest (SSSI)	
Seabird Vulnerability	Ranking is high	5
Fishing	Fish farm density is medium	2
	Nephrops fishing area	3
	Shellfish production area	1
	Shellfish waters	1
Amenity/Economy	1 Preferred Conservation Zone (PCZ)	1
Landscape	1 National Scenic Area (NSA)	3
	1 Environmentally Sensitive Area (ESA)	
Geological	1 Geological Conservation Review Site (GCR)	1
Total		22

A selection of highly sensitive areas around the UK coastline are shown in more detail from Figure 8.5 to Figure 8.15.

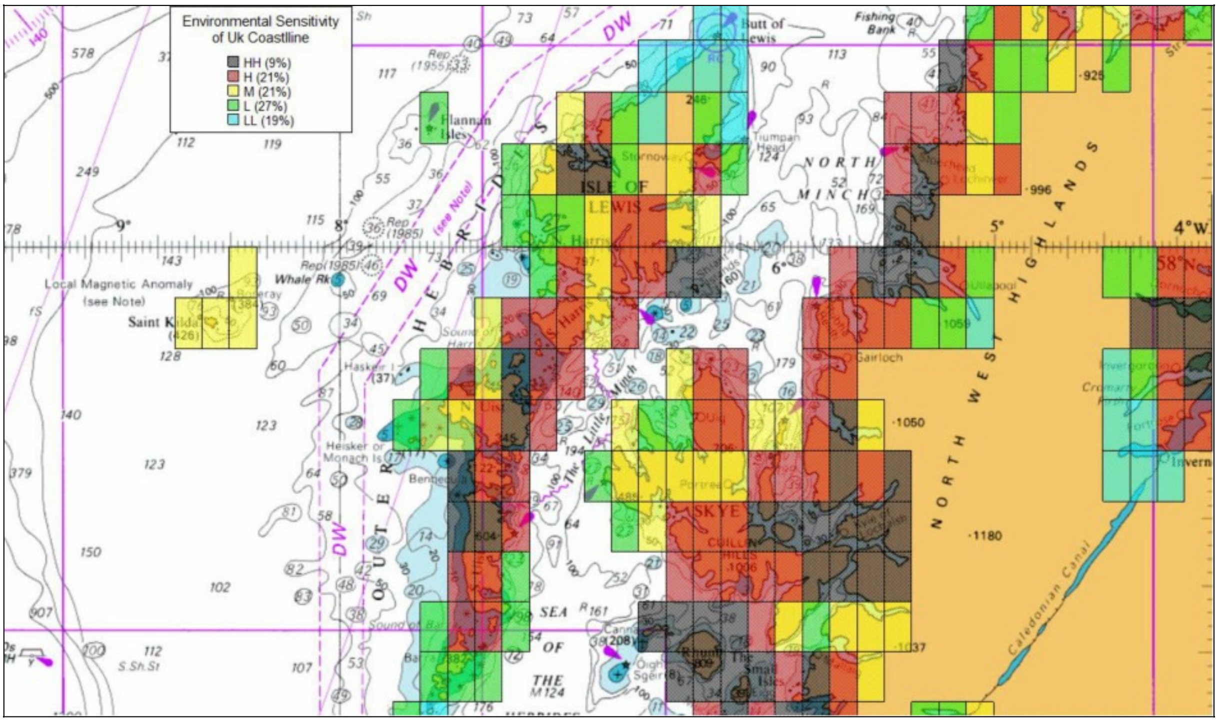

Figure 8.5 Environmental Sensitivity for the North West Coast of Scotland

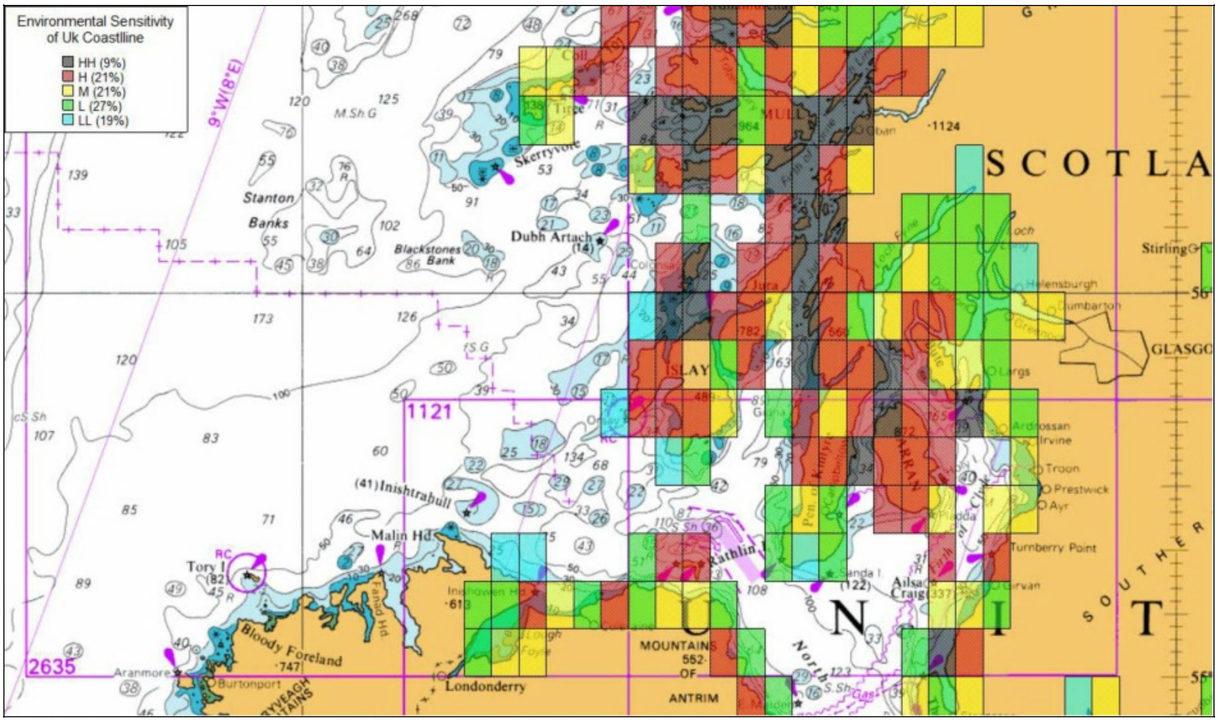

Figure 8.6 Environmental Sensitivity for West Coast of Scotland & N. Ireland

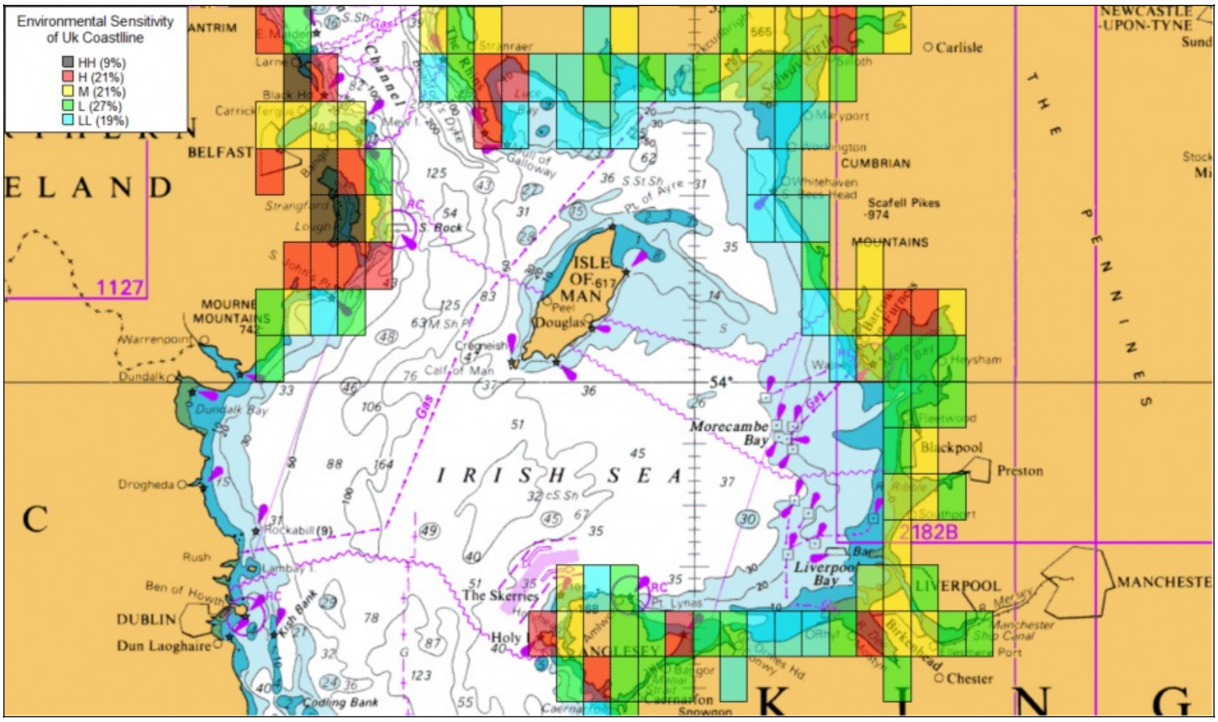

Figure 8.7 Environmental Sensitivity for Irish Sea Coast

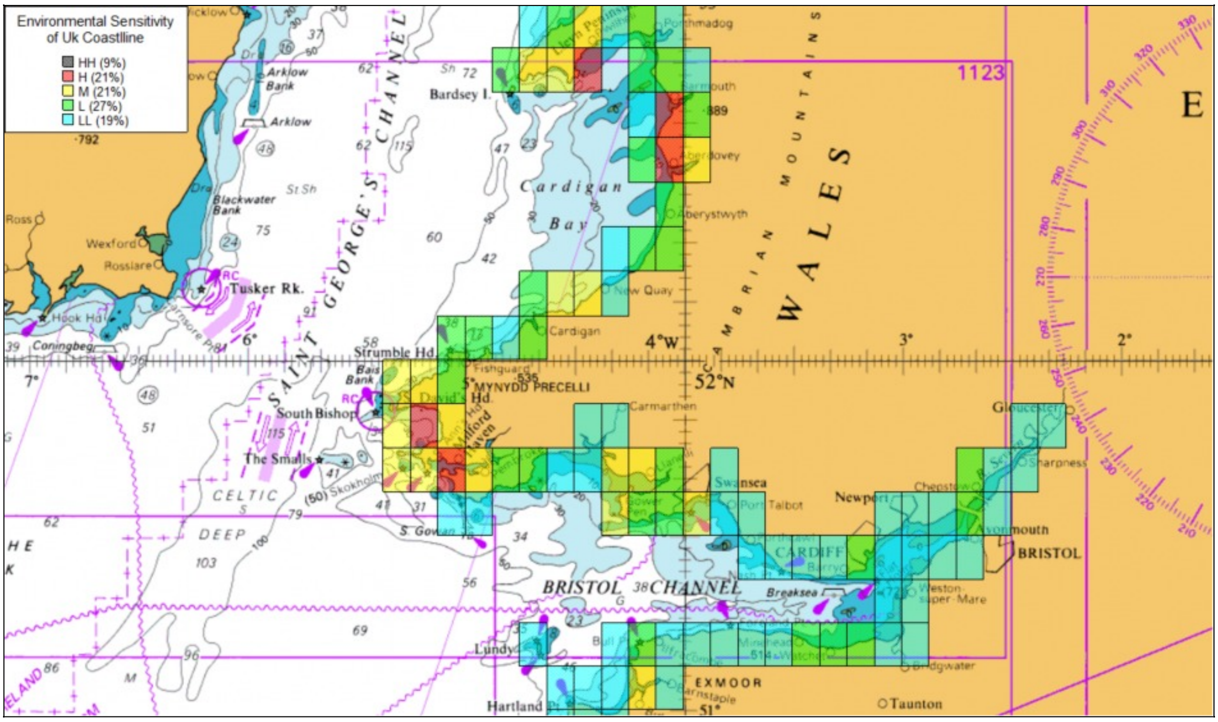

Figure 8.8 Environmental Sensitivity for St. George's Channel & Bristol Channel

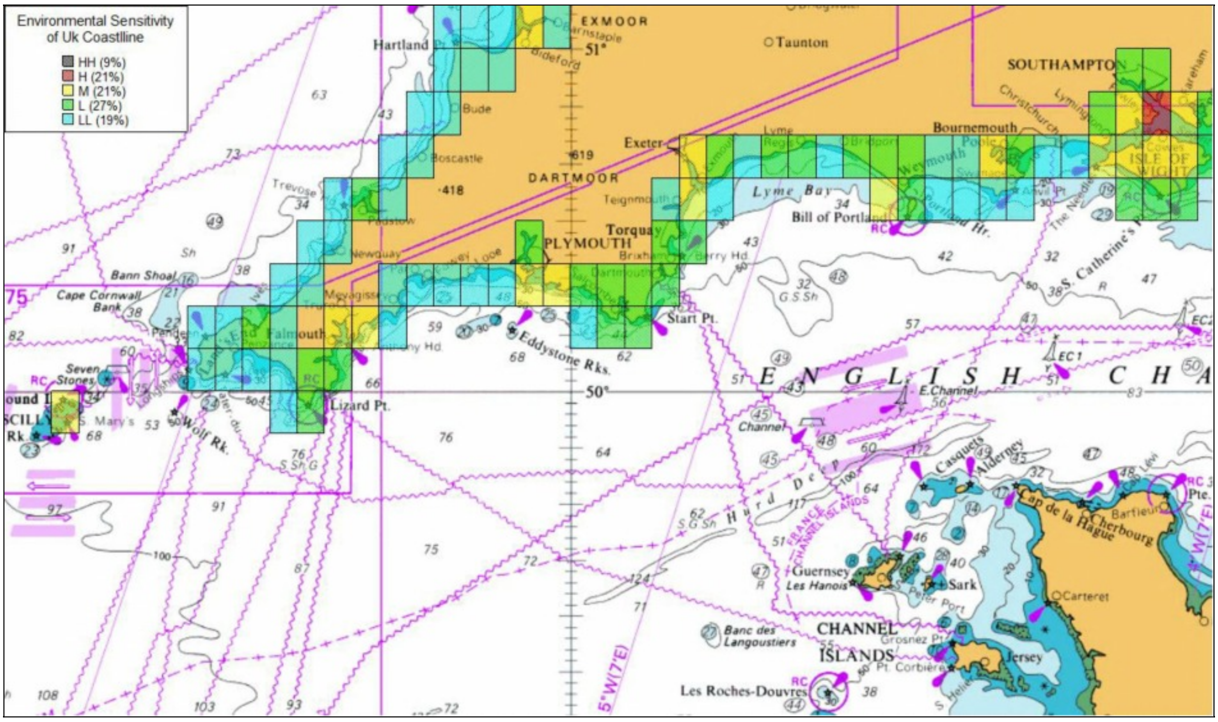

Figure 8.9 Environmental Sensitivity for the South West Coast of England

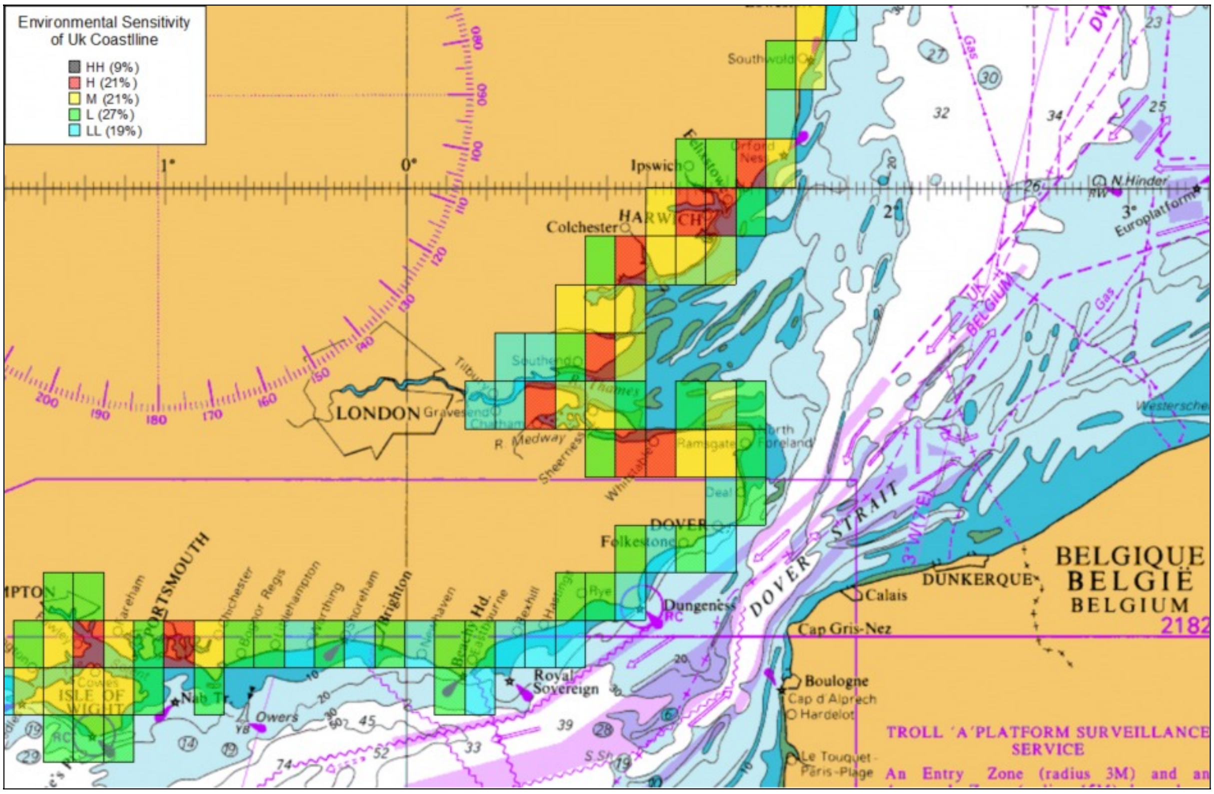

Figure 8.10 Environmental Sensitivity for the South East Coast of England

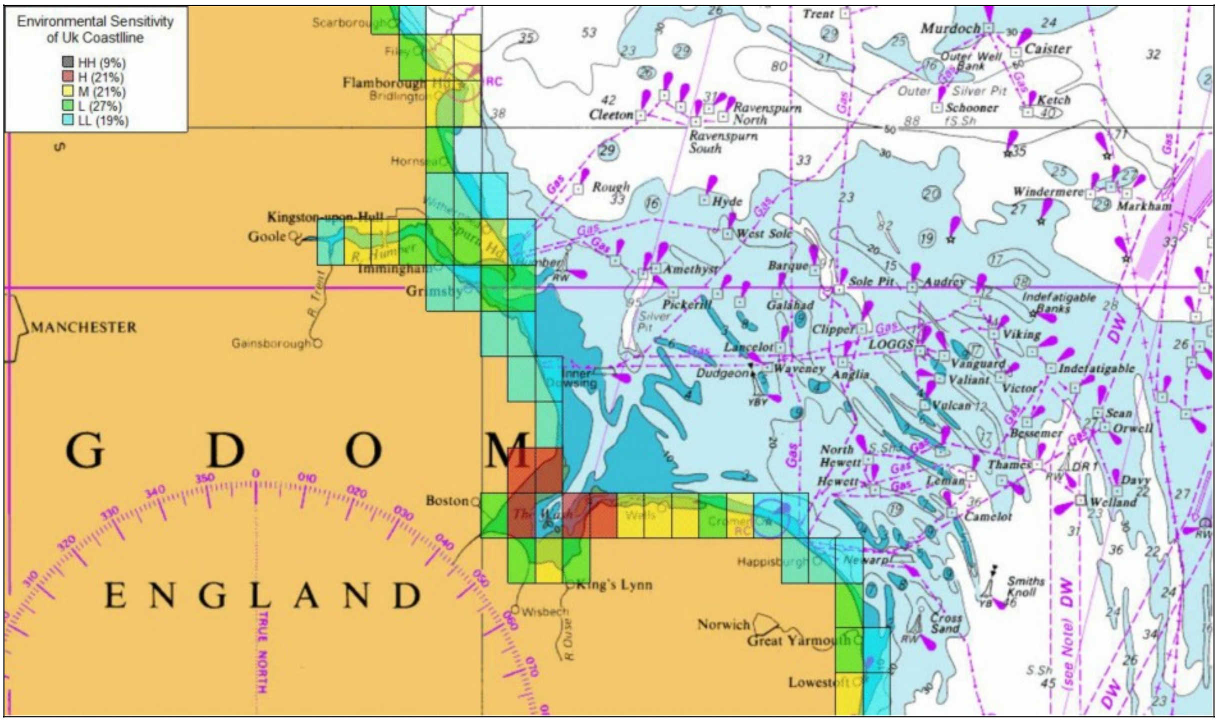

Figure 8.11 Environmental Sensitivity of East Coast of England

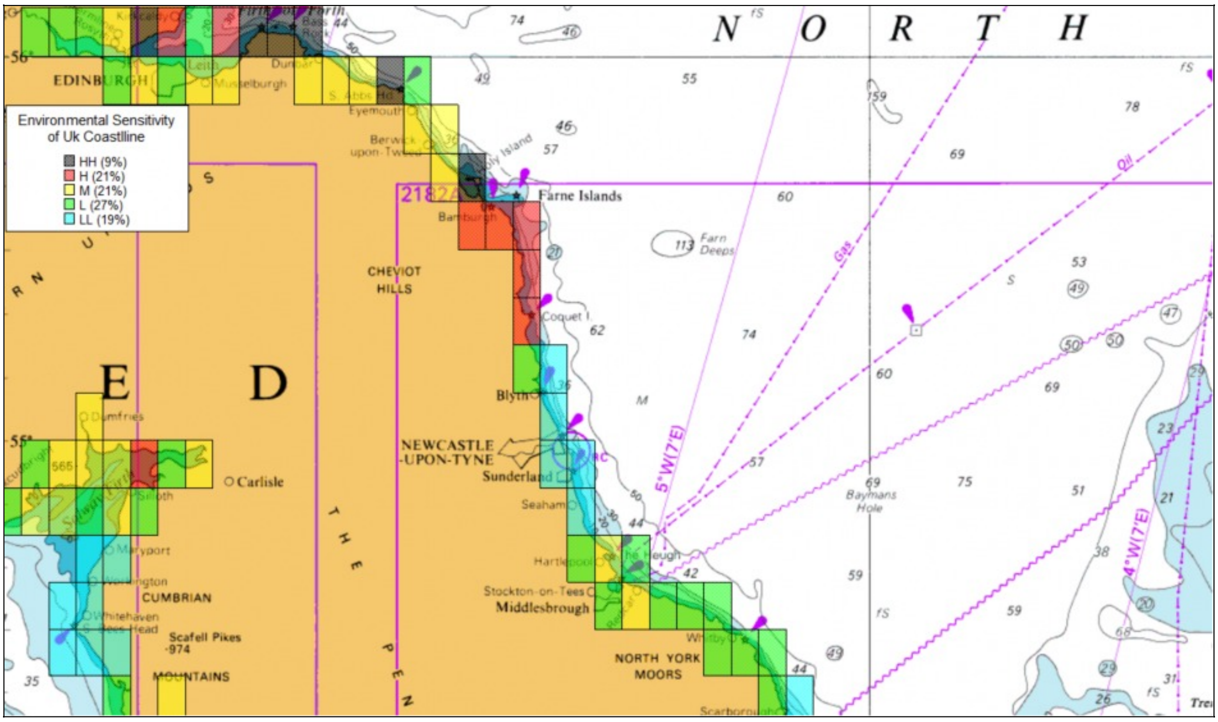

Figure 8.12 Environmental Sensitivity for Northern England & Southern Scotland

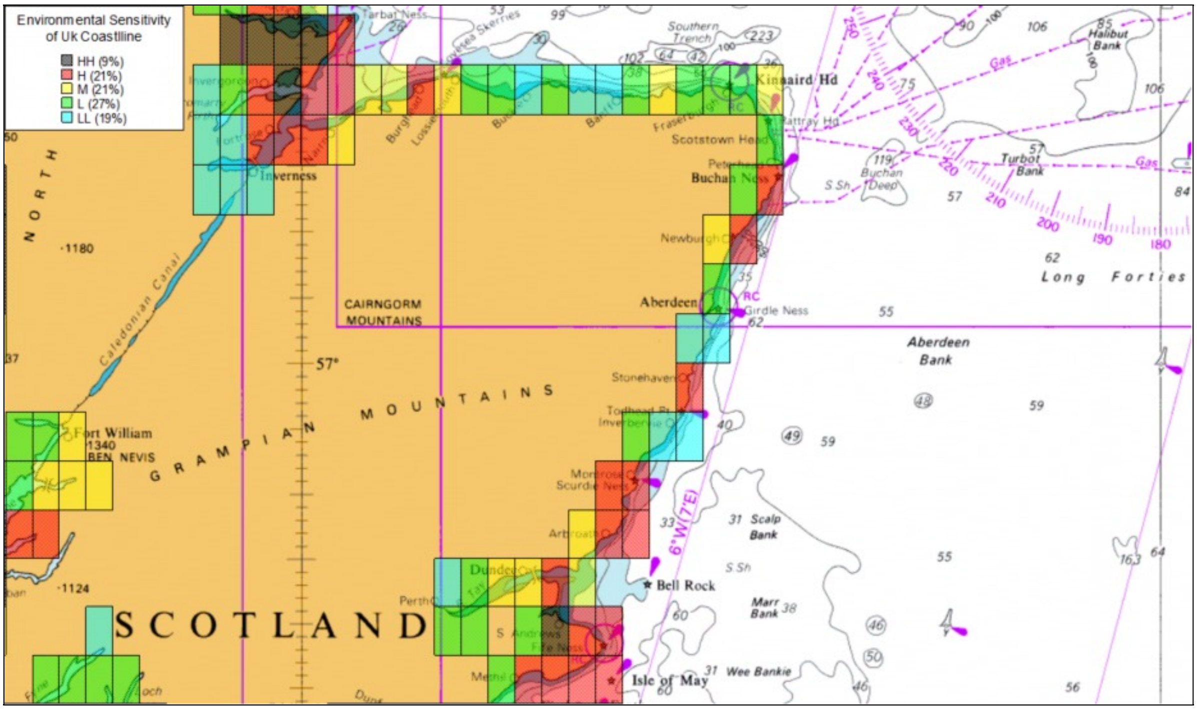

Figure 8.13 Environmental Sensitivity for North East Scotland and Moray Firth

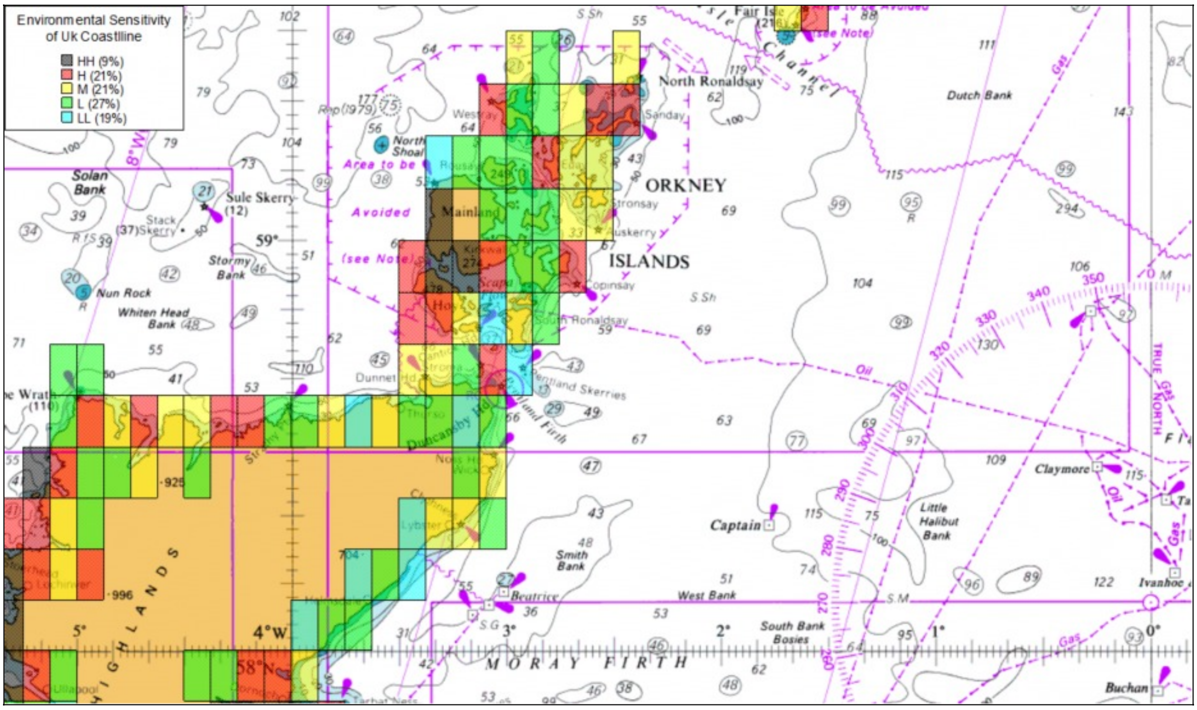

Figure 8.14 Environmental Sensitivity for North of Scotland & Orkney

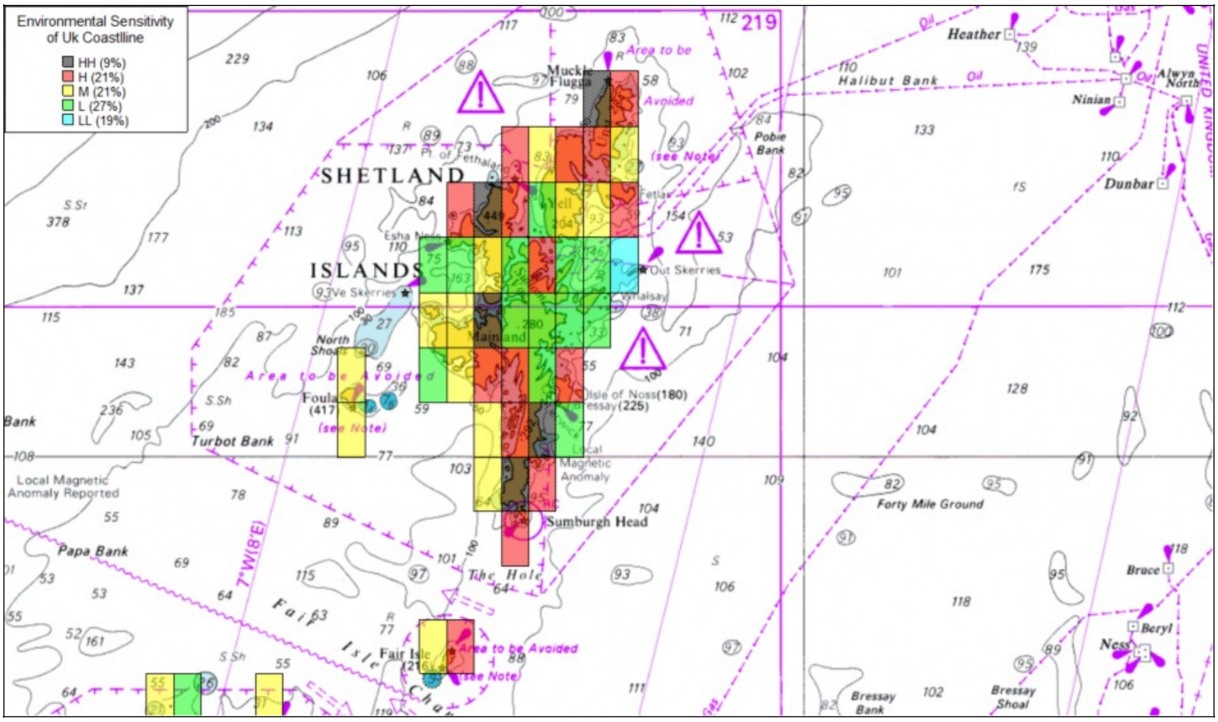

Figure 8.15 Environmental Sensitivity for Fair Isle & Shetland Islands

8.3.2 Sensitivity of Sea Cells

As with the coastal cells, the areas of open sea around the UK have also been ranked on sensitivity. The open sea areas cannot score on as many criteria as coastal cells, therefore, it is not possible for a sea cell to score as highly as a coastal cell. The sensitivity ranking is presented in Table 8.7. It should be noted that for presentation purposes only 1% of the sea cells have been given the very high ranking given the much larger area covered by these cells.

Table 8.7 Outline of Sensitivity Ranking of Sea Cells in UK Waters

Ranking	Colour Code	No. of Points	% of Cells
Very High (HH)	Black	>9	1%
High (H)	Red	6-9	8%
Medium (M)	Yellow	5-6	18%
Low (L)	Green	2-5	23%
Very Low (LL)	Blue	1-2	48%

A plot of the environmental sensitivity of the sea cells is presented in Figure 8.16.

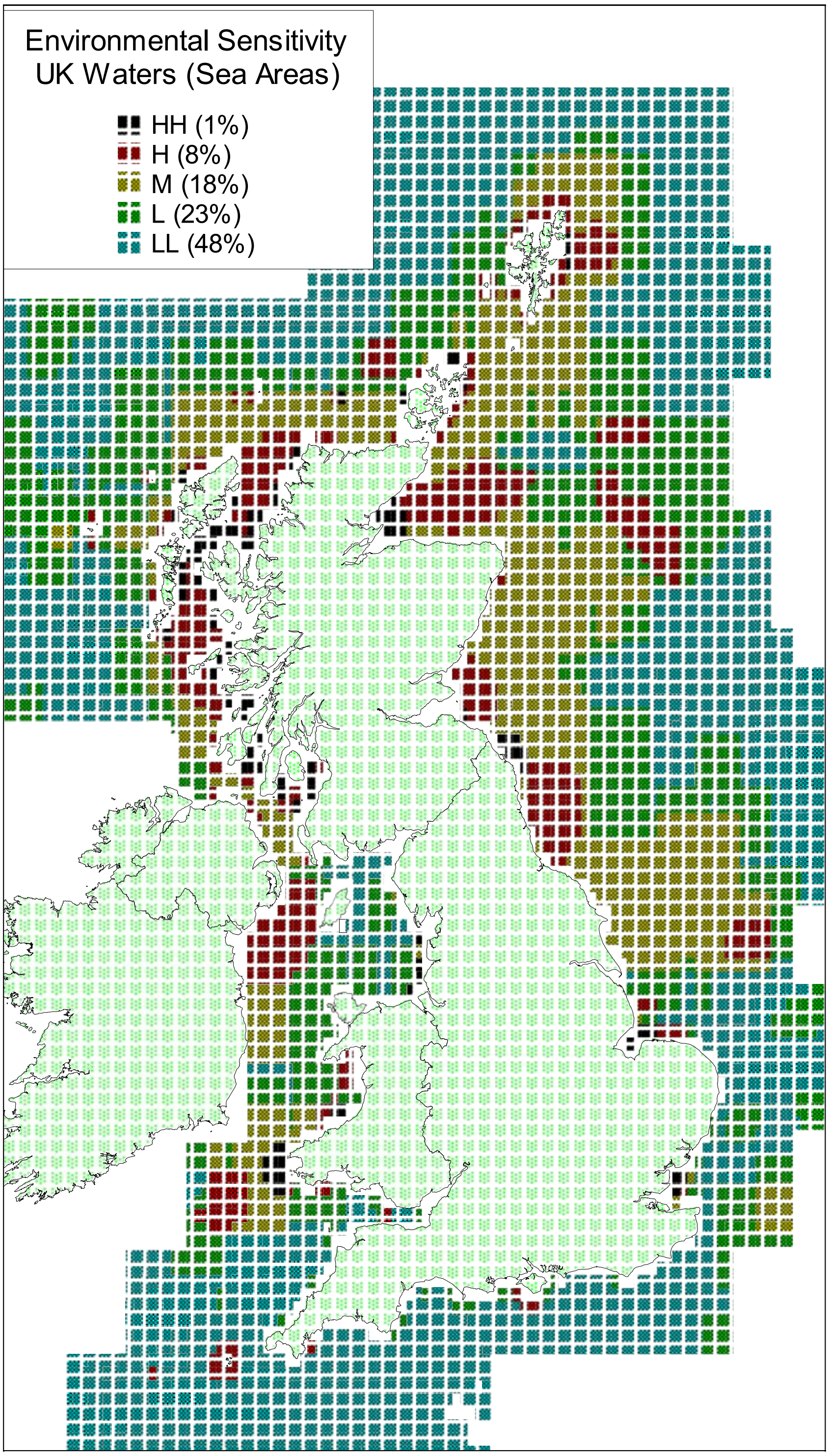

Figure 8.16 UK Sea Cells Ranked by Environmental Sensitivity

From the figure it can be seen that there is a distribution of sea areas of very high environmental sensitivity throughout the UK (e.g. Moray Firth, The Wash, West Wales, Orkney, Shetland and The Minches). Details of the top 10 sea area sensitivity sites in UK waters are presented in the following table.

Table 8.8 Top Sea Area Environmental Sensitivity Scores for UK

Cell No. Identifier	Location	Score
8108	Near the Isle of Rhum on the West Coast of Scotland	14
9138	Near Gairloch on the West Coast of Scotland	14
4067	The Wash near the North Norfolk Coast	13
9396	Adjacent to Lochinver (West Coast of Scotland)	13
9157	Tarbat Ness near Dornoch (Moray Firth on East Coast of Scotland)	13
9156	Tarbat Ness near Dornoch (Moray Firth on East Coast of Scotland)	13
4196	The Wash off the Coast of Lincolnshire	13
9783	Near Cape Wrath on the West Coast of Scotland	12
9284	Near Helmsdale (Moray Firth on East Coast of Scotland)	12
9268	Near Lochinver in The Minches (West Coast of Scotland)	12

The highest score of 14 is shared by two cells, both on the West Coast of Scotland. For Cell No. 8108 near the Isle of Rhum, the following table presents details of the different factors that contribute to the sensitivity of this area.

Table 8.9 Environmental Sensitivity For Cell No. 8108 Near Rhum on West Coast of Scotland

Category	Sites Within Category or Ranking	Score
Wildlife	1 Site of Special Scientific Interest (SSSI)	3
Seabird Vulnerability	Ranking is high	5
Fishing	Nephrops fishing area	3
Amenity/Economy	N/A	0
Landscape	1 National Scenic Area (NSA)	3
Geological	N/A	0
Total		14

It can be seen from the results presented that with the maximum score for a sea cell being 14, no sea cells score as highly as the top 10% of coastal cells.

A selection of highly sensitive areas around the UK coastline are shown in more detail from Figure 8.17 to Figure 8.25.

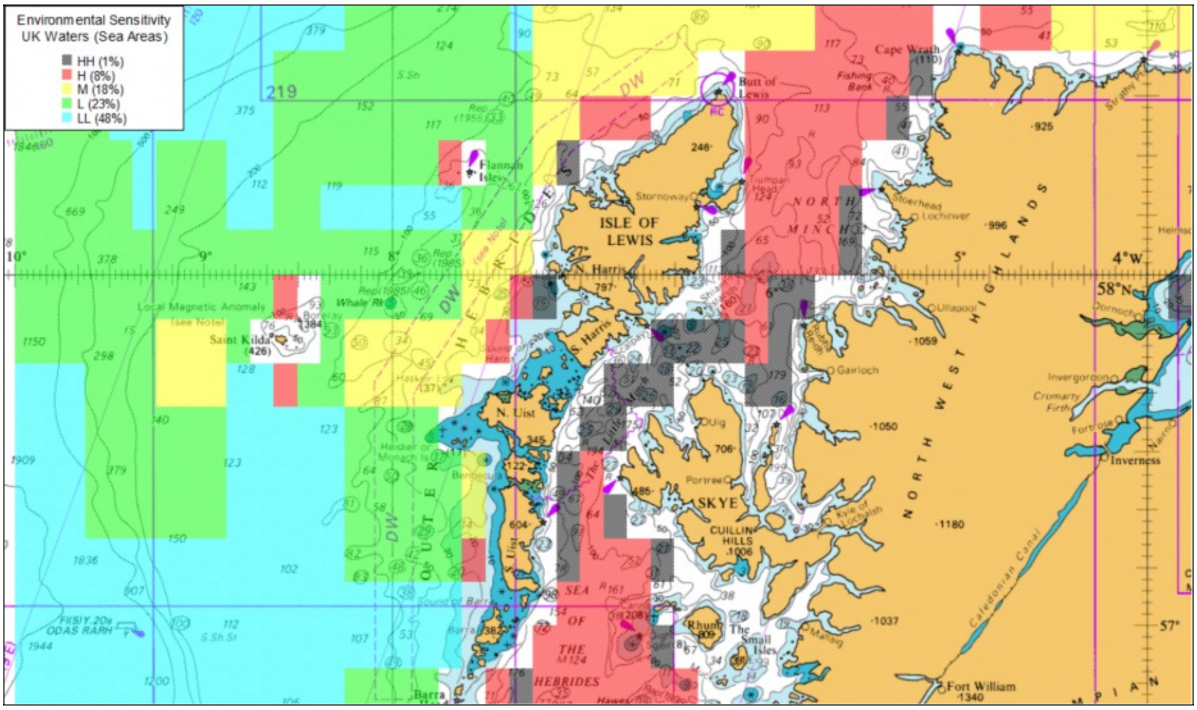

Figure 8.17 Environmental Sensitivity of Sea Areas in the Western Isles

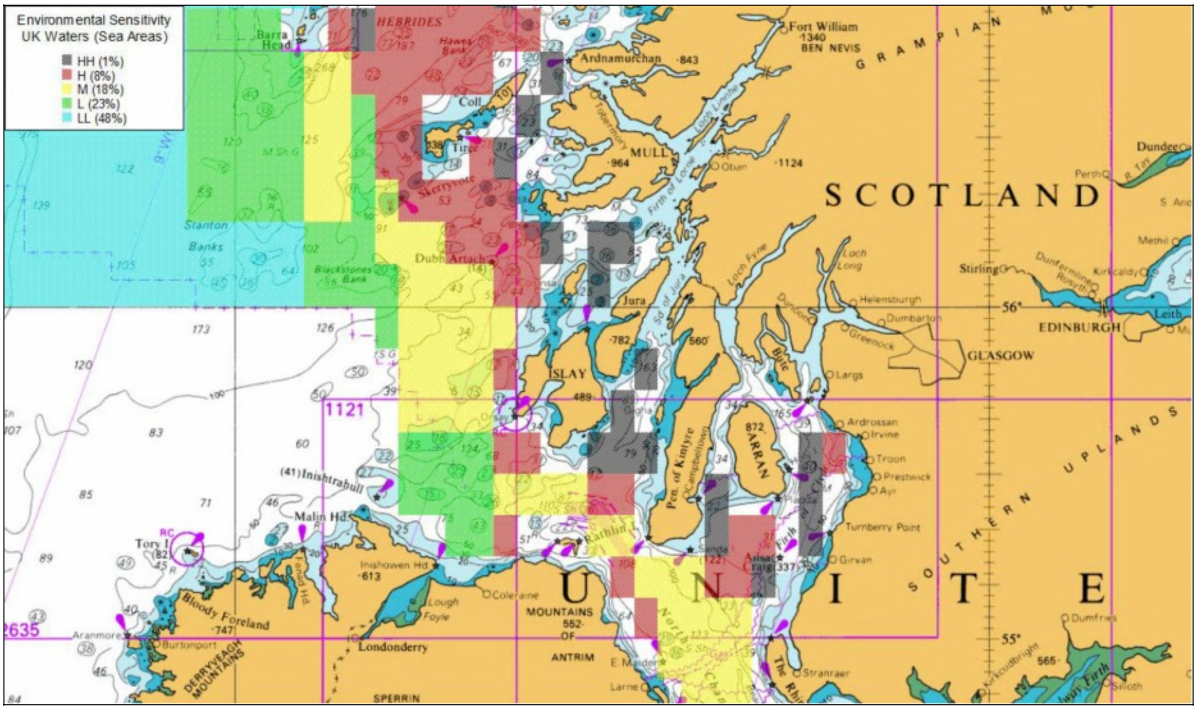

Figure 8.18 Environmental Sensitivity of Sea Areas in the West Coast of Scotland

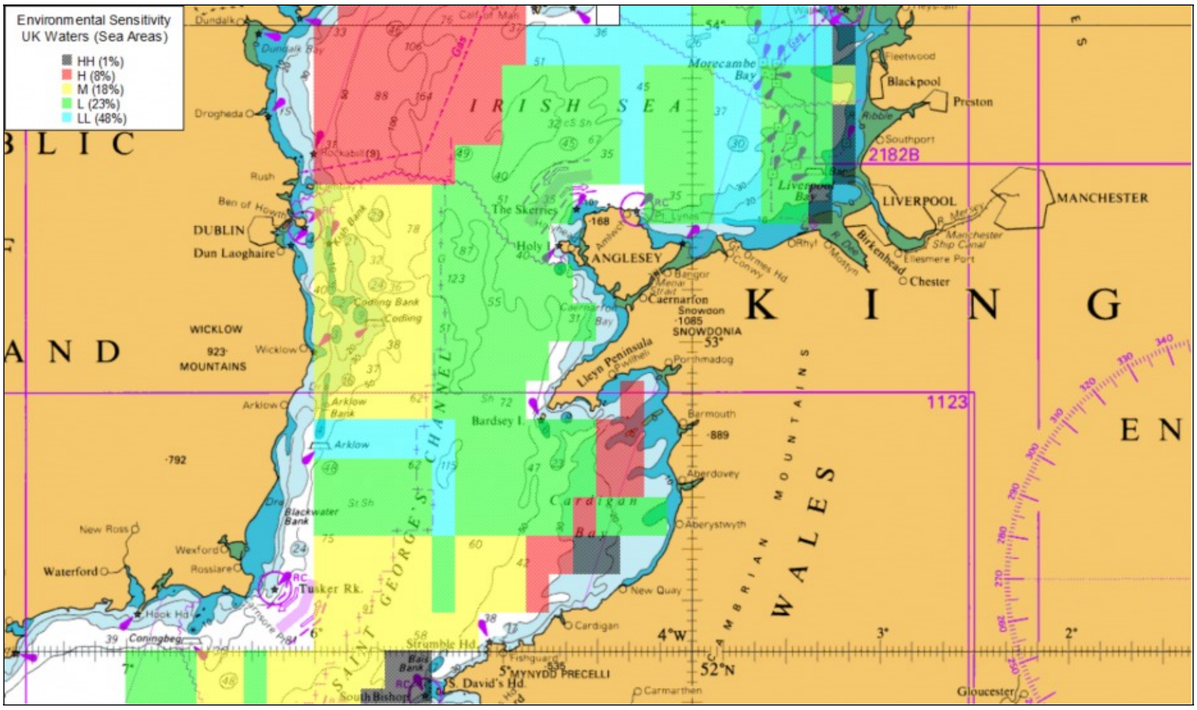

Figure 8.19 Environmental Sensitivity of Sea Areas in the Irish Sea

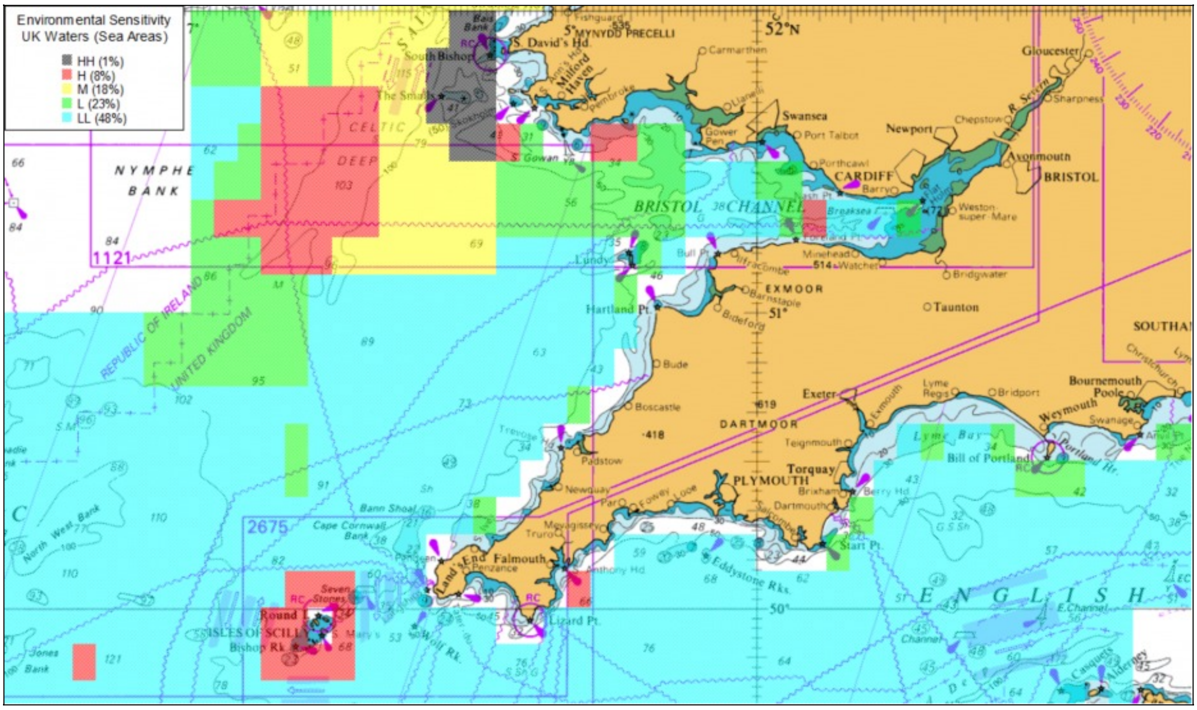

Figure 8.20 Environmental Sensitivity of Sea Areas in South West Approaches

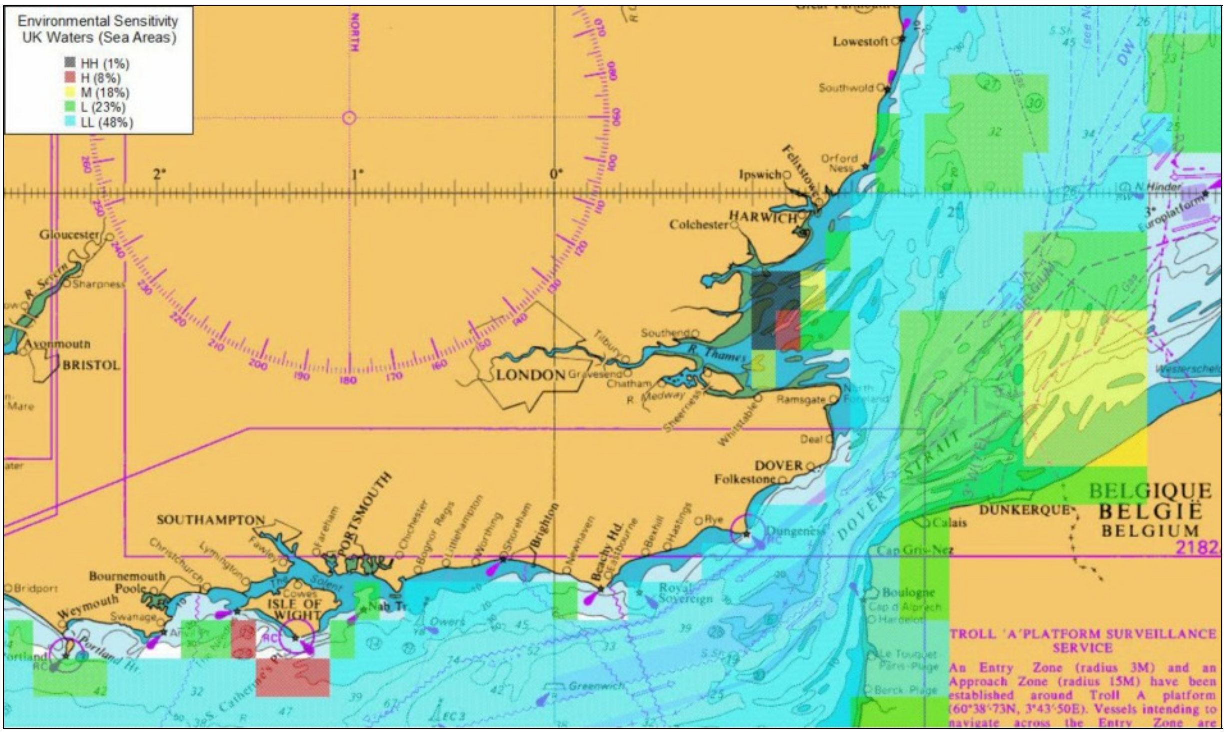

Figure 8.21 Environmental Sensitivity of Sea Areas in South & South East

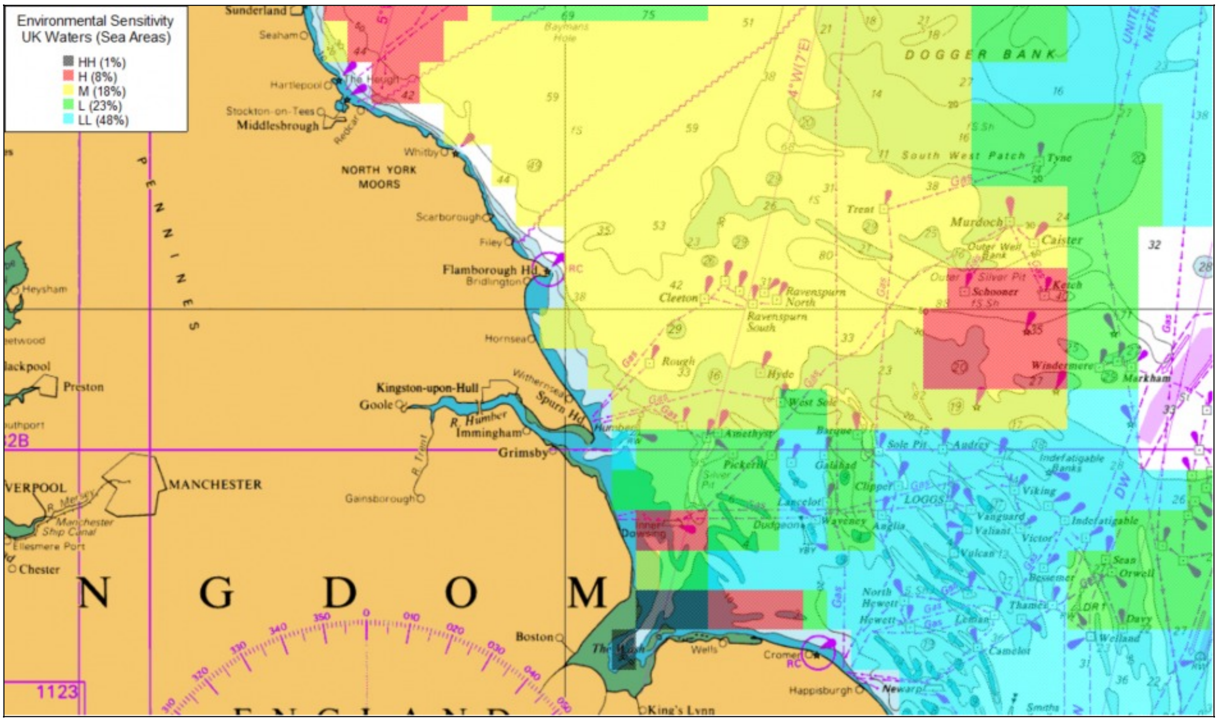

Figure 8.22 Environmental Sensitivity of Sea Areas off the East Coast of England

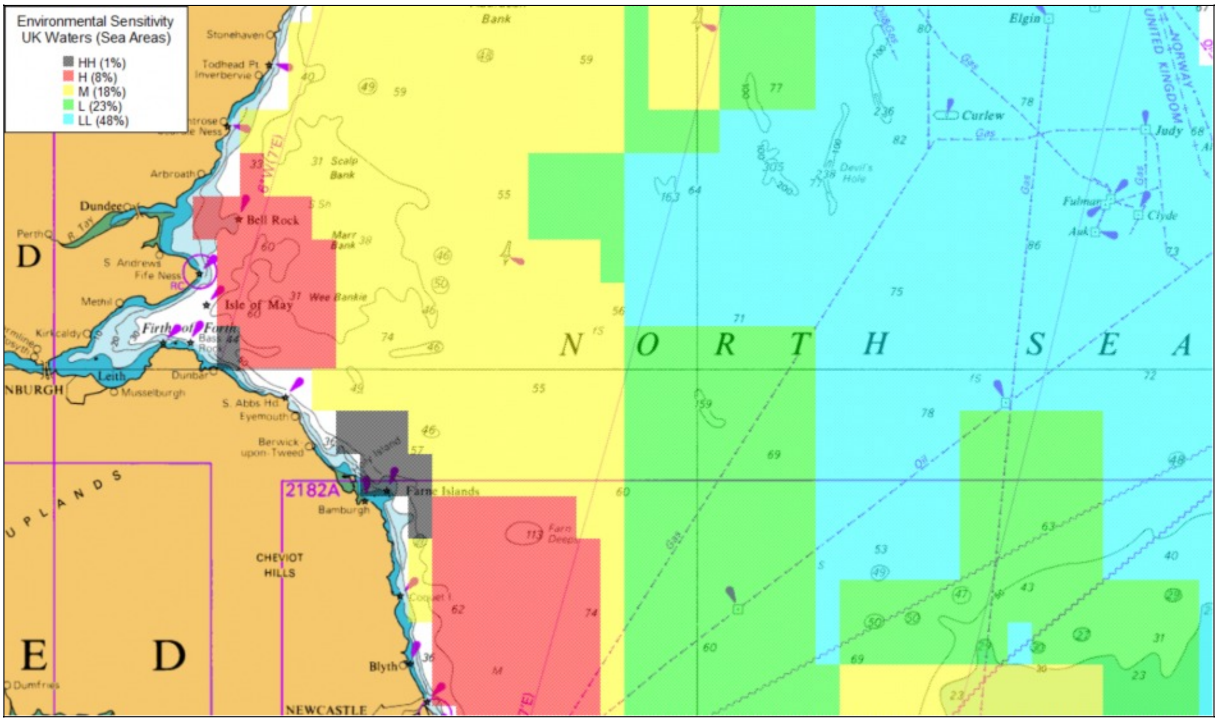

Figure 8.23 Environmental Sensitivity of Sea Areas off the East Coast of Scotland

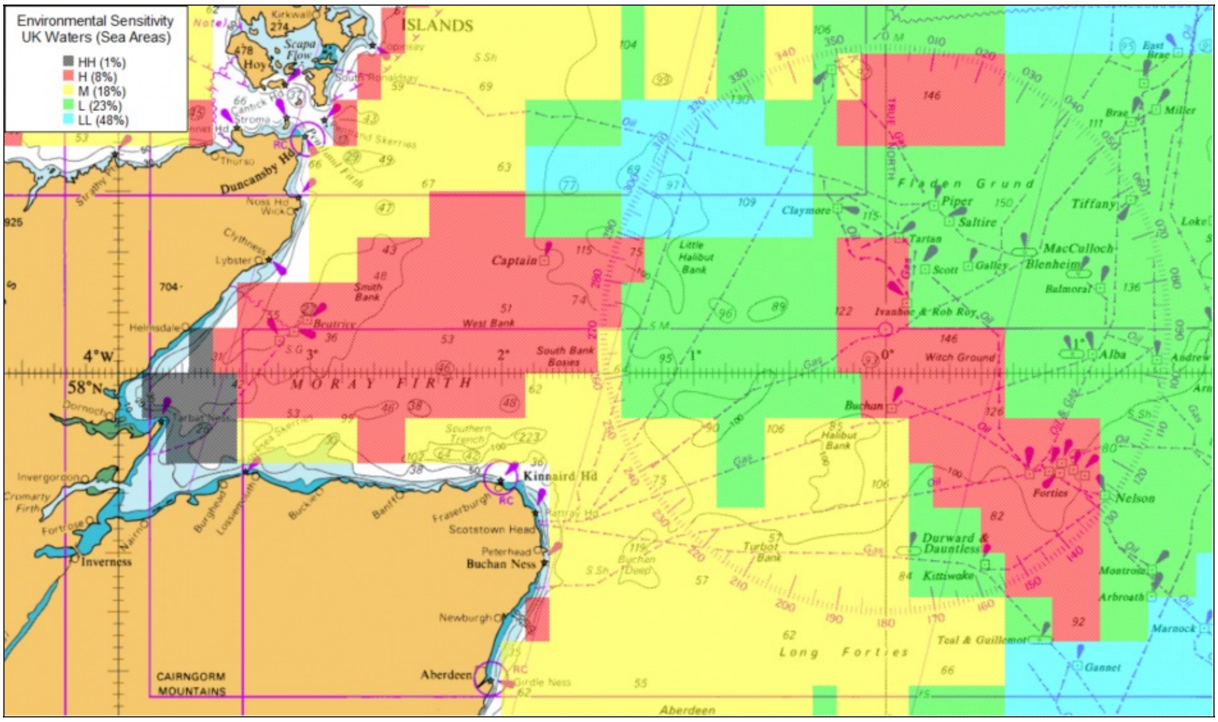

Figure 8.24 Environmental Sensitivity of Sea Areas off the North East Coast of Scotland

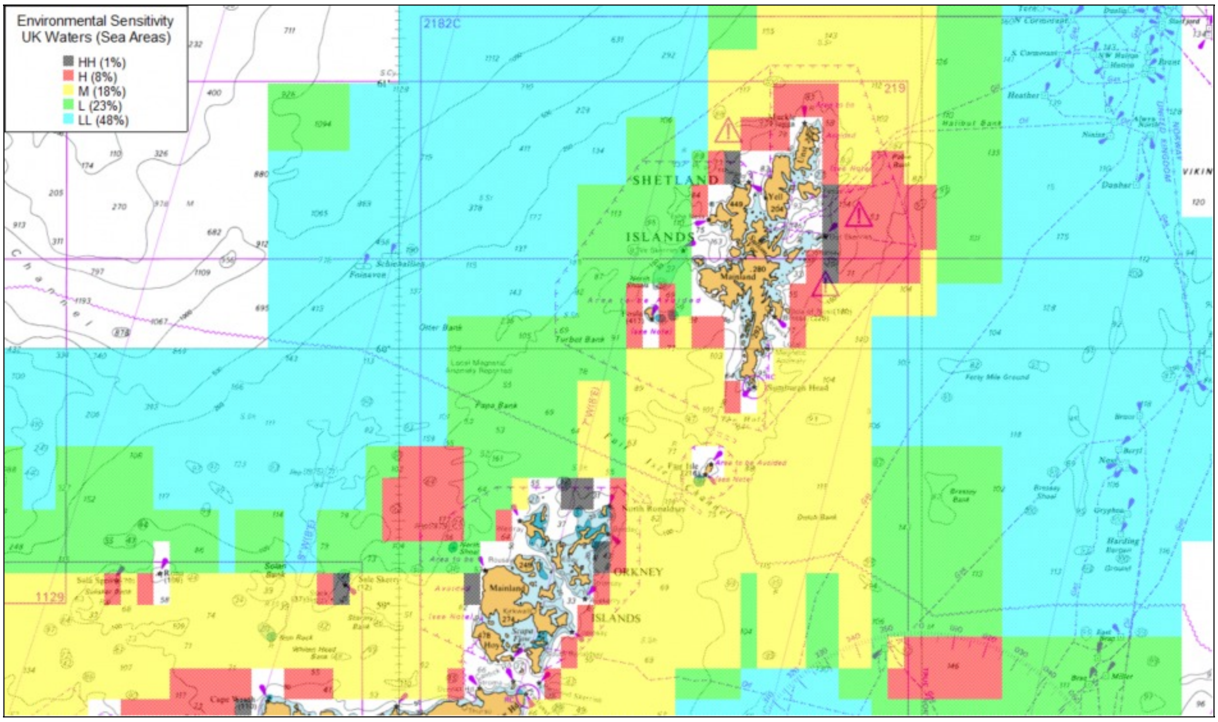

Figure 8.25 Environmental Sensitivity of Sea Areas around Orkney & Shetland

9 IDENTIFICATION OF MEHRA'S

9.1 Introduction

This section presents the identification of potential MEHRA's sites, based on the environmental sensitivity as well as on pollution risk from shipping.

9.2 Methodology for Identifying MEHRA's

The proposed MEHRA's sites are identified within this study using risk assessment. Risk is the product of frequency and consequence and therefore for this analysis is the product of the frequency of oil spills infringing on the coast (Section 4 to 7) and the environmental sensitivity of the coast (Section 8) exposed to the release.

In order to determine the MEHRA's, the results of the pollution risk and the environmental sensitivity were re-calibrated to ensure both factors had equal weighting in the assessment process. This was done by re-ranking the pollution on a similar scoring system to that used for environmental sensitivity. The environmental scores ranged from 1 (lowest) to 22 (highest). Therefore, the pollution risk was ranked using a similar scale, down to a score of 1 for cells with less than 0.1 tonnes of oil spilled per annum. However, if no oil was predicted to be spilled within a cell, a pollution score of zero was allocated (unlike the environmental scoring where even the least sensitive cell has a score of 1). This was because MEHRA's need to have both a risk of pollution and be environmentally sensitive.

The full ranking system for pollution is given in Table 9.1.

Table 9.1 Re-Ranking of Pollution Scores to Identify MEHRA's

Pollution Score	Predicted Oil Spill (Tonnes Per Annum)
0	0
1	0-0.1
2	0.1-0.5
3	0.5-1.0
4	1-2
5	2-3
6	3-4
7	4-5
8	5-6
9	6-8
10	8-10
11	10-15
12	15-20
13	20-40
14	40-60

Pollution Score	Predicted Oil Spill (Tonnes Per Annum)
15	60-80
16	80-100
17	100-140
18	140-180
19	180-220
20	220-260
21	260-300
22	300-350

To identify candidates for Marine Environmental High Risk Areas, these new values were combined as follows:

MEHRA's Score = Environmental Sensitivity x Pollution Risk

Using this formula ensures that coastal cells have to qualify on both sets of criteria to obtain a high overall score. The results of this analysis are presented in Section 9.3.

9.3 MEHRA's Results for UK Coastline

Applying the methodology outlined in Section 9.2, all coastal cells around the UK have been ranked. Table 9.2 presents the ranking which has been carried out for the coastal cells.

Table 9.2 Outline of MEHRAS Ranking of UK Coastline

Ranking	Colour Code	No. of Points	% of Cells
Very High (HH)	Black	>132	10%
High (H)	Red	73-132	21%
Medium (M)	Yellow	36-73	25%
Low (L)	Green	16-36	24%
Very Low (LL)	Blue	0-16	18%

The following figure presents the ranking of the UK Coastline with the top 10% shaded in black identified as being the most likely candidates for MEHRA's.

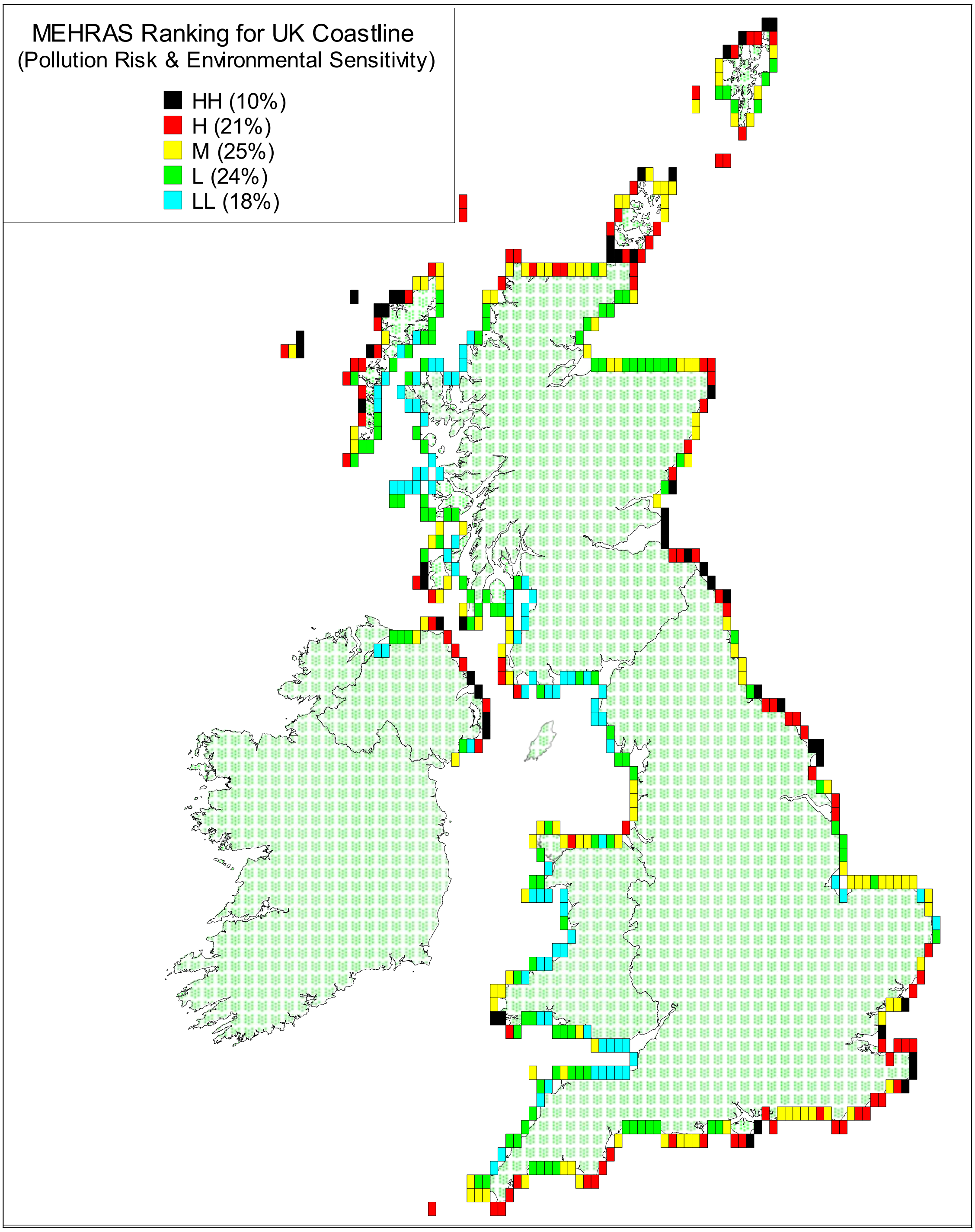

Figure 9.1 Ranking of UK Coastline Based on Marine & Environmental Risk (i.e. Pollution Risk & Environmental Sensitivity Combined)

Table 9.3 highlights the top 20 sites, which are highly likely to be candidates for MEHRA's.

Table 9.3 Top Ranking MEHRA's Scores for UK

Cell No. Identifier	Location	Score
12,121	Muckle Flugga (North Coast of Unst in Shetland)	224
11,990	West of Yell (Shetland)	210
7,244	Bass Rock (Adjacent to Firth of Forth)	208
7,372	Isle of May (Adjacent to Firth of Forth)	196
6,866	Holy Island near Berwick Upon Tweed	192
10,053	West Coast of Hoy (Pentland Firth, Orkney)	182
9,514	Near Carloway (West Coast of Lewis)	182
6,447	Rathlin Island (North Coast of Northern Ireland)	182
5,939	Near Larne (East Coast of Northern Ireland)	169
6,740	Farne Islands (North East Coast of England)	169
2,284	South Foreland (South East Coast of England)	168
12,122	Muckle Flugga (North Coast of Unst in Shetland) #2	168
9,928	Duncansby Head (Pentland Firth, North Coast of Scotland)	168
6,993	Near Berwick Upon Tweed (South East Coast of Scotland)	168
7,119	St. Abbs Head Near Berwick Upon Tweed (South East Coast of Scotland)	160
5,216	Flamborough Head (East Coast of England)	156
6,829	Rhinns of Islay (West Coast of Scotland)	156
2,742	Skomer & Skokholm Island (West Wales)	156
9,117	Saint Kilda (West Coast of Scotland)	156
5,812	Near Bangor (East Coast of Northern Ireland)	156

Figure 9.2 to Figure 9.11 present a geographical overview of the MEHRA's rankings around the UK Coastline.

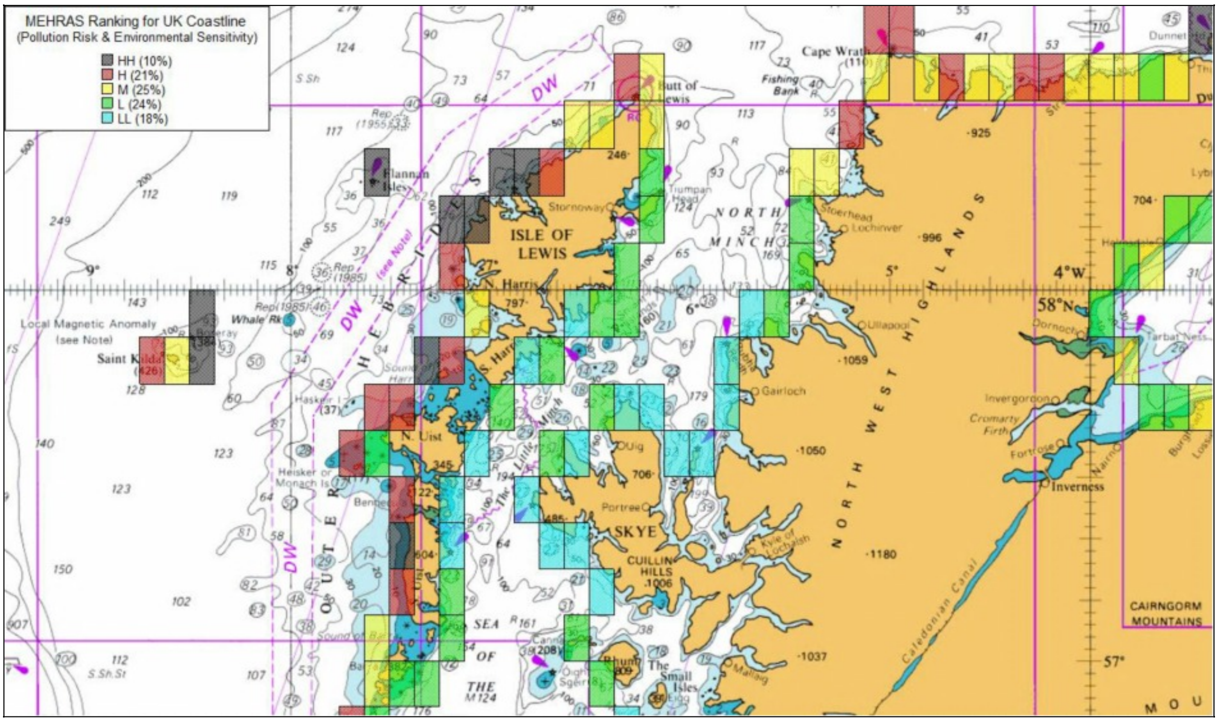

Figure 9.2 MEHRA's Ranking for the North West Coast of Scotland

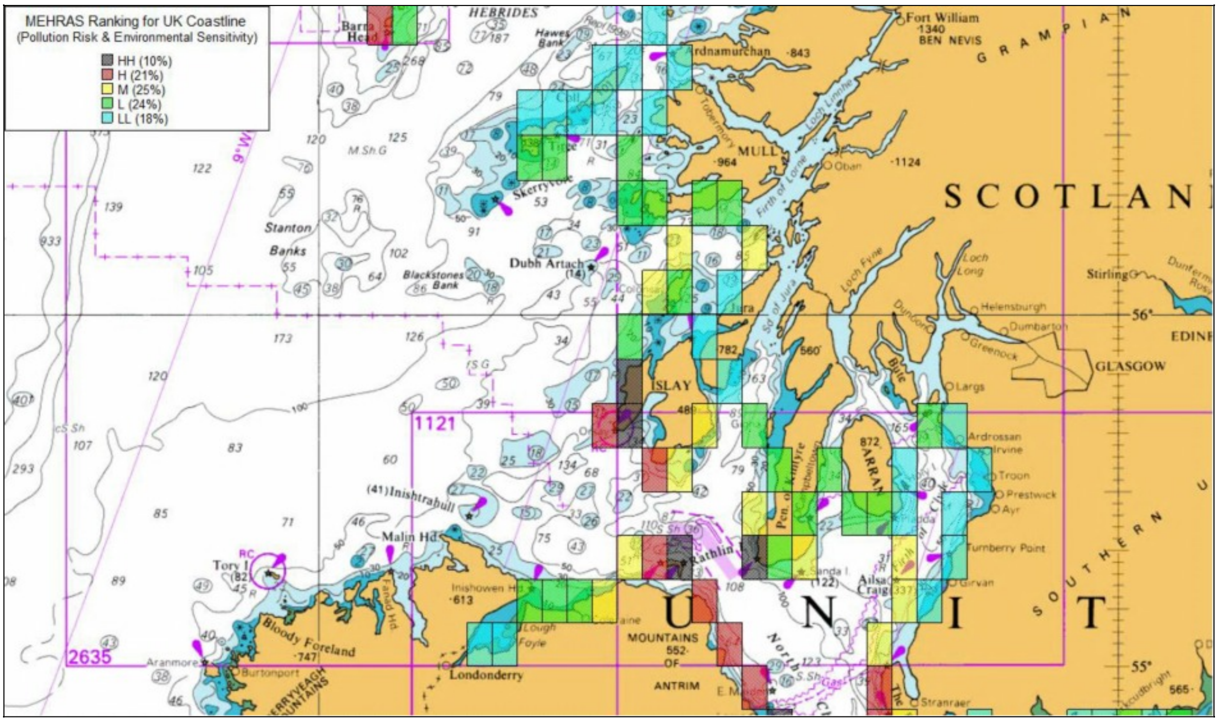

Figure 9.3 MEHRA's Ranking for the West Coast of Scotland

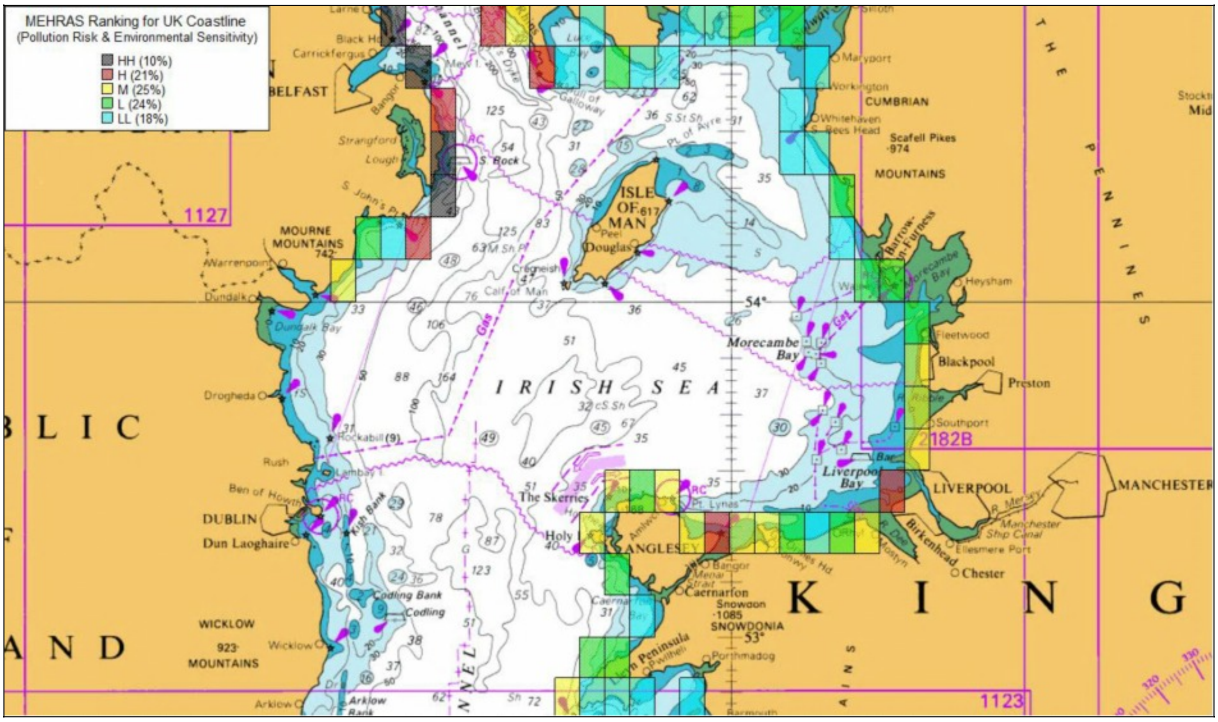

Figure 9.4 MEHRA's Ranking for the Irish Sea Coast

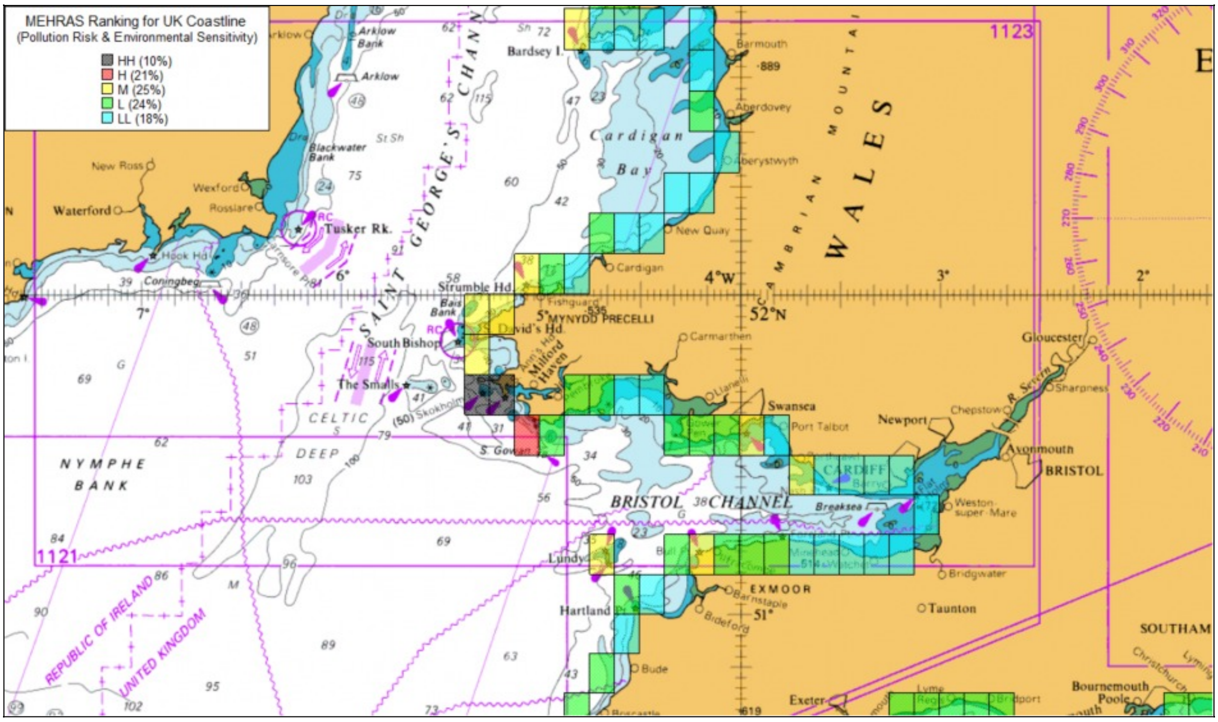

Figure 9.5 MEHRA's Ranking for Saint George's Channel and Bristol Channel

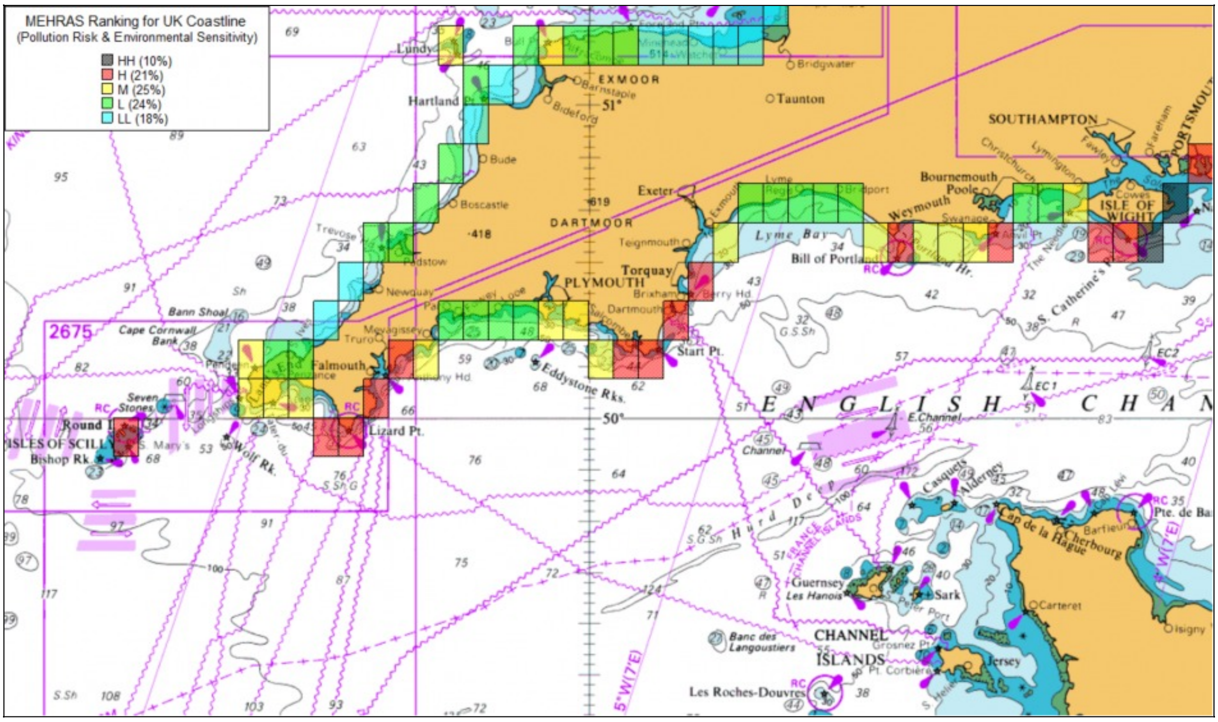

Figure 9.6 Environmental Sensitivity for the South West Coast of England

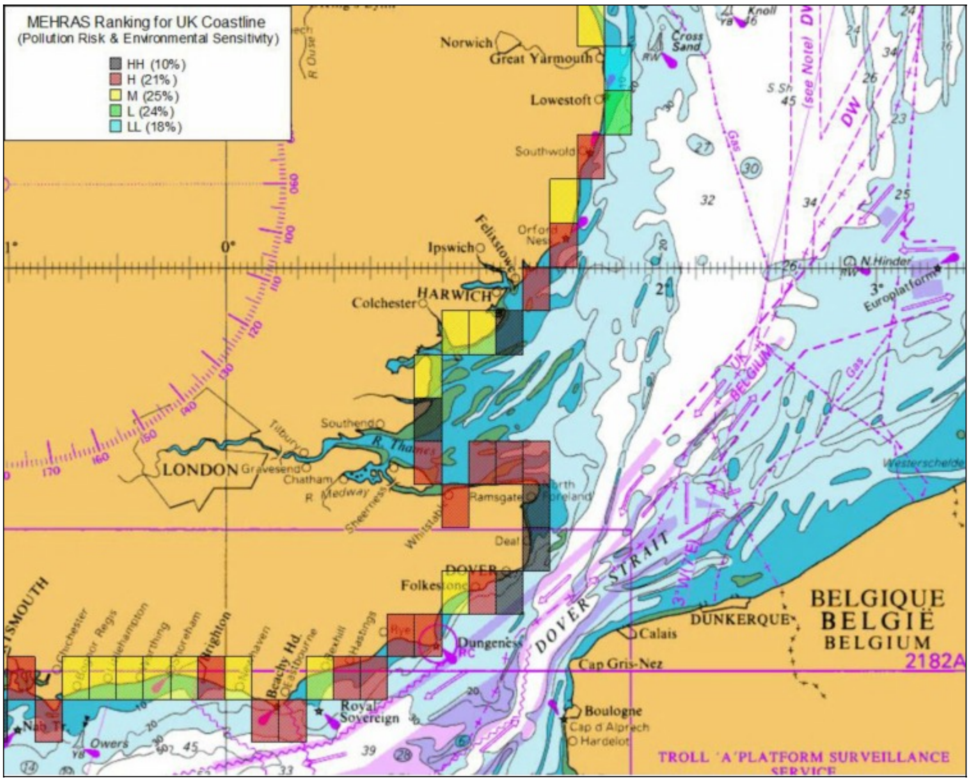

Figure 9.7 MEHRA's Ranking on the Thames & South East Coast

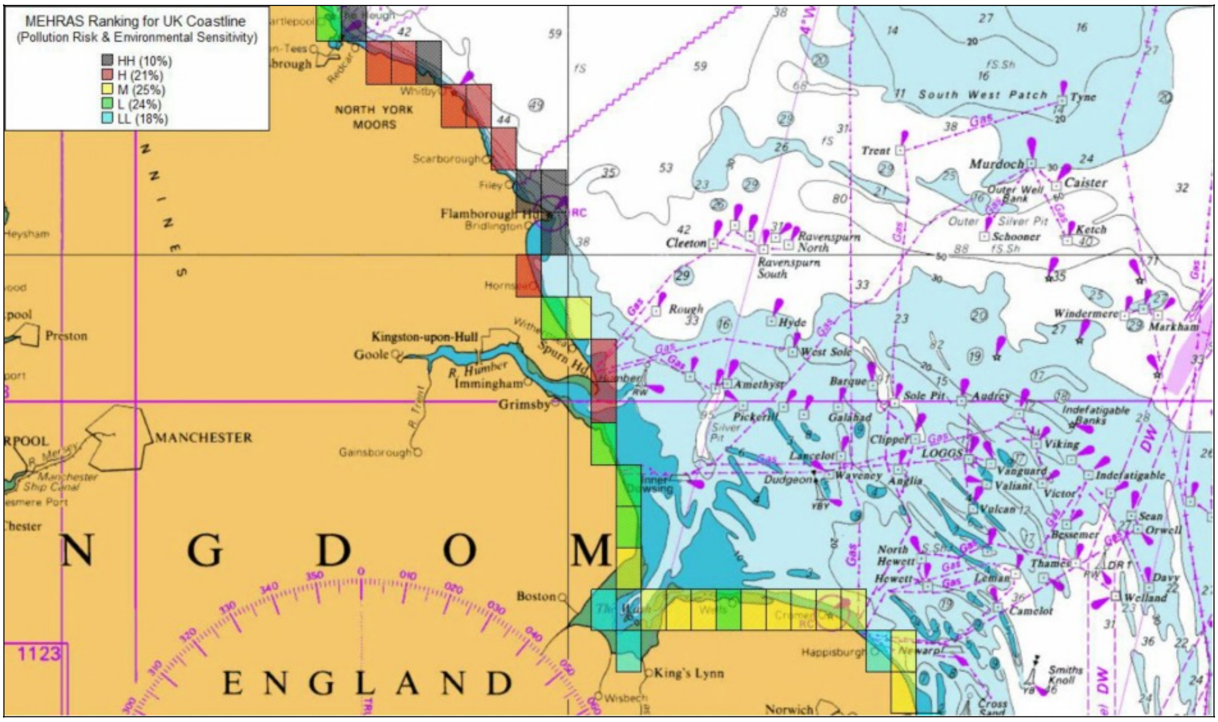

Figure 9.8 MEHRA's Ranking for Humberside & North East England

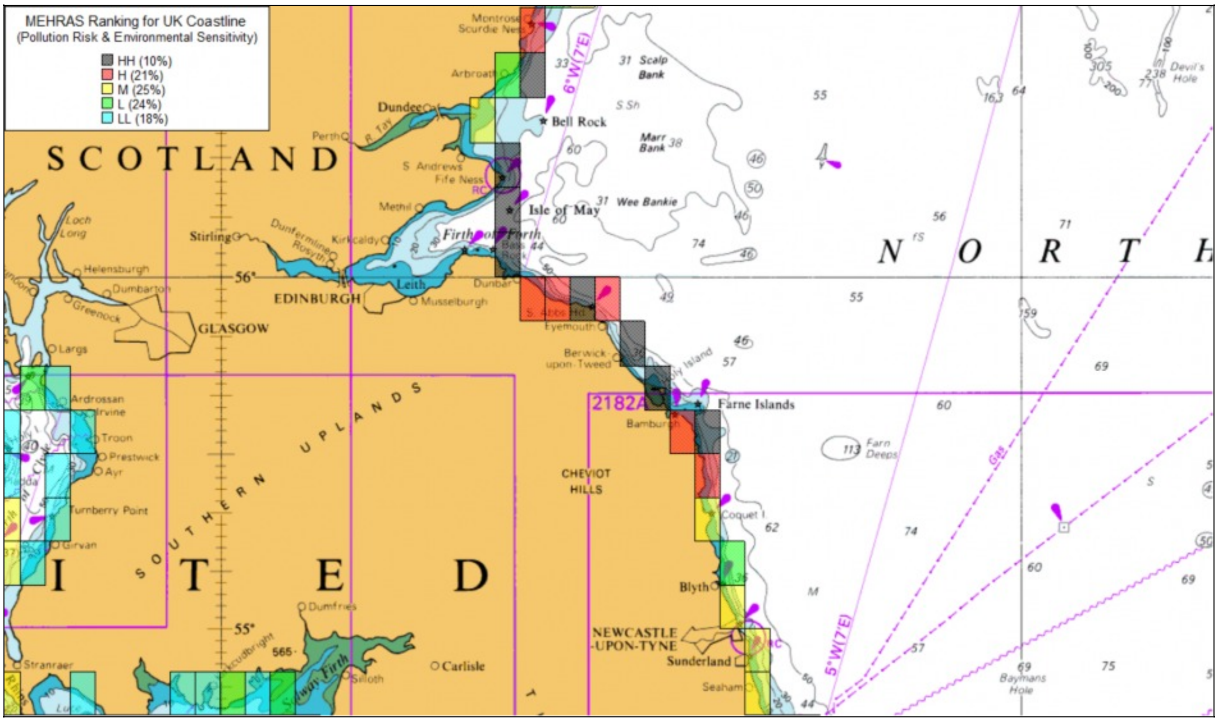

Figure 9.9 MEHRA's Ranking for Southern Scotland & Northern England

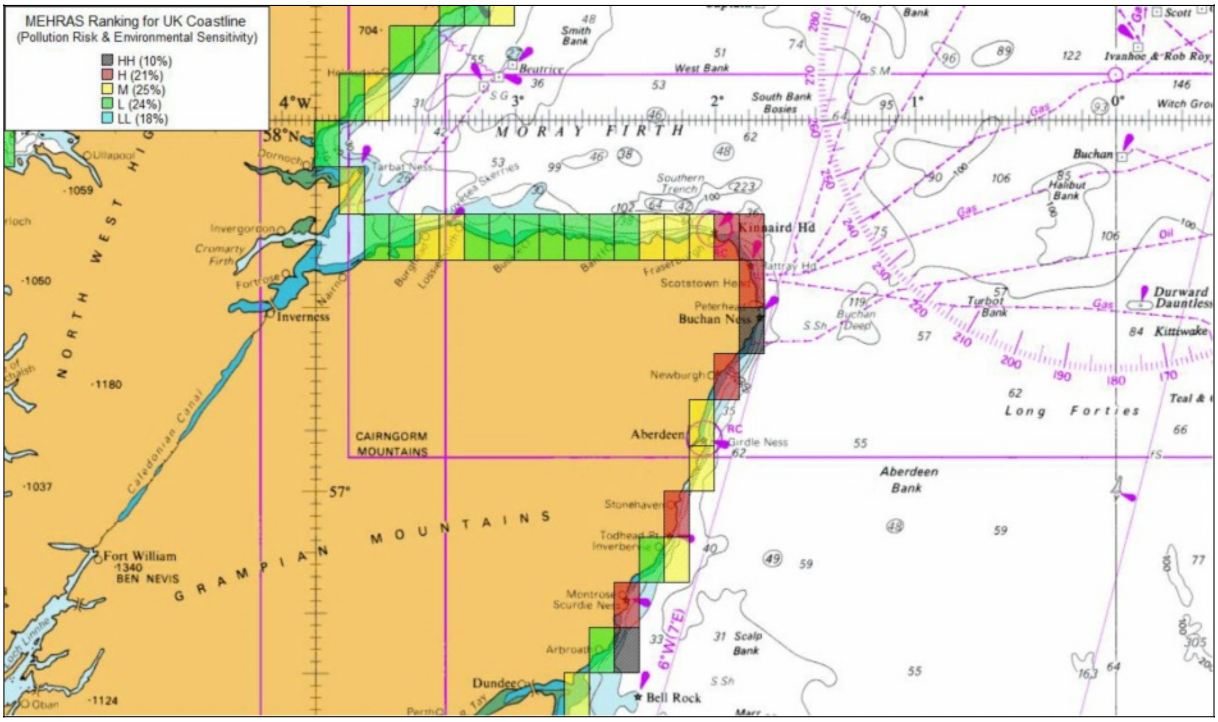

Figure 9.10 MEHRA's Ranking for North East Coast of Scotland

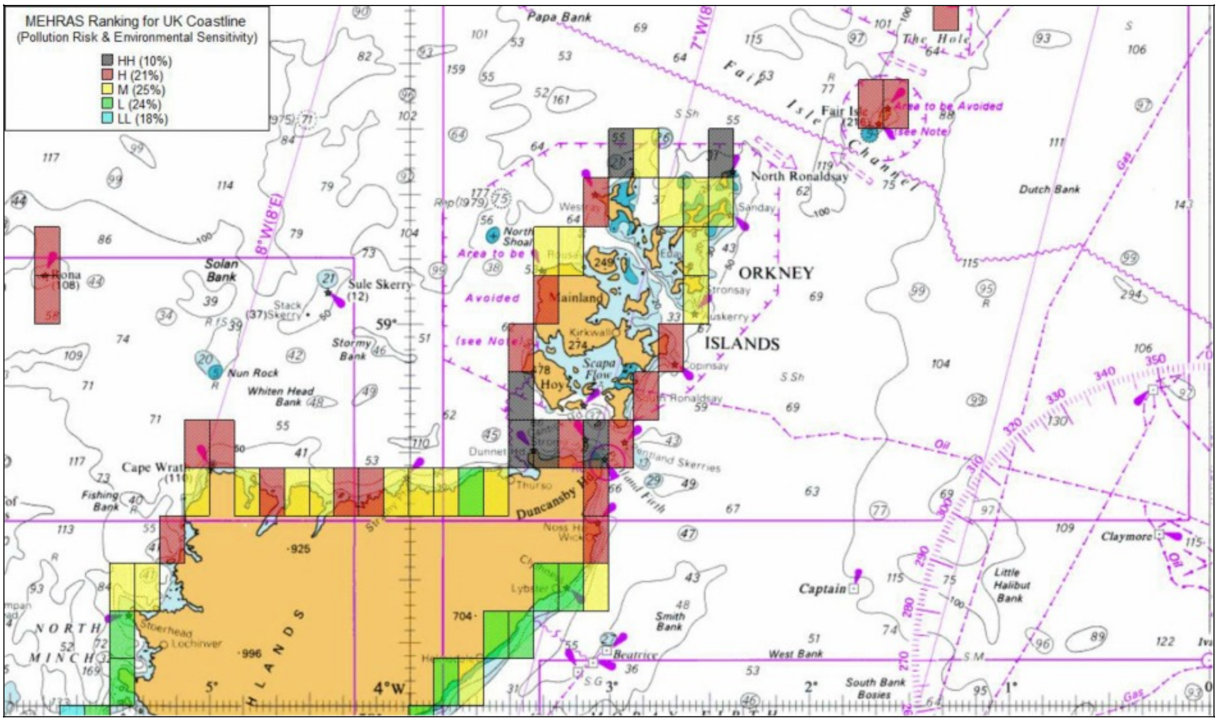

Figure 9.11 MEHRA's Ranking for North of Scotland & Orkney & Fair Isle

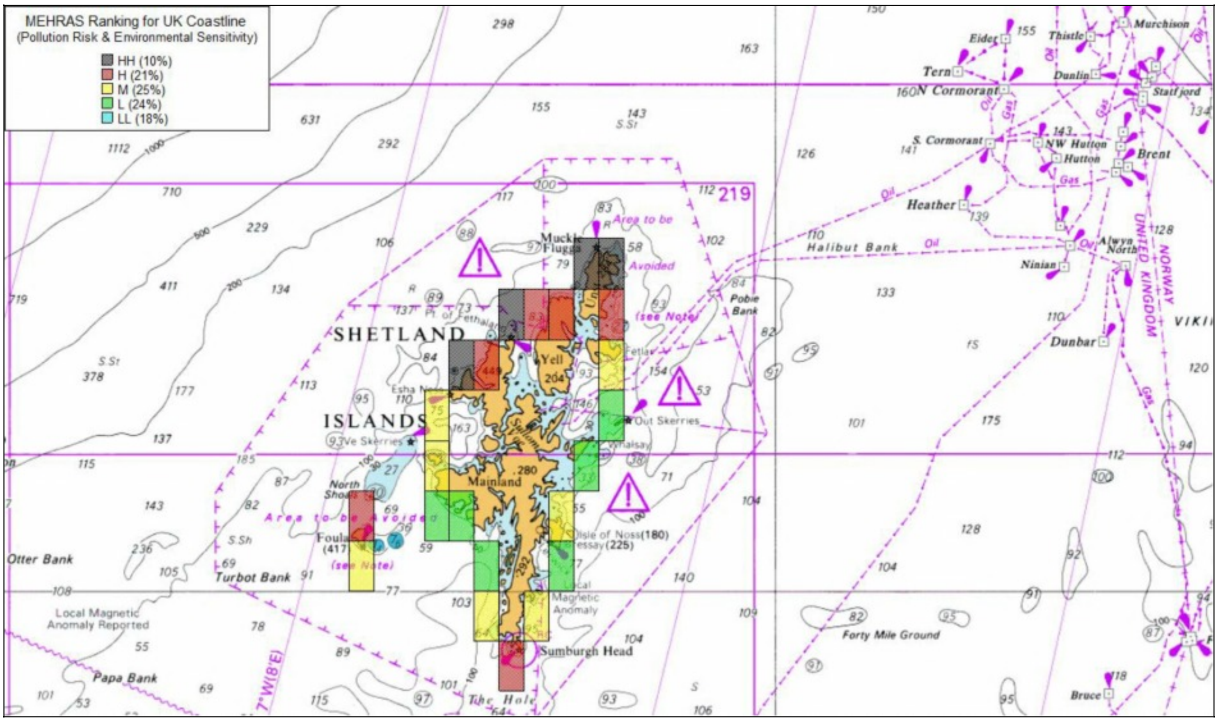

Figure 9.12 MEHRA's Ranking for Shetland

9.4 MEHRA's Results for UK Sea Areas

Applying the methodology outlined in Section 9.2, all sea cells around the UK have been ranked. Table 9.2 presents the ranking which has been carried out for the sea cells.

Table 9.4 Outline of MEHRA's Ranking of Sea Areas Around the UK

Ranking	Colour Code	No. of Points	% of Cells
Very High (HH)	Black	>50	1%
High (H)	Red	17-50	9%
Medium (M)	Yellow	10-17	17%
Low (L)	Green	4-10	30%
Very Low (LL)	Blue	0-4	40%

Figure 9.13 presents the ranking of the UK sea areas with the top 1% shaded in black.

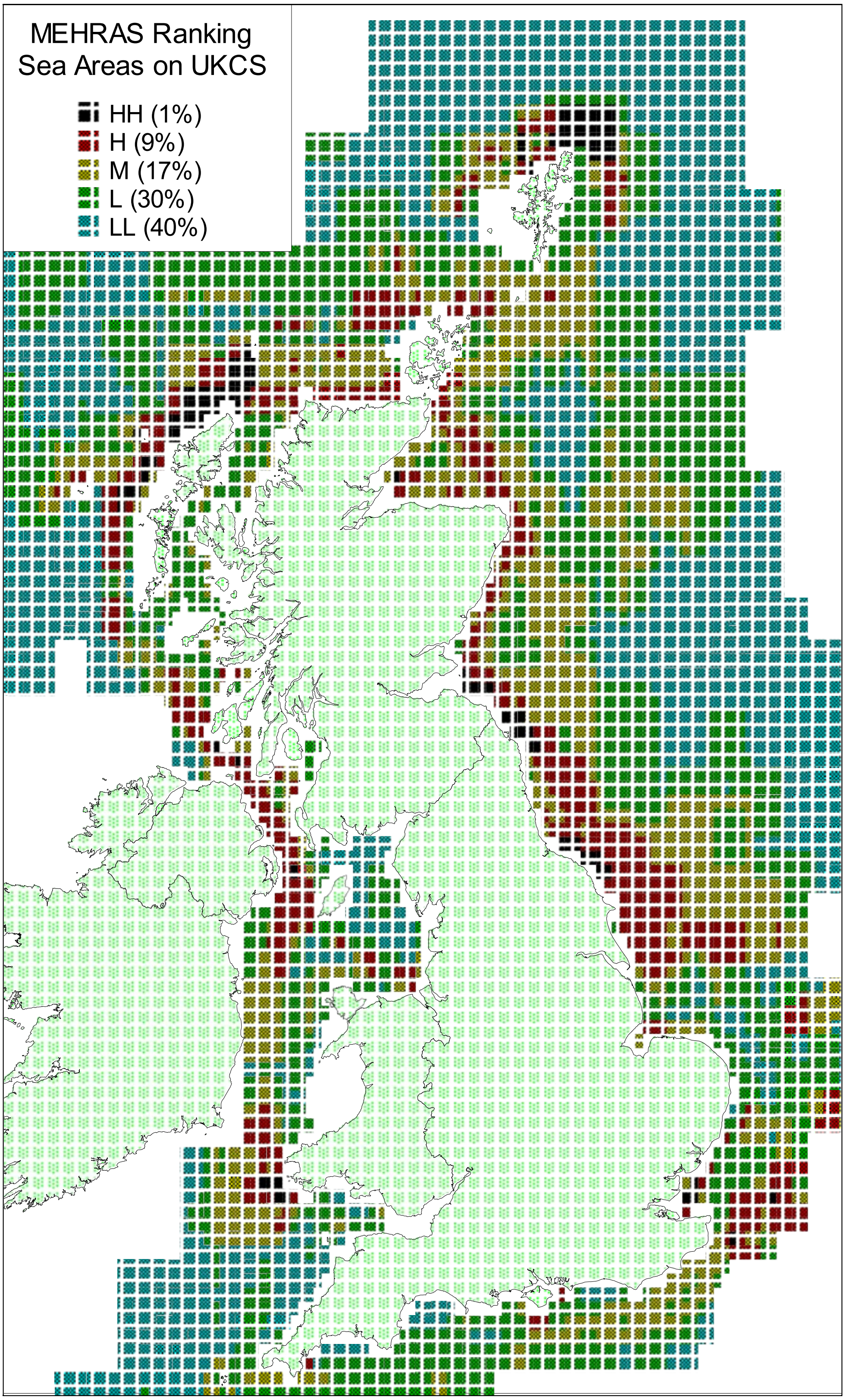

Figure 9.13 Overview of MEHRA's Ranking for Sea Areas around the UK

The figure shows that the highest scores are in the sea areas around:

- West Coast of the Isle of Lewis
- West Wales
- North of Shetland Islands
- South East Coast of Scotland
- Coast of North East England

The highest ranking sea cell with a score of 120 is located within the Deep Water Route to the West of the Isle of Lewis on the West Coast of Scotland. It should be noted that no sea area scored highly enough to rank within the top 10% of coastal cells.

10 CONCLUSIONS & RECOMMENDATIONS

10.1 Conclusions

It is concluded that a non-subjective methodology has been developed to assist in the identification of MEHRA's. The methodology developed gives account to both the shipping pollution risk and coastal environmental sensitivity as recommended by Lord Donaldson and is both transparent and traceable.

It is further concluded that the methodology gives account to all the parameters highlighted within the Donaldson Inquiry as having the potential to influence MEHRA's plus others. These include:

- the number, type and size of vessels passing and the nature of their cargoes;
- the distance of the usual shipping lanes from the shore;
- any circumstances giving rise to an increased risk of collision such as a significant amount of traffic going across normal flow;
- prevailing meteorological and tidal characteristics;
- existence of wildlife feeding or breeding sites of international significance or the presence of biological communities of either flora or fauna or both of particular interest or rarity: designation as a Special Protection Area under the EC Birds Directive or any area of special conservation under the Habitats Directive will normally be regarded as evidence of this.
- the existence of commercially exploitable biological resources and mariculture sites; and
- the extent to which the area provides a public recreational amenity.

It is finally concluded that the methodology developed has been computerised into a MEHRA's toolkit, which will facilitate easy update and revision of this work.

10.2 Recommendations

It is recommended that:

1. The data within the MEHRA's toolkit be updated regularly as part of this initiative to ensure future assessments can be conducted at low cost.
2. Consideration should be given to the inclusion at a later date of marine benthic sensitivity data for sea areas in the assessment of environmental sensitivity.
3. Periodic reviews of this work be undertaken.

4. Consideration be given to putting the GIS system on the Internet to aid in the public consultation process. This can easily be achieved and would allow feedback to be recorded, and amendments of the data to be undertaken effectively prior to the finalisation of the MEHRA's sites.

5. Methods of informing mariners and monitoring the MEHRA's be investigated following their establishment.

11 REFERENCES

1 Donaldson (1994): "Safer Ships, Cleaner Seas", Report of Lord Donaldson's Inquiry into Marine Safety, HMSO 1994.

2 Ongoing Project on "Risks Associated With Chemical Tankers in UK Waters" being carried out by Safetec on behalf of MCA, scheduled for completion Jan, 2000.

3 Data from 1990 UN Report The State of the Marine Environment – UNEP Regional Sea reports and Studies No. 115.

4 MARPOL regulations annex I, II and V.

5 Lloyds casualty data 1989-1998.

6 Dovre Safetec Ltd., Development of UKCS Vessel Traffic Database for DOT/UKOOA/HSE, Report No. DST-95-CR-110-02, May 1996.

7 IMO (1991), Guidelines for the Designation of Special Areas and Identification of Particularly Sensitive Sea Areas, Resolution A.720 (17).

APPENDIX 1

MARINE TRAFFIC DATA

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1 INTRODUCTION

A primary input to the identification of MEHRA's is the shipping traffic and routeing data. The COAST database was used to obtain merchant shipping information for the project. This appendix describes the development of the database and how it has been updated for use in this project.

1.1 Background Information about the COAST Database

COAST was developed by Safetec in 1995/96 in a Joint Industry Project funded by the Department of Transport, Health and Safety Executive and UK Offshore Operators Association (Ref. 1). The database improved upon the reliability of existing traffic databases by utilising a large number of data sources. The main data sources used included:

- Port Callings Data provided by LMIS
- Offshore Traffic Surveys carried out by Standby Vessels
- Platform and Coastal Based Radar Systems
- Information from Offshore Operators (Standby/Supply/Shuttle Tanker details)
- Information from Ferry Operators
- Vessel Passage Plans
- Deep Sea Pilot Route Details

By combining these data sources it was possible to determine the position of the routes utilised by traffic traversing UK waters, the volumes of traffic and type/size distributions of the vessels on each of the routes, and the width of the routes. On identification of the route positions a sample of the routes was reviewed by a panel of independent, experienced mariners for verification purposes.

COAST was released as a new product in March 1996 and its maintenance is actively pursued by Safetec by commissioning and analysing a minimum of 20 offshore traffic surveys per year, targeted at areas on the UKCS where there may be uncertainty in routeing. Several other surveys have also been analysed and used to update COAST, for example, surveys commissioned by the MCA off the West Coast of Scotland and data received from platform and shore-based radar systems. Plots from recent surveys on the UKCS are presented in Figure 1.1 and Figure 1.2.

1.2 Updating of COAST for MEHRA's Project

Several updates were made to COAST (Version 2.0) to add more detailed information on vessel characteristics held within the database, such as vessel type and speed, to ensure the results of the study met the requirements of the project. In addition, new ship movements data was purchased up to October 1998 to ensure the traffic volumes in the database were up-to-date.

A detailed description of the information within the updated COAST database used in this project is provided in Section 2.

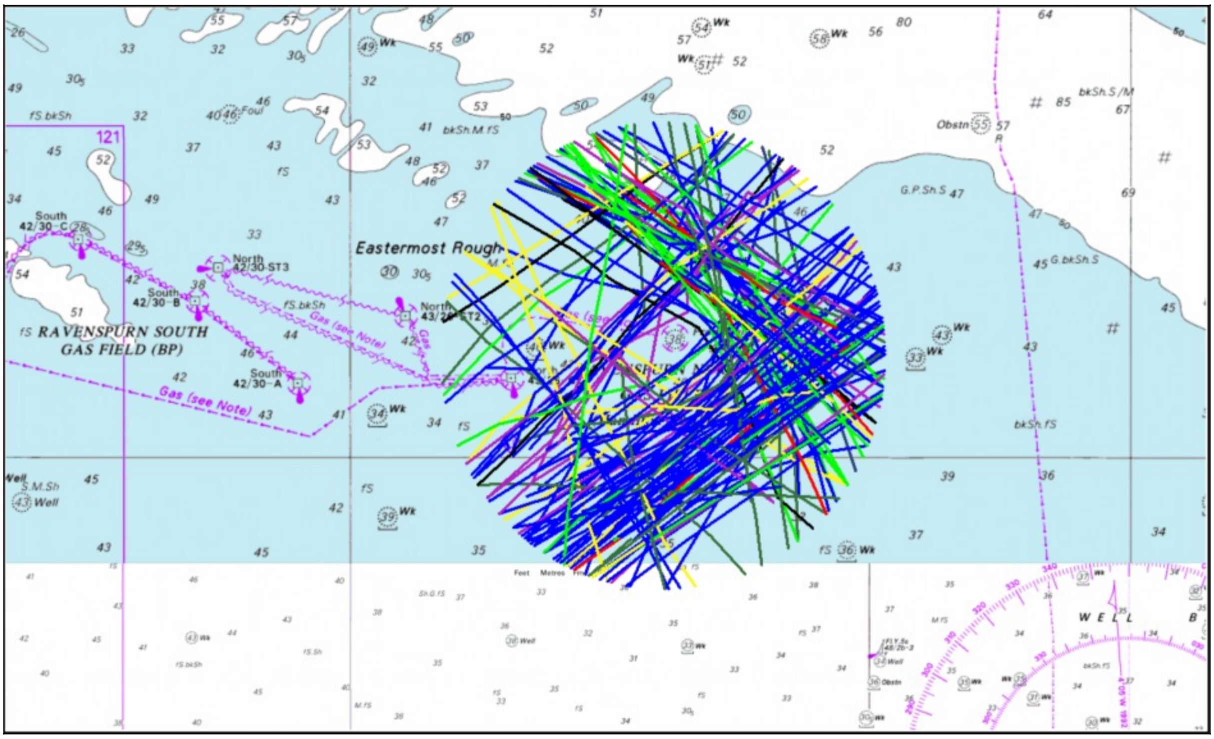

Figure 1.1 Shipping Data from Drilling Location Survey in the Southern North Sea

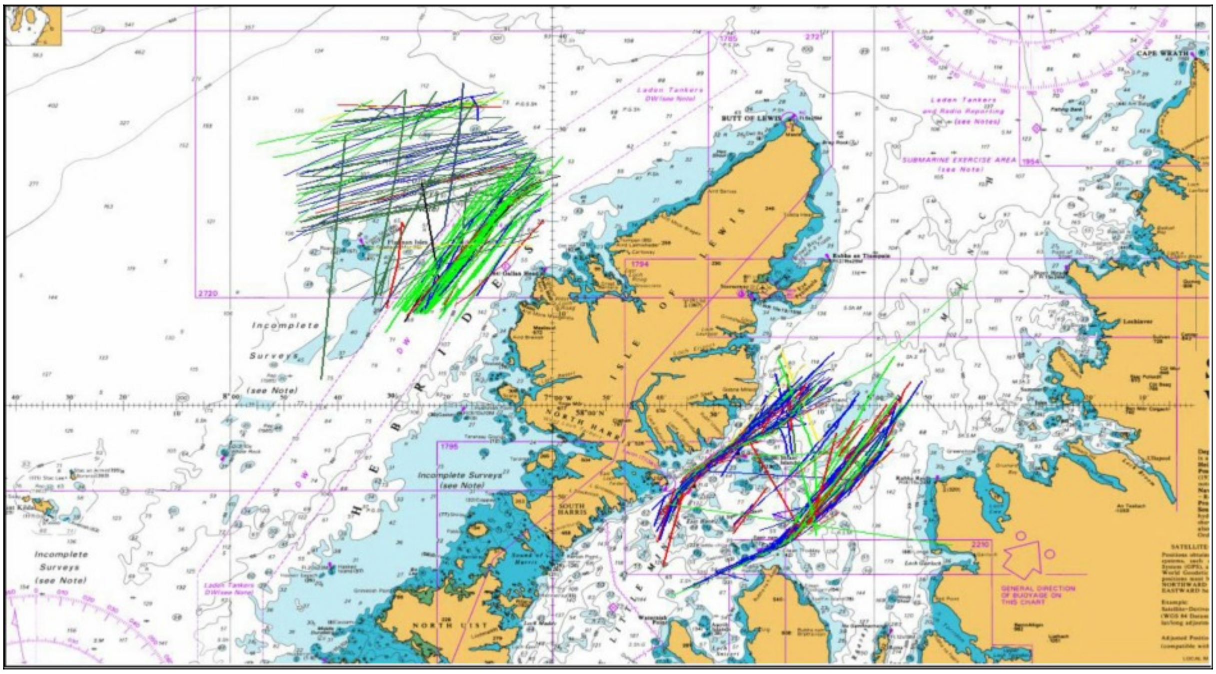

Figure 1.2 Shipping Data from MCA Survey West of Lewis and through the Minches

2 DESCRIPTION OF COAST DATABASE

The main information contained in the COAST database for each route is as follows:

- Port of Departure/Destination
- Route Waypoints
- Number of Vessels per year
- Vessel Type Distribution
- Vessel Size Distribution
- Flag Distribution
- Age Distribution
- Speed Distribution

Each of these characteristics is described in the following subsections.

2.1 Port of Departure/Destination

Data on vessel movements between ports in 1998 was obtained from Lloyd's Maritime Information Services (LMIS). The area covered included the whole of Western Europe from the Baltic Sea to Greenland and from Iceland to the Mediterranean Sea, as shown in Figure 2.1.

Figure 2.1 Geographical Area for which LMIS Port Callings were Acquired

This coverage ensured that all routes to/from UK ports were identified, but also other routes passing through UK waters were included, e.g., Rotterdam to Santander via the English Channel.

For passenger ferries and offshore vessels (e.g. supply vessels, standby vessels and shuttle tankers), the LMIS data is not comprehensive, however, this information is included in COAST Version 2, based on data received directly from vessel operators and oil companies chartering such vessels.

2.2 Route Waypoints

The routes followed by vessels between ports is contained within the COAST database as a series of waypoints (latitude and longitude).

Every waypoint on each route in COAST has the following attributes:

- Direction - One-way or both-ways
- Standard Deviation - Route width
- Distribution - Gaussian or uniform

As discussed in Section 1.1, the routes were mainly based on analysis of offshore traffic surveys and were reviewed by experienced mariners. This ensured account was taken of routeing measures within UK waters such as the following:

- Areas To Be Avoided (see Figure 2.2)
- Traffic Separation Schemes (see Figure 2.3)
- Deep Water Routes (see Figure 2.4)

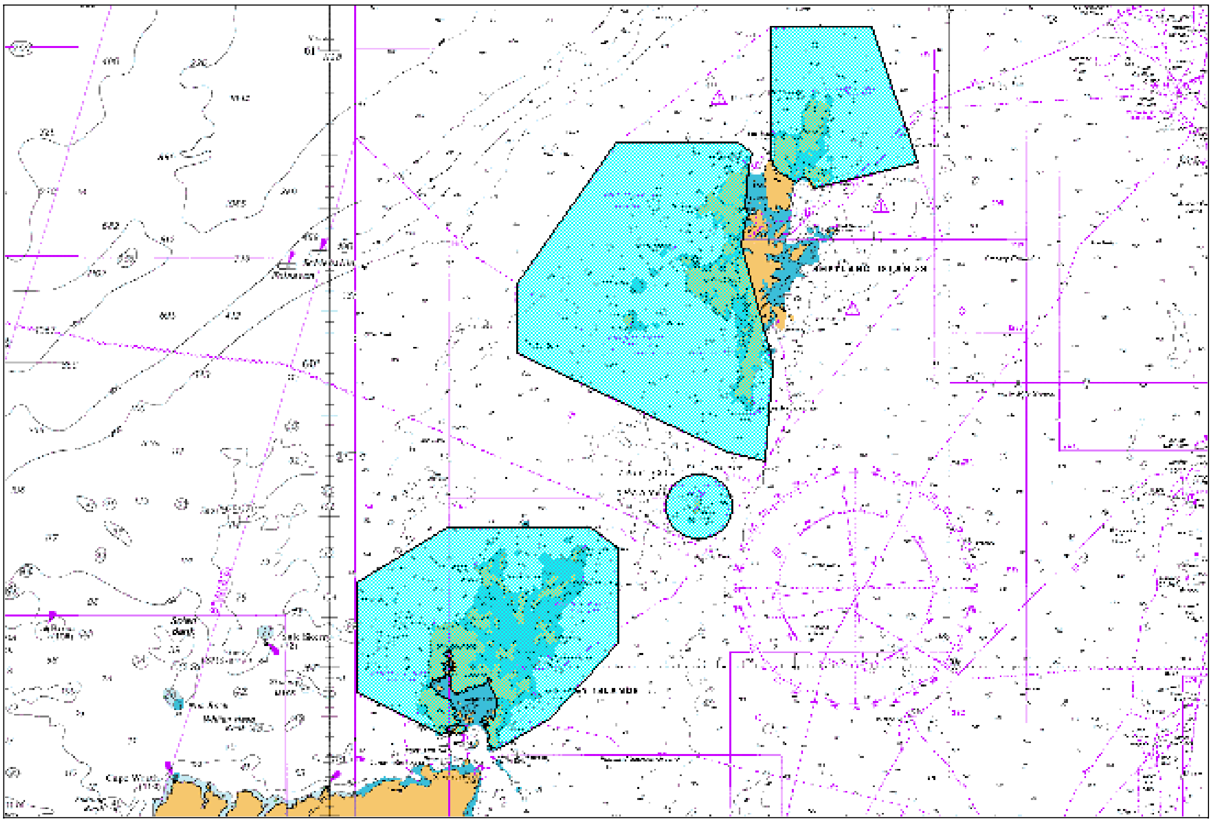

Figure 2.2 Areas To Be Avoided around the Orkneys, Fair Isle and Shetland

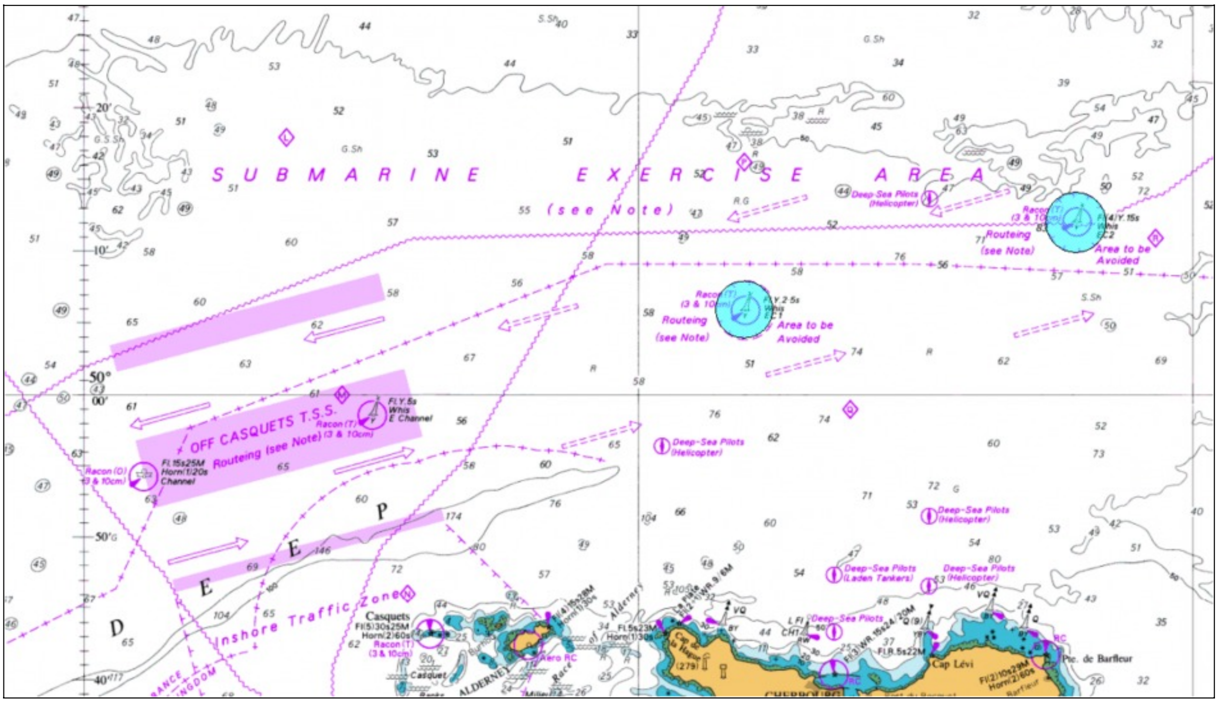

Figure 2.3 Casquets Traffic Separation Scheme in the English Channel (ATBAs also shown)

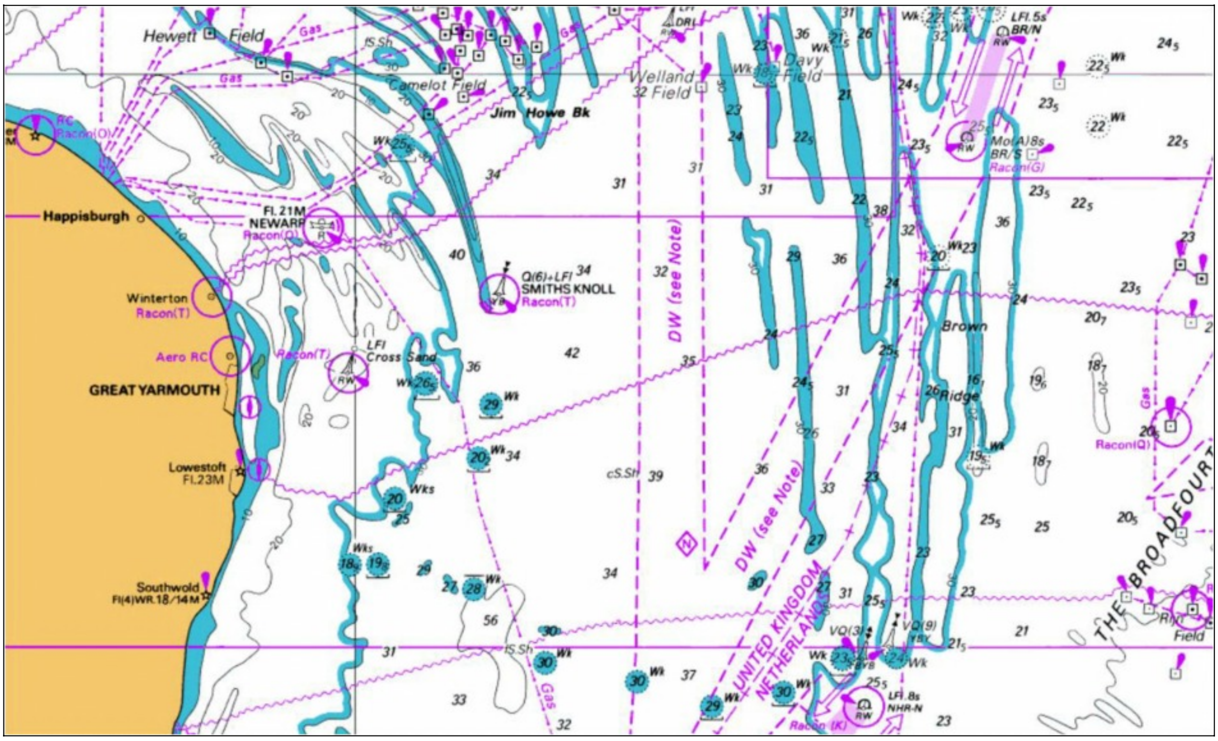

Figure 2.4 Deep Water Routes in the Southern North Sea

2.3 Number of Vessels Per Year

The number of vessels travelling on each route per year was estimated by purchasing 13 weeks of LMIS data for selected periods in January, April, July and October 1998. This ensured that potential seasonal variations in shipping movements were accounted for and provided a large enough statistical base to give confidence that any error in factoring to an annual basis will be minimal.

As mentioned previously, for passenger ferries and offshore vessels the LMIS data is not comprehensive, therefore, information on the number of vessels on these routes per year was taken from the existing COAST database. This information was obtained directly from the ferry and offshore vessel operators, and is updated biannually under the COAST project.

2.4 Vessel Type Distribution

In COAST Version 2, vessels were divided into the following five type categories:

- Merchant
- Tanker
- Ferry
- Supply
- Standby

However, for the MEHRA's project it was decided that more detailed information was required on vessel type, to more clearly distinguish between the pollution risks posed by different vessel types.

Therefore, the updated version of COAST divides vessels into the following ten categories:

Table 2.1 Vessel Types included in the Updated COAST

Code	Type	Subtypes included
1	Bulk	Bulk Carrier
		Bulk/Containership
		Cement Carrier
		Ore Carrier
		Wood-chip Carrier
		Bulk/Oil Carrier
		Ore/Oil Carrier
2	Cargo	Cargo/Training
		General Cargoship
		Multipurpose Cargoship
		Refrigerated Cargoship
		Livestock Carrier
		Containership
		Refrigerated Containership

Code	Type	Subtypes included
3	Ferry	--
4	Liquefied Gas Tanker	LPG Carrier
		LNG Carrier
		LNG/LPG Carrier
5	Ro-Ro	Ro-Ro Ship
		Ro-Ro/Containership
		Vehicle Carrier
		Passenger Ro-Ro
6	Standby Vessel	--
7	Supply Vessel	--
8	Chemical Tanker	--
9	Oil Tanker	--
10	Shuttle Tanker	-

2.5 Vessel Size Distribution

All vessel types have been divided into the following five size categories, based on dead weight tonnage:

Table 2.2 Vessel Size Categories in Dead Weight Tonnage (dwt)

Code	Size Category (dwt)
1	Under 2,000
2	2,000 to 5,000
3	5,000 to 20,000
4	20,000 to 50,000
5	Over 50,000

It was decided for this project that the five main categories provided a sufficient level of detail for the analysis, although a further three subdivisions per category are available in COAST, giving a potential 15 size categories in total.

2.6 Flag Distribution

The flags of registration of vessels operating in UK waters were divided into three categories on the basis of the frequency of serious casualties occurring to vessels of each flag state from 1994 to 1998, taking into account the number of movements by vessels of each flag (Ref. Appendix 2).

- Flag Group A - Flag states with significantly lower probability of serious casualty per vessel movement than the average (Example: Norway).

- Flag Group B - Flag states with significantly higher probability of serious casualty per vessel movement than the average (Example: Libya).

- Flag Group C - All remaining flag states.

2.7 Age Distribution

The age distribution in COAST is divided by vessel type and by vessel size. The six age categories used are as follows:

- Under 5 Years
- 5- 10 Years
- 10 - 15 Years
- 15 - 20 Years
- 20 - 25 Years
- Over 25 Years

2.8 Speed Distribution

Each vessel type has been allocated a low speed, average speed and high speed based on data from over 100 offshore surveys performed in UK waters. From these recordings, vessels were divided by type and then split into three equal categories based on speed. Within each of these categories, the average speed was calculated to give the speed of a representative slow vessel, average vessel and fast vessel of each type. These speeds are given in Table 2.3.

Table 2.3 Speed Breakdown for each Type of Vessel

Vessel Type(1)	Speed (knots)		
	Slow	Average	Fast
Bulk	9.0	11.0	14.1
Cargo	9.0	11.0	14.1
Chemical Tanker	9.7	12.7	15.2
Ferry	13.2	16.3	21.5
Liquefied Gas Tanker	9.7	12.7	15.2
Oil Tanker	9.7	12.7	15.2
Ro-Ro	13.2	16.3	21.5
Shuttle Tanker	9.7	12.7	15.2
Standby Vessel	7.1	10.5	12.5
Supply Vessel	7.1	10.5	12.5

(1) The following matches were made between the survey data vessel types and COAST vessel types:

Cargo = Bulk, Cargo
Tanker = Chemical Tanker/Liquefied Gas Tanker/Oil Tanker/Shuttle Tanker
Ferry = Ferry/Ro-Ro
Offshore = Standby/Supply

3 COMPLETED ROUTE DATABASE

This section presents plots of the shipping routes within the updated COAST database and, following this, demonstrates how the route-based shipping data was used to generate shipping density data for use in the risk models.

3.1 Overview of Shipping Routes in COAST

An overview of all the shipping routes in COAST passing through UK waters is presented in Figure 3.1. As shown on the figure, the routes have been colour-coded based on vessel type. The width of the route lines is indicative of the volume of vessels on the route (i.e., wider line = higher shipping density).

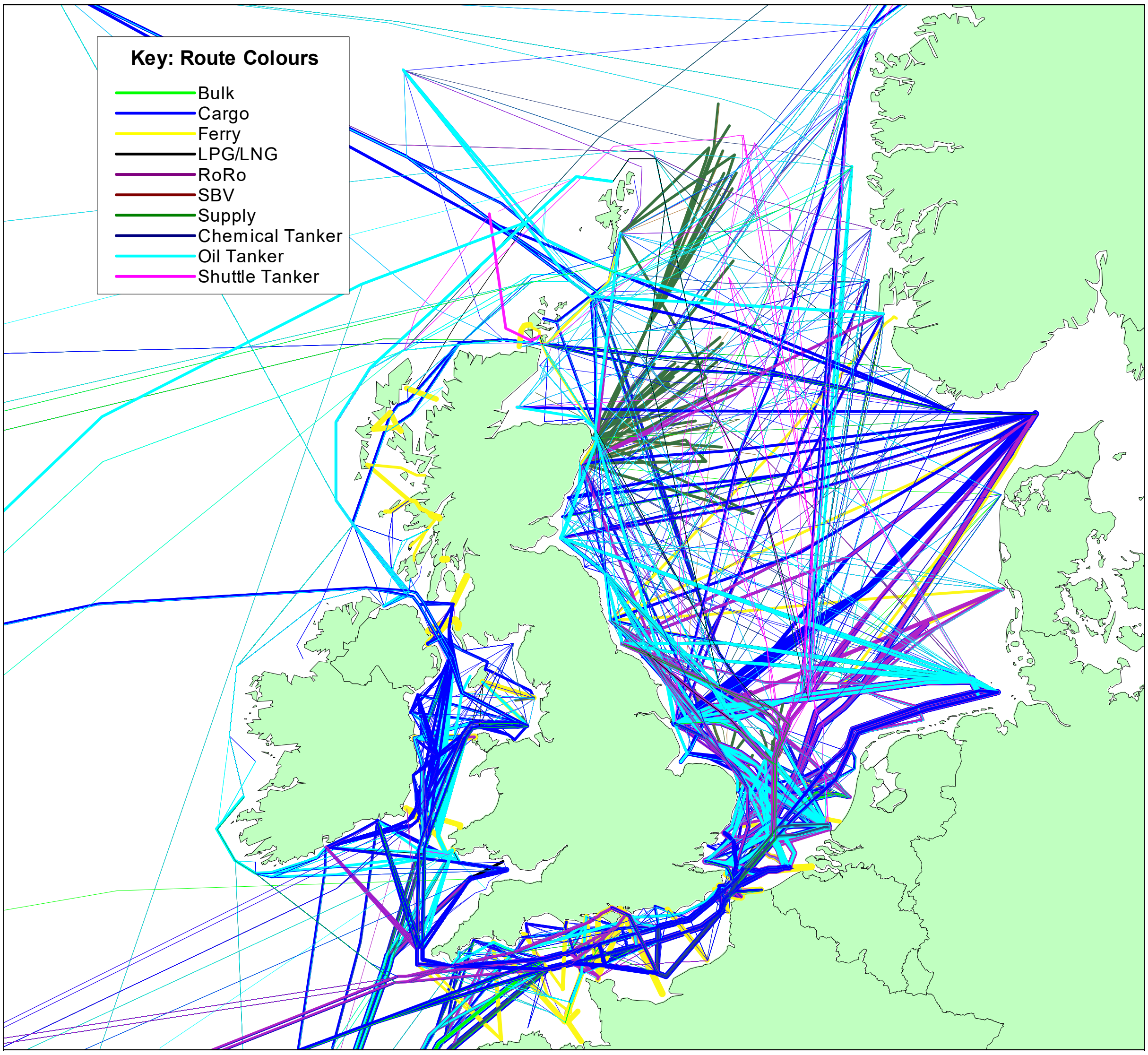

Figure 3.1 COAST Shipping Routes (All Vessel Types)

3.2 Example Route Plots

Within COAST, the facility exists to interrogate the database to isolate specific information of interest. The routes in COAST can be filtered by several criteria, such as:

- Vessel Type
- Vessel Size
- Vessel Flag
- Traffic Volume

A combination of these criteria may also be used to provide an even more detailed breakdown of the information within the COAST database.

In the following pages, example plots of the COAST shipping routes are presented. One of the main vessel types of interest in the MEHRA's project are oil and shuttle tankers. A combined plot of these vessel routes overlaid on Admiralty Chart No. 2 is presented in Figure 3.2.

Following this, further plots are presented showing routeing information for individual vessel types passing through different areas of the UK.

Figure 3.2 Oil and Shuttle Tanker Routes in COAST

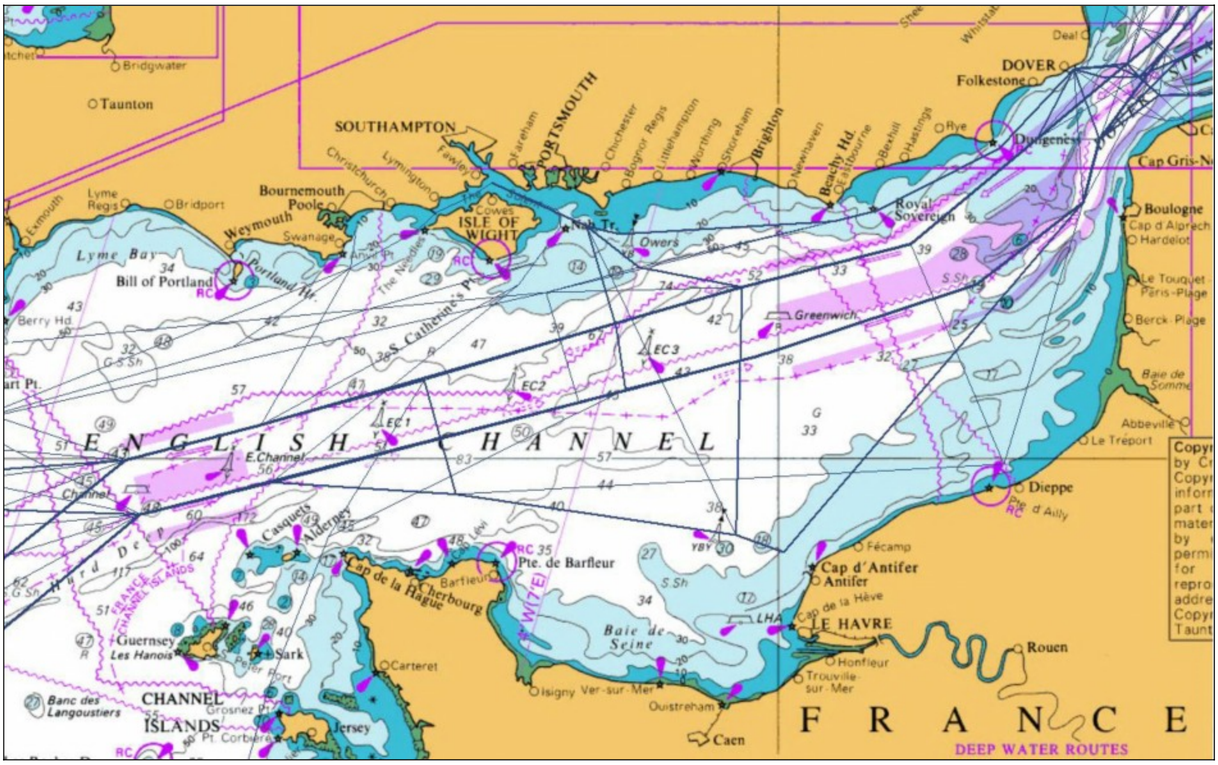

Figure 3.3 Chemical Tanker Routes in the English Channel

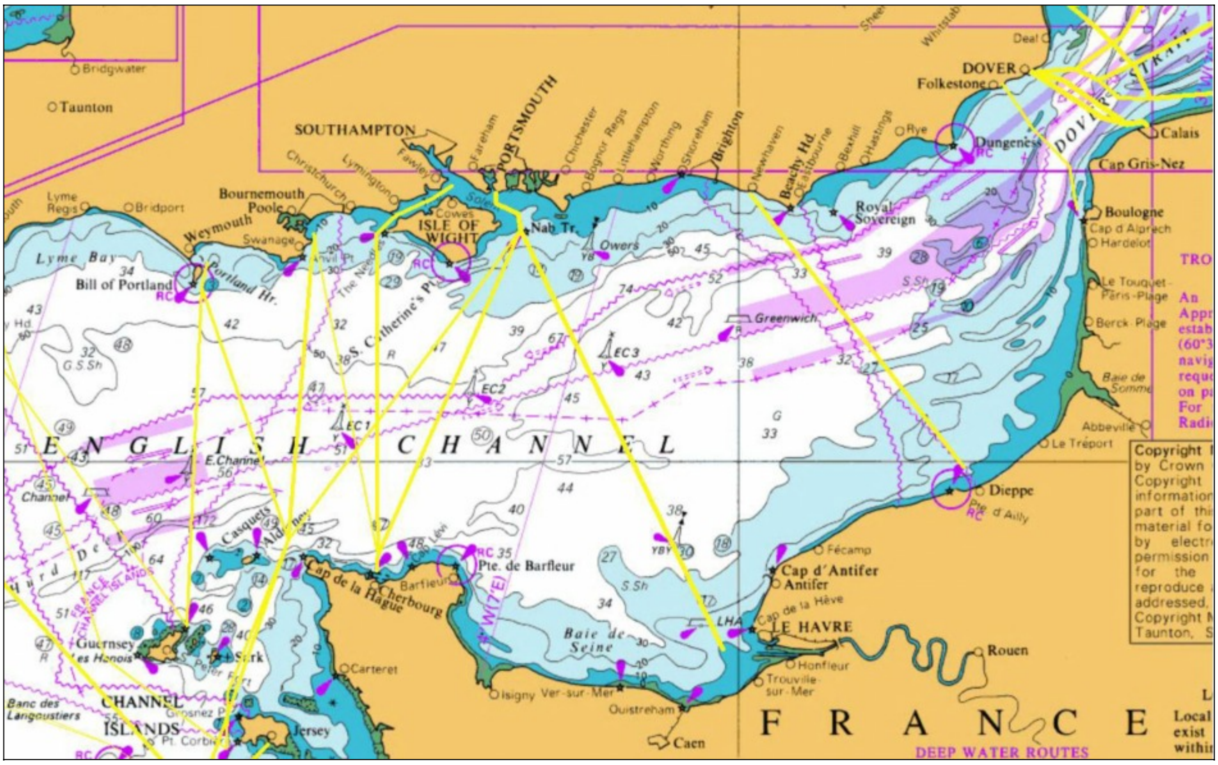

Figure 3.4 Ferry Routes in the English Channel

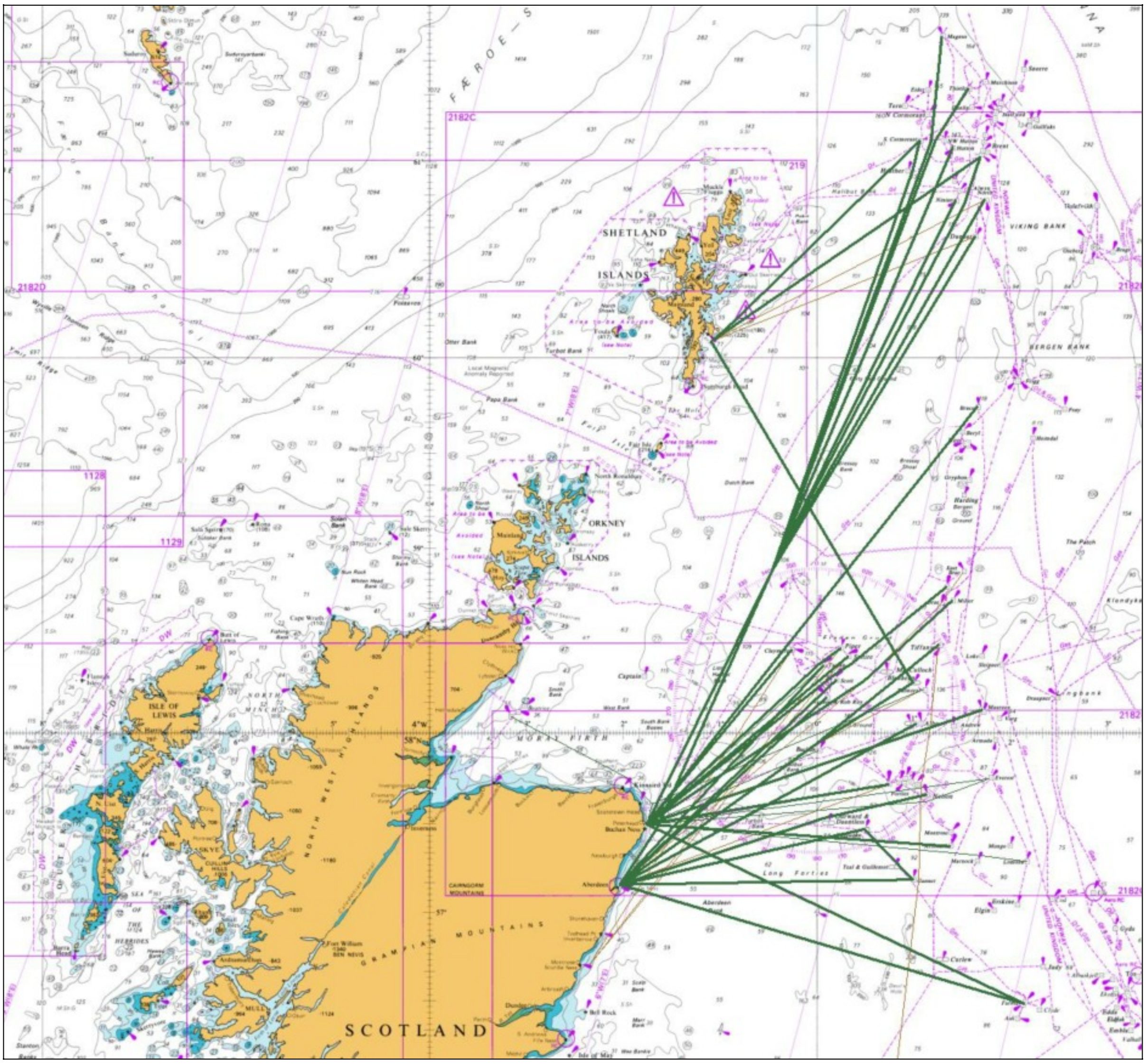

Figure 3.5 Offshore Support Vessel Routes in the Northern North Sea

3.3 Shipping Density Maps

For use in the risk models (Ref. Appendix 6), the route-based shipping data in COAST was converted to a density-based model. UK waters were divided into a grid of cells and the number of vessels passing through each cell per annum was calculated.

To demonstrate this, an overview of the cells around the UK colour-coded by vessel volume is presented in Figure 3.6. (It should be noted that although additional cells are presented, only those within UK waters are considered in the MEHRA's risk models.)

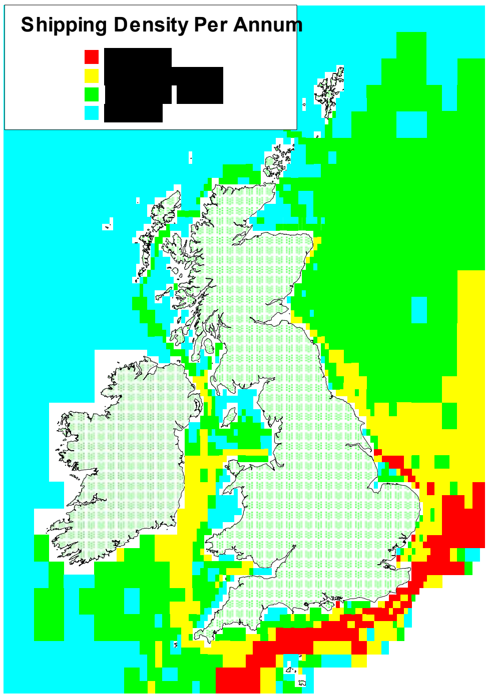

Figure 3.6 Shipping Densities in UK Waters

It can be seen from the previous figure that the areas of highest shipping density in the UK (red coloured cells corresponding to over 20,000 vessel movements per annum) are within the English Channel and to the East of the Humber Estuary.

A detailed plot of the cells within the English Channel, overlaid on an Admiralty Chart, is presented in Figure 3.7.

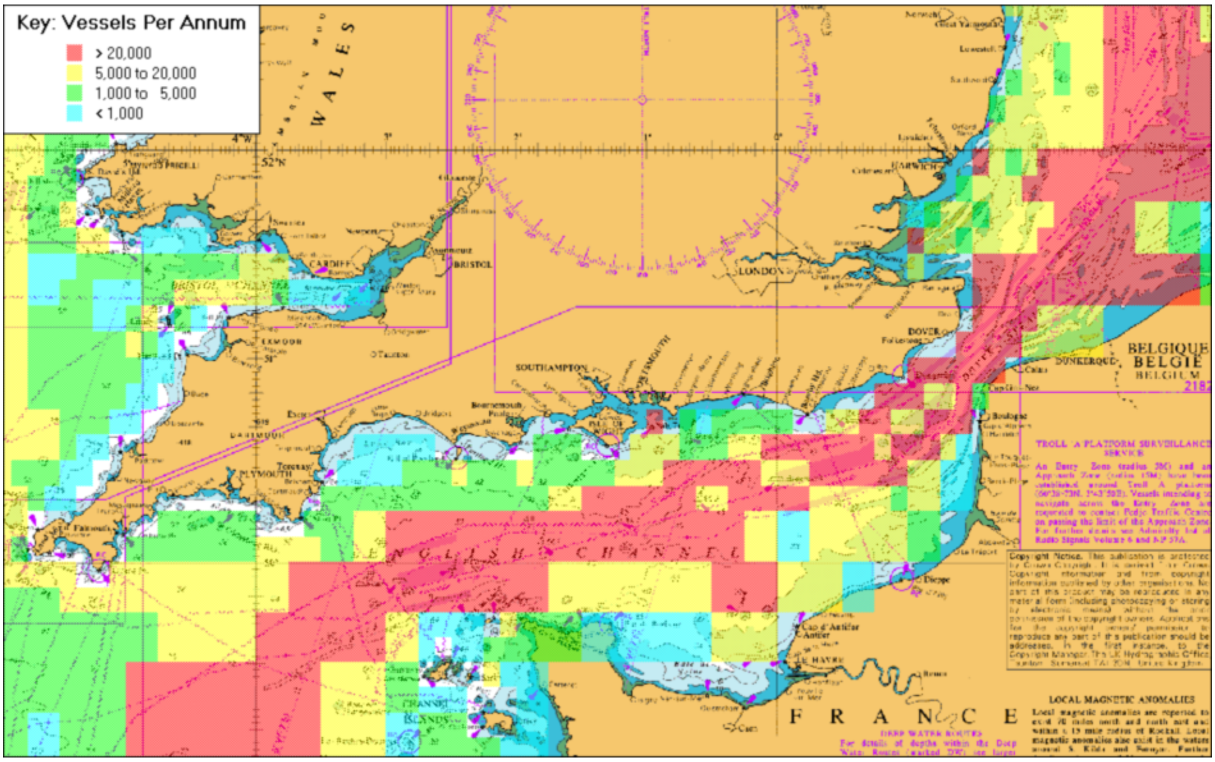

Figure 3.7 Shipping Densities within the English Channel

Similar plots can be generated to provide specific information of interest (e.g., filtered by vessel type, size, etc.). A colour-coded plot of oil tanker densities within cells in the Southern part of the UK is presented in Figure 3.8.

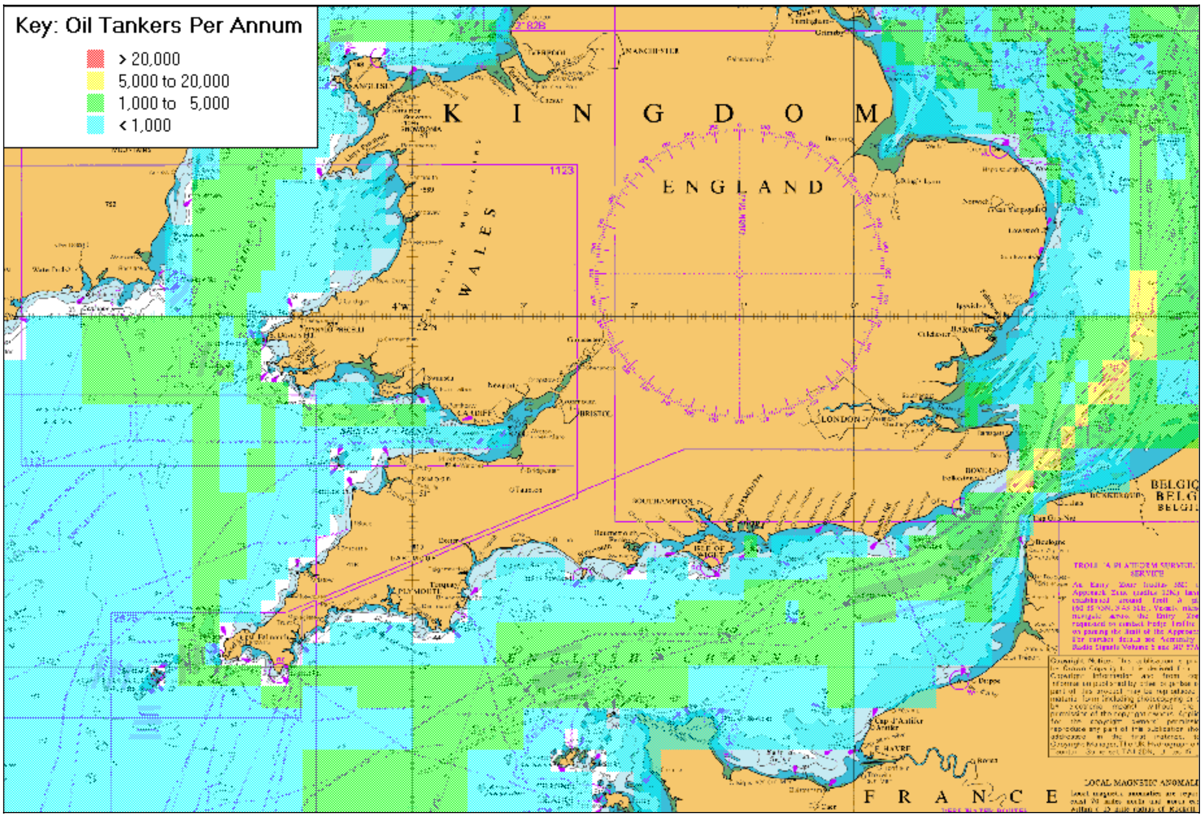

Figure 3.8 Southern UK Cells Colour-Coded Based on Annual Oil Tanker Movements

For use in the risk models, the number of vessels within each cell is stored in a database. The risk calculations are discussed in detail within Appendix 6.

4 REFERENCES

1 Dovre Safetec Ltd., Development of UKCS Vessel Traffic Database for DOT/UKOOA/HSE, Report No. DST-95-CR-110-02, May 1996.

APPENDIX 2

FACTORS INFLUENCING VESSEL RISKS IN UK WATERS

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1 REVIEW OF FACTORS INFLEUNCING VESSEL RISKS IN UK WATERS

1.1 Introduction

The objective of this appendix is to identify any factors which may affect the likelihood of serious marine incidents occurring within UK territorial waters. To achieve this, analysis was undertaken of historical data to determine which factors, if any, influence specific types of vessel incidents. Findings from this analysis were used as factors within the shipping incident frequency and oil spill risk models developed for this study. Historical data was also utilised to estimate the annual frequency for each incident type. These frequencies were then used in the calibration of the risk models.

1.2 Historical Incident Data

For the purpose of this study the Lloyd's Register Casualty Database was utilised. This database is recognised by industry as the most comprehensive database of its kind. Details are recorded on all casualties reported to have occurred to self-propelled sea going merchant vessels and tankers of 100 GRT or above world-wide since 1978. Data was obtained on all serious casualties which occurred to merchant vessels (cargo, bulk carriers, tankers, ro-ro, offshore and ferries) travelling within UK territorial waters over the period January 1989 to December 1998 (10 years). Within the database a serious casualty is defined as a casualty which results in:

1. structural damage rendering the ship unseaworthy
2. breakdown (loss of propulsion, steering etc)
3. total loss (ships foundering beyond recovery or missing ships)
4. any undefined situation resulting in damage or financial loss which is considered to be serious

It should be noted that within this study consideration is given to serious casualties encountered by vessels traversing in open seas and coastal waters and excludes incidents which occur within harbour areas, canals, rivers and lakes.

1.3 Identification of Major Marine Incidents

In the initial stages of this study a review of historical casualty data was undertaken to determine which major marine incidents have the potential to result in a detrimental effect to the marine environment. From this review it was established that there were five main categories which are listed as follows:

Ship to Ship Collision	Striking or being struck by any self propelled ship whilst at sea whether the ship is in transit or anchored and excluding collisions with any underwater vessel/wreck and self propelled oil installations.

Fire & Explosion	Accidents where fire and/or explosion is the first event reported. Casualties involving fires and/or explosions after collision stranding etc. are categorised under "Collision", "Stranding" etc.
Foundering & Structural Failure	Includes ships which sank or were damaged as a result of hull failure, heavy weather damage, springing leaks, breaking in two etc., and not as a consequence of the other defined casualties.
Powered Grounding	Includes grounding, bumping over bars, striking underwater wrecks and ships, reported hard and fast for an appreciable period of time, and cases reported as touching bottom when the reporting ship is under power.
Drifting Grounding	Includes grounding, bumping over bars, striking underwater wrecks and ships, reported hard and fast for an appreciable period of time and cases reported as touching bottom when the reporting ship is adrift due to loss of power, steering or due to adverse weather conditions which cause a moored vessel to drag anchor.

1.3.1 Frequency of Incidents

Initial analysis of the data identified a total of 341 reported incidents between 1989 and 1998. Figure 1.1 presents a breakdown of these incidents into the five major accident groups identified in the previous section.

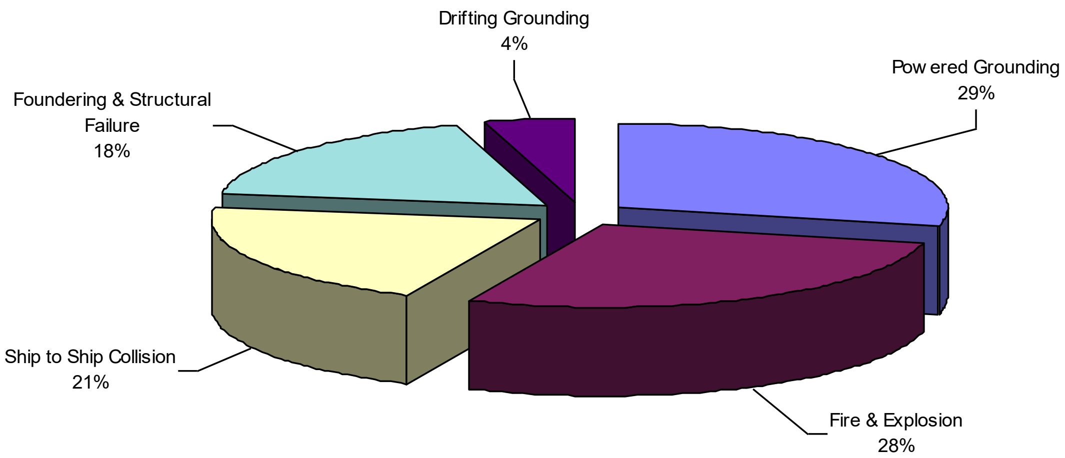

Figure 1.1 Breakdown of Serious Casualties by Accident Group – 1989 to 1998

From Figure 1.1 it can be seen that powered groundings are the most frequent incident type closely followed by fire and explosions whilst drifting grounding incidents are the least common.

These major accident groups were isolated within the database to allow further, more in-depth analysis to be carried out. Within this analysis various factors such as ship's age, size and type were assessed as well as the environmental conditions at the time of each incident to establish if any underlying trends exist which influence the likelihood of each incident type occurring. The following sub-sections present the results of this analysis.

1.3.2 Ship to Ship Collision

Review of the casualty data for vessels of 100 GRT or greater identified a total of 70 ship to ship collisions, which occurred to vessels travelling within the UKCS between 1989 and 1998. This equates to an average of 7 collisions per annum. The distribution of these incidents by vessel type, age and size are presented in Figure 1.2, Figure 1.3 and Figure 1.4, respectively.

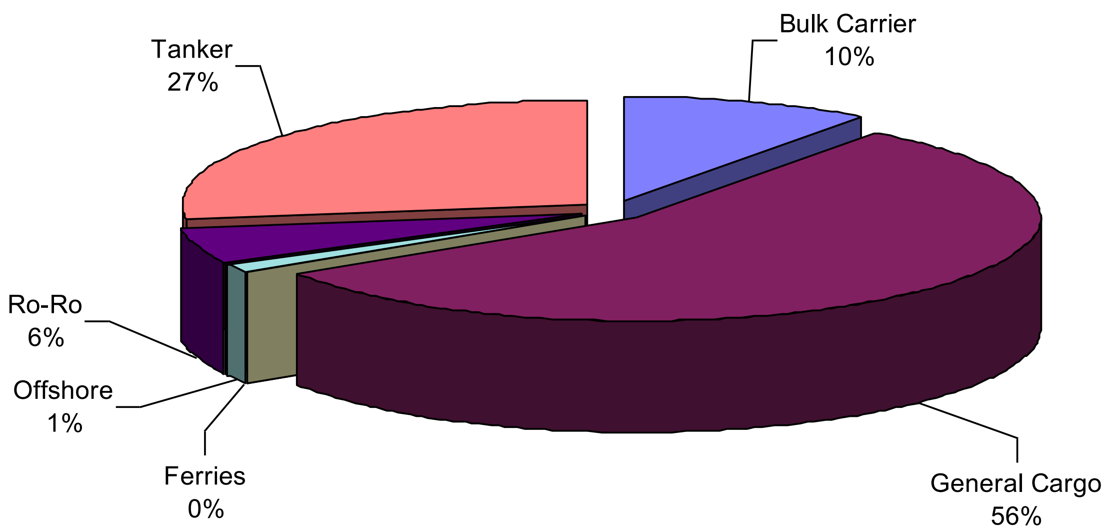

Figure 1.2 Distribution by Vessel Type for Ship to Ship Collisions (1989-1998)

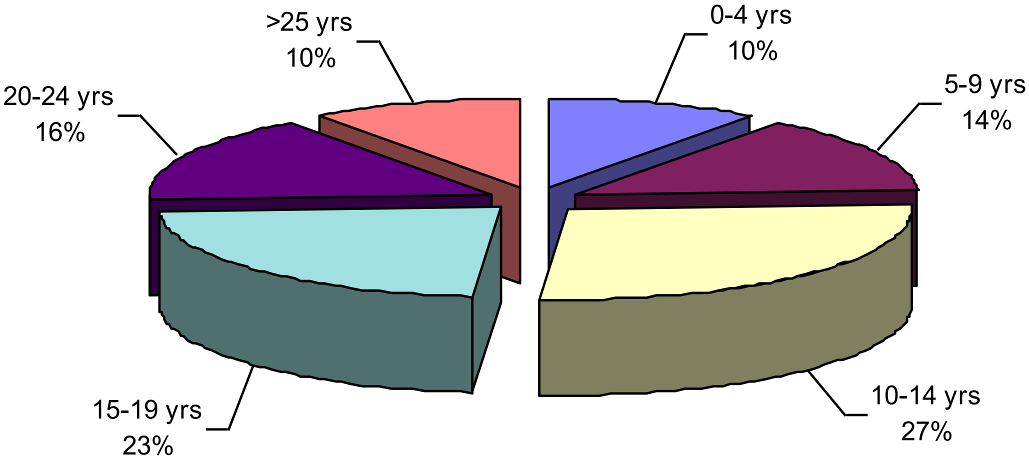

Figure 1.3 Distribution by Vessel Age for Ship to Ship Collisions (1989-1998)

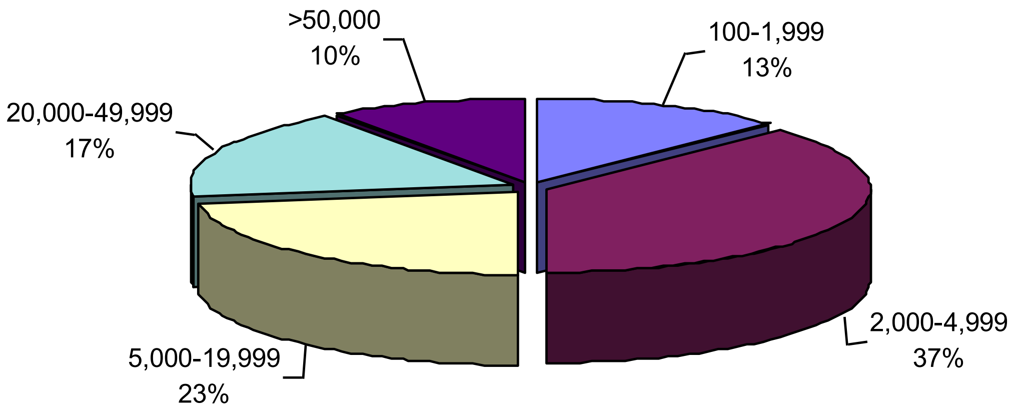

Figure 1.4 Distribution by Vessel Size (in dwt) for Ship to Ship Collisions (1989-1998)

From the casualty statistics and the COAST route database a frequency of ship to ship collision per vessel movement was estimated to be 9.35 x 10^{-6}. This value was calculated by dividing the average number of collisions per annum by the total number of movements for merchant ships travelling through the UKCS on a per annum basis. It is acknowledged that there is a limitation associated with this estimate, in that the shipping traffic data (number of movements) is from 1998, whereas the incident data stretches over a 10 year period, with variations in the volumes likely over this period. Nevertheless, the figures should be of the correct order of magnitude.

Figure 1.5 presents the ratio of incidents by vessel type against the annual frequency for ship to ship collision, which has been re-calibrated to an industry average of 1.0. This provides an effective means of comparing any individual group character with the "*industry average*" i.e. any value greater than one shows a higher than average incident rate while a value less than one indicates a lower than average rate.

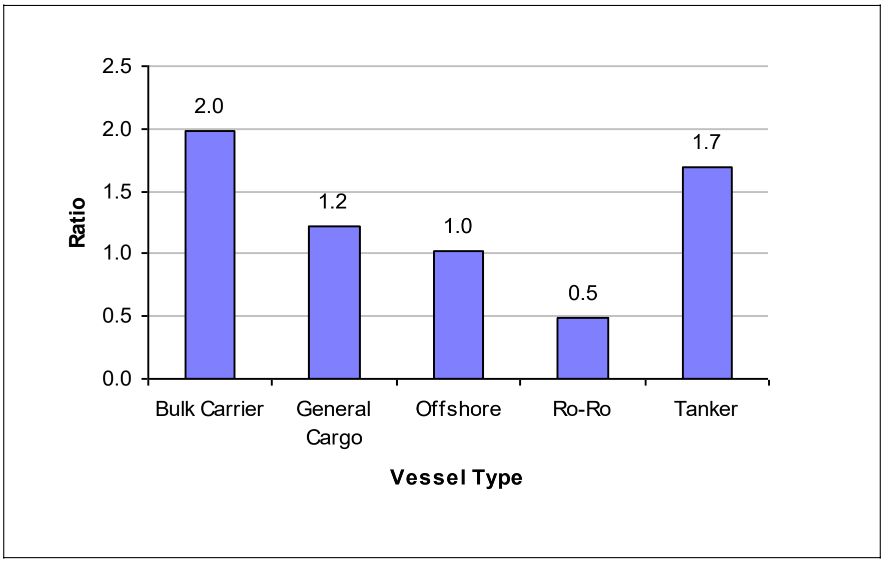

Figure 1.5 Ratio of Incidents by Vessel Type for Ship to Ship Collision

From Figure 1.5 it can be seen that bulk carriers are approximately twice as likely to be involved in a scenario as the average merchant vessel, and four times more likely than a Ro-Ro vessel.

Figure 1.6 presents the ratio of incidents by vessel age based on the industry average for ship to ship collisions giving due consideration to the total number of vessels in each category.

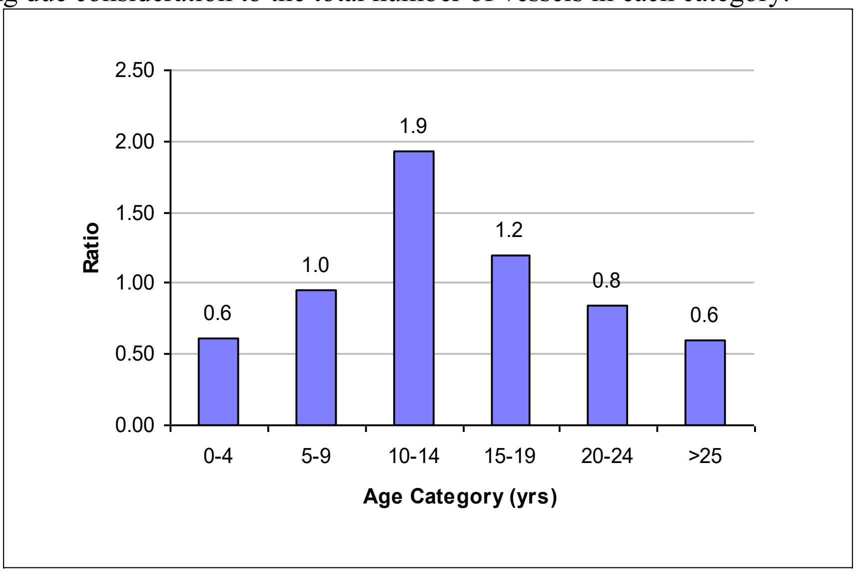

Figure 1.6 Ratio of Incidents by Vessel Age for Ship to Ship Collisions

From this figure it can be seen that there is increased likelihood of ship to ship collision for vessels aged between 5 and 15 years. It is noted that newer vessels are less likely to be involved in collision incidents compared to the industry average which may be due to the fact that these vessels tend to be operated by experienced and well trained personnel. With the increase in age many vessels change hands and although the original shipowner may have operated with high standards the second-hand buyer tends to operate to a tighter budget and will often opt to sail under the flag of whatever nation tolerates the lowest and cheapest standards. This action by smaller ship owners is considered to increase the likelihood of the older vessel being involved in a collision. However, it has also been noted that after 15 years there is a steady decrease in the likelihood of collision.

Figure 1.7 presents the ratio of incidents by vessel size based on the industry average for ship to ship collisions giving due consideration to the total number of vessels in each size category.

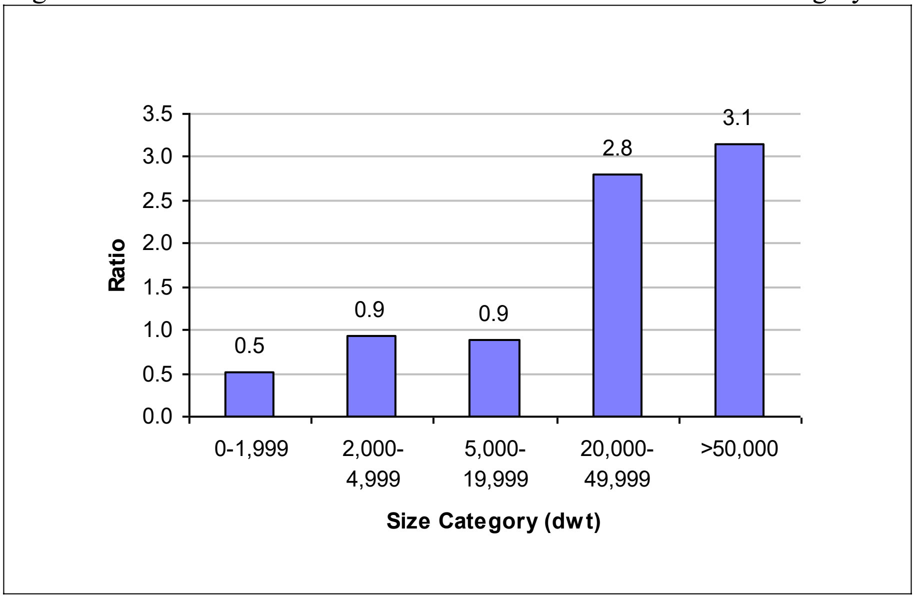

Figure 1.7 Ratio of Incidents by Vessel Size for Ship to Ship Collision

It can be seen from the figure above that there is a steady increase in the likelihood of ship collision with increase in vessel size. It is considered that this is due to the fact that smaller vessels present a smaller collision target area and are generally more manoeuvrable then larger vessels and therefore have a greater ability to avoid collisions.

1.3.2.1 Environmental Conditions - Ship to Ship Collisions

Figure 1.8 presents a breakdown of the weather conditions that were reported at the time of each incident.

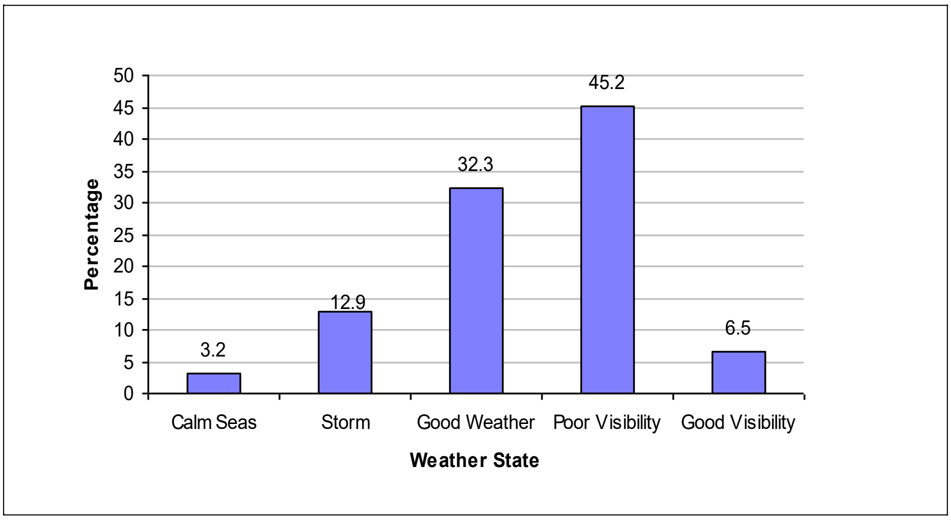

Figure 1.8 Breakdown of Weather Conditions during Ship to Ship Collision Incidents

It is only possible to identify broad trends as the reporting of weather conditions by LLP is not "scientific" and therefore Met Office data cannot be used to quantify the occurrence of each weather condition per year. However, it appears that the likelihood of ship to ship collision is higher in poor visibility.

1.3.3 Fire and Explosion

Review of the casualty data identified a total of 95 fire and explosion incidents, which occurred to vessels travelling within the UKCS between 1989 and 1998. This equates to an average of 9.5 incidents of this type per annum. The distribution of these incidents by vessel type, age and size are presented in Figure 1.9,Figure 1.10 and Figure 1.11.

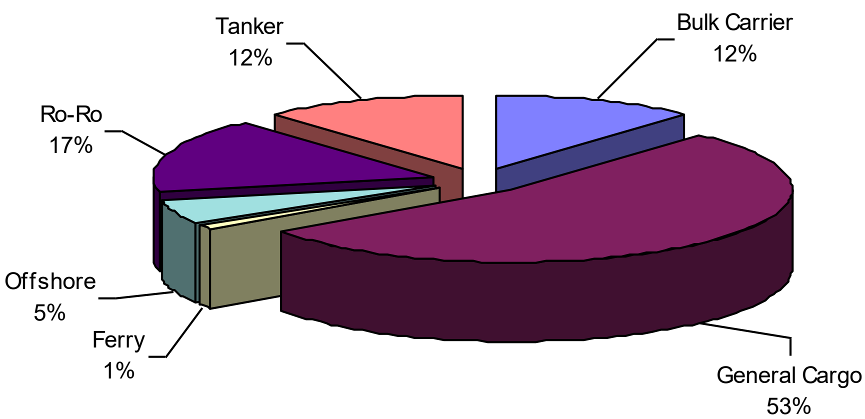

Figure 1.9 Distribution by Vessel Type for Fire and Explosion (1989-1998)

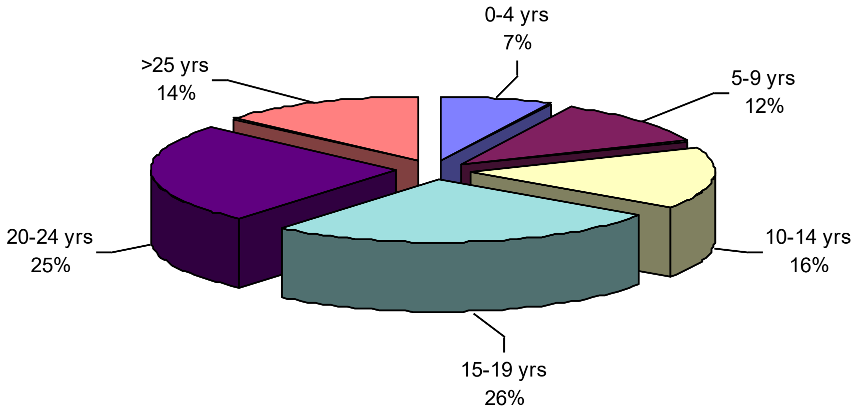

Figure 1.10 Distribution by Vessel Age for Fire and Explosion (1989-1998)

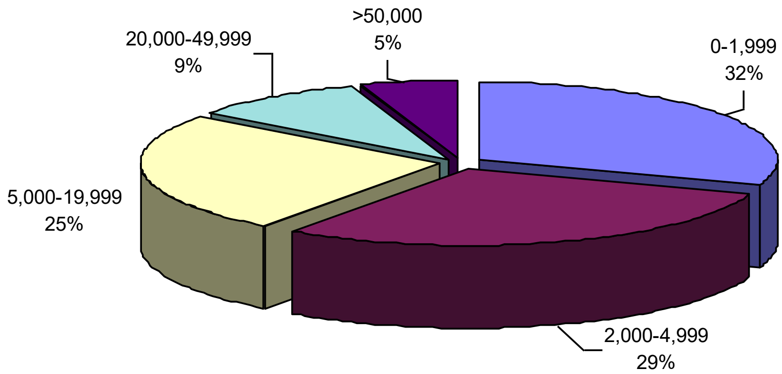

Figure 1.11 Distribution by Vessel Size (in dwt) for Fire and Explosion (1989-1998)

From the casualty statistics and the COAST route database the frequency of a fire and explosion incident occurring per vessel movement was estimated to be 1.27 x 10^{-5}. This value was calculated by dividing the average number of fire and explosions per annum by the total number of movements for ships travelling through the UKCS. Figure 1.12 presents the ratio of incidents by vessel type against the industry average for fire and explosions which has been set as a base value of 1.0. It should be noted that consideration was given to the number of vessels in each type category.

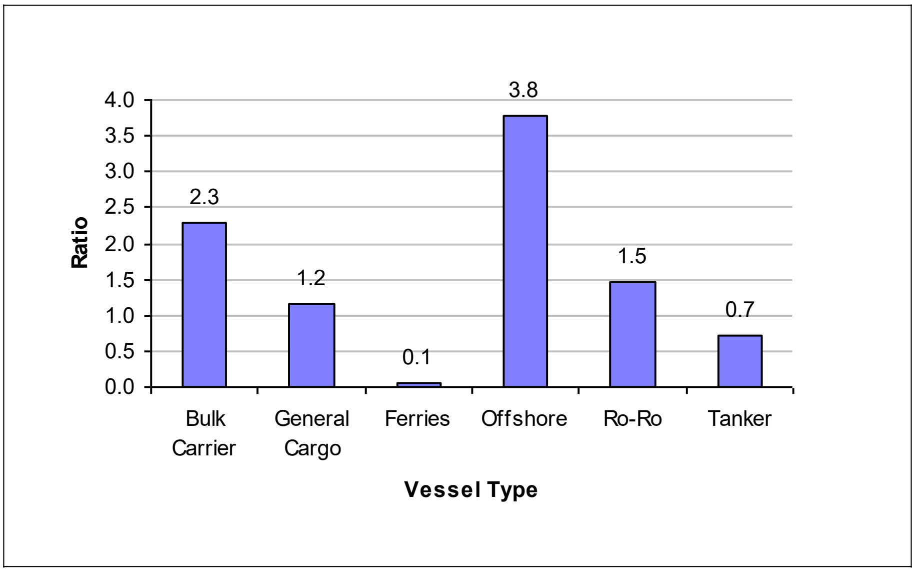

Figure 1.12 Ratio of Incidents by Vessel Type for Fire and Explosions

From Figure 1.12 it can be seen that ferries recorded a very low ratio of 0.1 with the respect to the industry average while offshore support vessels showed an unexpectedly high ratio of 3.8. This may be due to the strict operating conditions that ships operate under in the oil industry which makes them more likely to report such incidents. However, it is considered that there is insufficient information to draw a definite conclusion.

Figure 1.13 presents the ratio of incidents by vessel age against the industry average for fire and explosion incidents and gives due consideration to the total number of vessels in each age category.

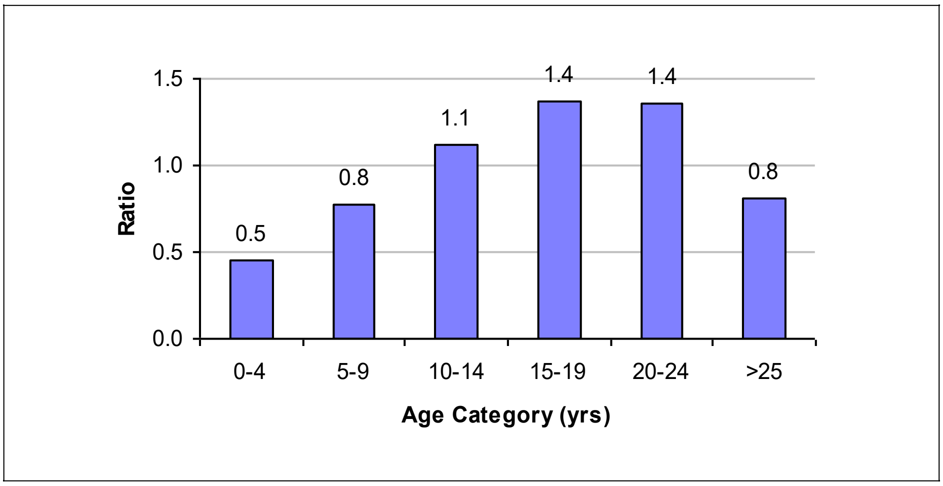

Figure 1.13 Ratio of Incidents by Vessel Age for Fire and Explosion

From the figure above it can be seen that in general there is an increase in the likelihood of a vessel suffering from a fire or explosion incident with increase in age, with the exception of vessels over 25 years. This may be due to the fact that with age many components within the engine room, where the vast majority of fire and explosions occur, become prone to failure. However this does not explain the unexpected drop within the final category.

Figure 1.14 presents the ratio of incidents by vessel size against the industry average for fire and explosion giving due consideration to the total number of vessel in each size category.

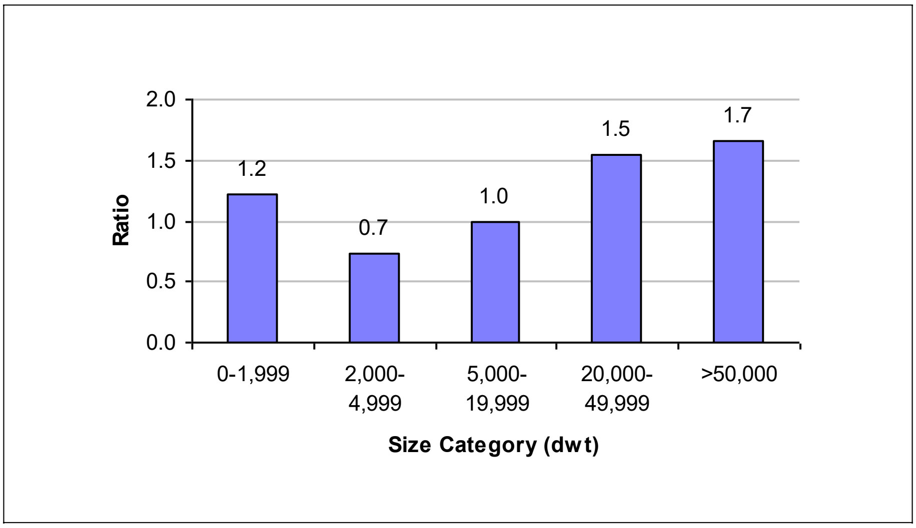

Figure 1.14 Ratio of Incidents by Vessel Size for Fire and Explosions

From Figure 1.14 it can be seen that for vessel size the ratios for fire and explosion with respect to the industry average range from 0.7 for vessels in size category 2,000-4,999 dwt to 1.6 for vessels greater than 50,000 dwt. There is no clear trend between the size of vessels and the likelihood of them suffering a fire or explosion scenario.

1.3.3.1 Environmental Conditions – Fire and Explosion

Due to the nature of fires and explosions it is considered that these incidents occur independently of external conditions and therefore no further analysis was undertaken with regard to environmental conditions.

1.3.4 Foundering and Structural Failure

Review of the casualty data identified a total of 73 incidents under the category of foundering and structural failure, which occurred within the UKCS between 1989 and 1998. This equates to an average of 7.3 incidents of this type per annum. The distribution of these incidents by vessel type, age and size are presented in Figure 1.15, Figure 1.16 and Figure 1.17, respectively.

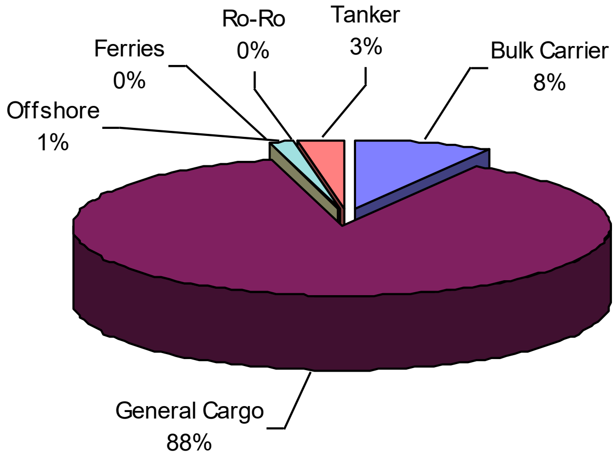

Figure 1.15 Distribution by Vessel Type for Foundering and Structural Failure (1989-1998)

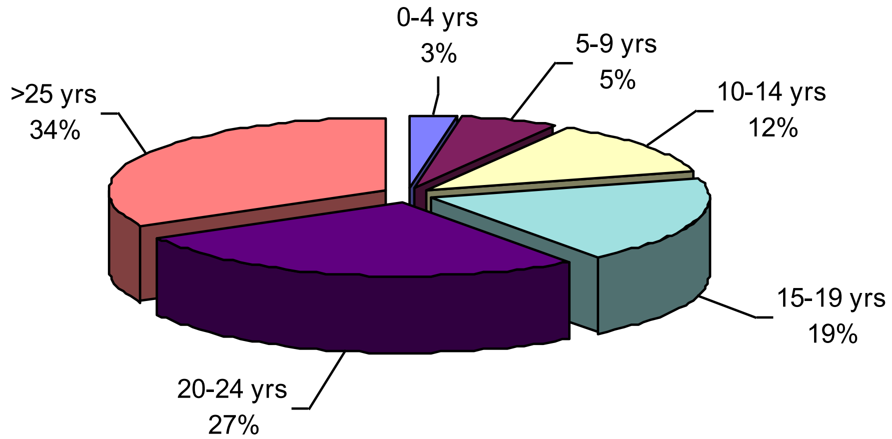

Figure 1.16 Distribution by Vessel Age for Foundering and Structural Failure (1989-1998)

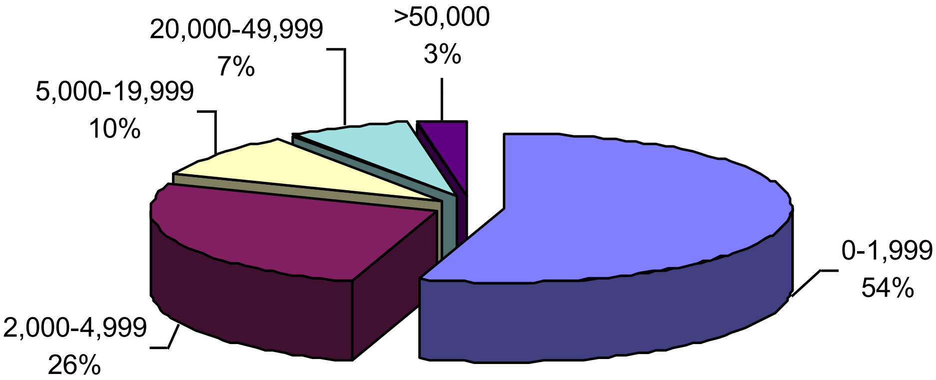

Figure 1.17 Distribution by Vessel Size for Foundering and Structural Failure (1989-1998)

From the casualty statistics and the COAST route database the frequency of a foundering or structural failure occurring per vessel movement was estimated to be 9.75×10^{-6}. This value was calculated by dividing the average number of foundering and structural incidents per annum by the total number of movements for ships travelling through the UKCS. Figure 1.18 presents the ratio of incidents by vessel type against the industry average, for foundering and structural failures which has been set as a base value of 1.00. It should be noted that consideration is also given to the number of vessels within each category.

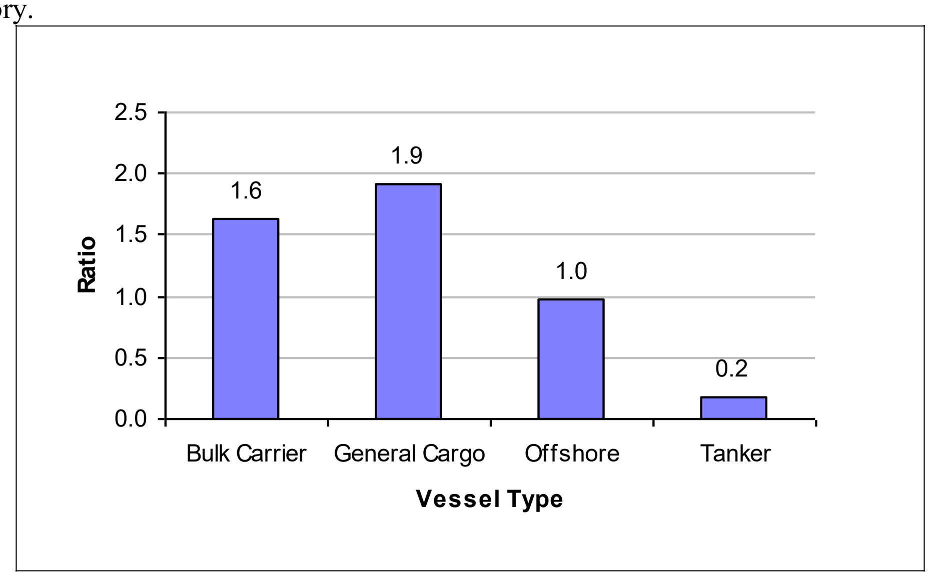

Figure 1.18 Ratio of Incidents by Vessel Type for Foundering and Structural Failure

From the figure above it can be seen that there were only four vessel categories (Bulk Carriers, General Cargo, Offshore Vessels and Tankers) which reported incidents of this nature. With respect to the industry average it can be seen that the ratios with regard to foundering and structural failure range from a minimum of 0.2 to a maximum of 1.9. It is also noted that both bulk carriers and general cargo vessels have a greater than average chance of incurring this type of incident.

Figure 1.19 presents the ratio of incidents by vessel age against the industry average for foundering and structural failure giving due consideration to the number of vessels in each age category.

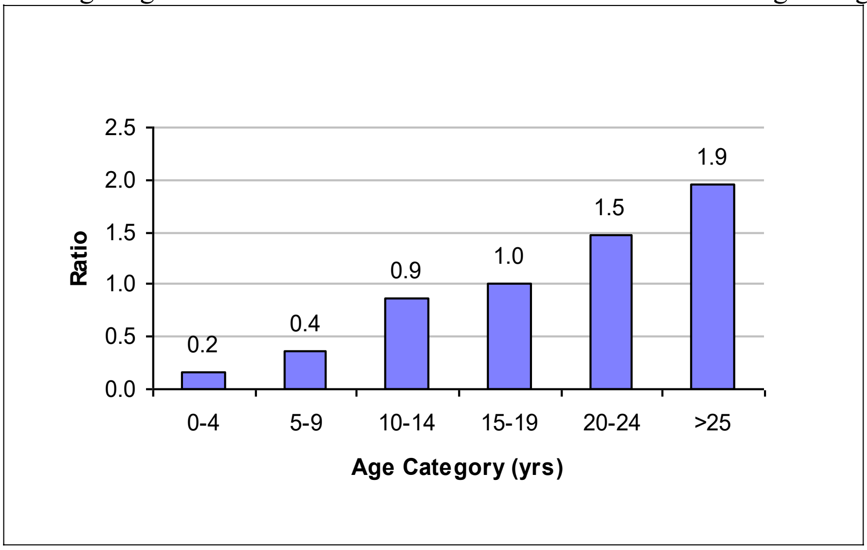

Figure 1.19 Ratio of Incidents by Vessel Age for Foundering and Structural Failure

From Figure 1.19 it can be seen that there is a definite trend with regard to the age of vessels and the likelihood of foundering or structural failure. This is as expected and is considered to be a result of deterioration of hull due to corrosion stresses and fractures.

Figure 1.20 presents the ratio of incidents by vessel size based on the industry average for foundering and structural failures giving due consideration to the number of vessels in each category.

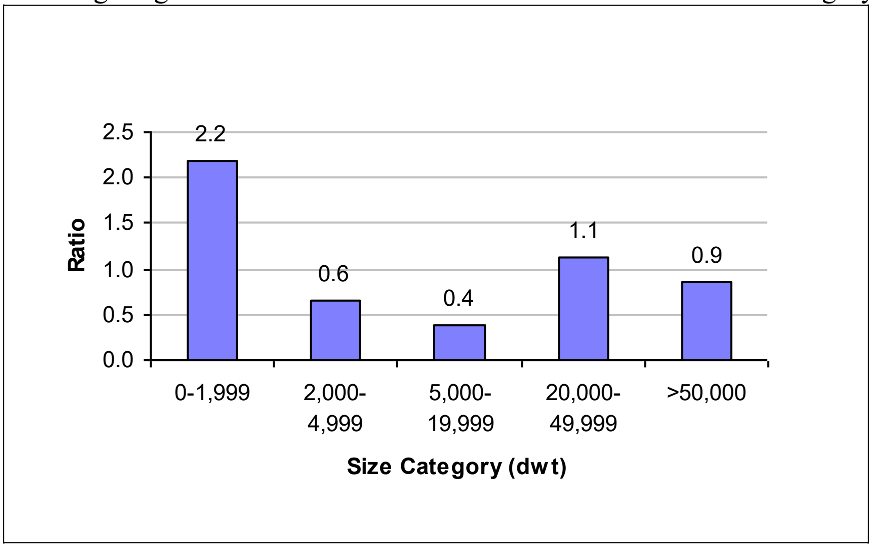

Figure 1.20 Ratio of Incidents by Vessel Size for Foundering and Structural Failure

From Figure 1.20 it can be seen that for vessel size the ratios vary from a minimum of 0.4 for vessels in size category 5,000-20,000 dwt to a maximum of 2.2 for vessels less than 2,000 dwt.

1.3.4.1 Environmental Conditions – Foundering and Structural Failure

Of the incidents of foundering and structural failures, which occurred between 1989 and 1998, approximately 98% were reported to have happened in rough seas with the remaining 2% occurring in calm waters. This indicates as expected, that seastate does influence the likelihood of a vessel foundering or suffering from a structural failure.

This may be due to the fact that during rough seas large waves often break over the vessel deck (green water) which results in a large ingress of water causing foundering. It is also noted that severe seas increase the stresses placed upon vessel hulls, increasing the likelihood of structural failure.

1.3.5 Powered Grounding

Review of the casualty data identified a total of 98 powered groundings, which occurred to vessels travelling within the UKCS between 1989 and 1998. This equates to an average of 9.8 powered groundings per annum. The distribution of these incidents by vessel type, age and size are presented in Figure 1.21, Figure 1.22 and Figure 1.23, respectively.

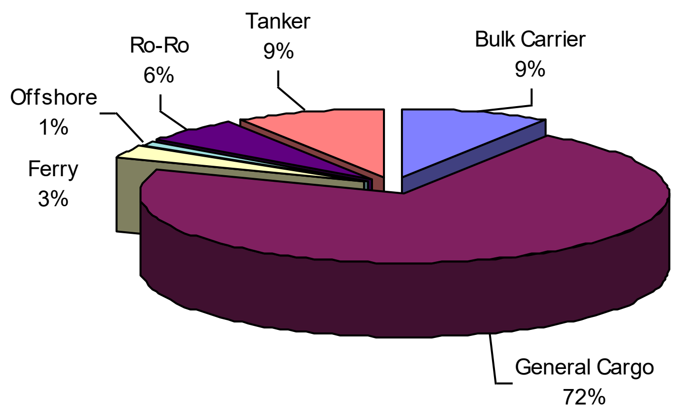

Figure 1.21 Distribution by Vessel Type for Powered Groundings (1989-1998)

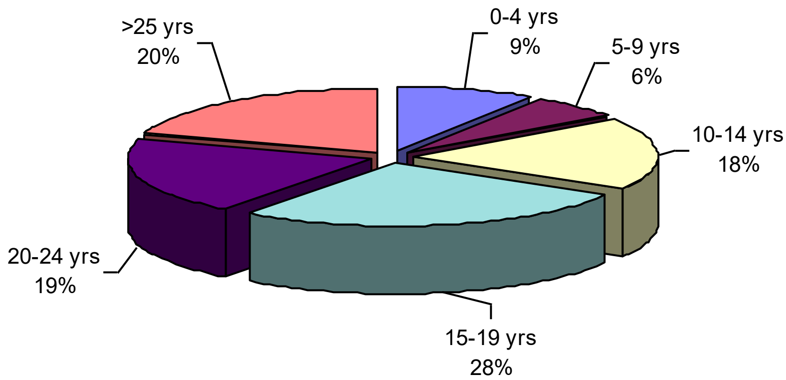

Figure 1.22 Distribution by Vessel Age for Powered Groundings (1989-1998)

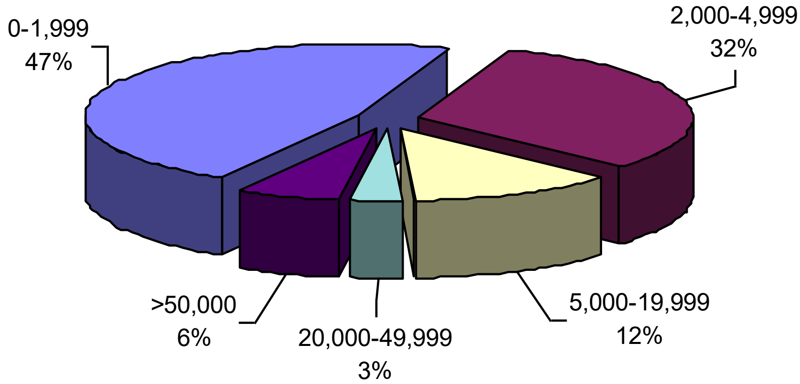

Figure 1.23 Distribution by Vessel Size for Powered Groundings (1989-1998)

From the casualty statistics and the COAST route database a frequency for powered grounding per vessel movement was estimated to be 1.31 x 10^{-5}. This value was calculated by dividing the average number of powered groundings per annum by the total number of movements for ships travelling through the UKCS. Figure 1.24 presents the ratio of incidents by vessel type against the industry average for fire and explosions which has been set as a base value of 1.0. It should be noted that consideration is also given to the number of vessels within each category.

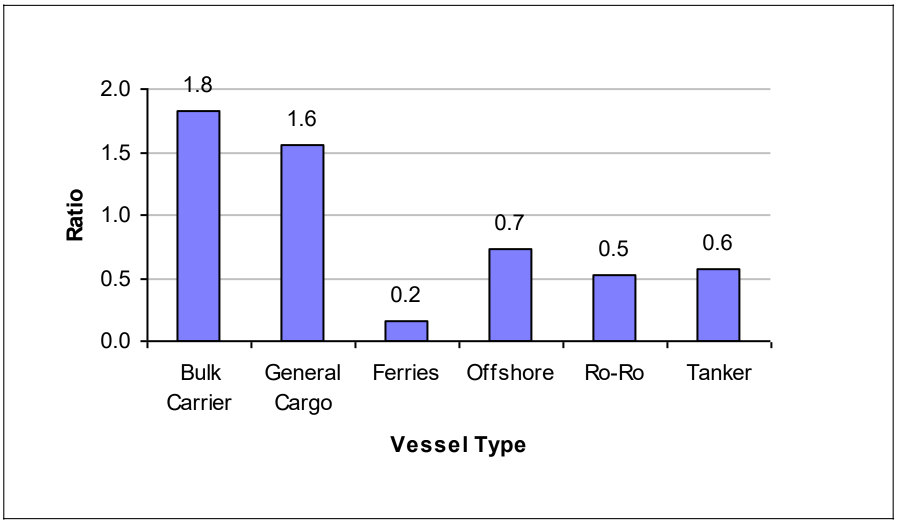

Figure 1.24 Ratio of Incidents by Vessel Type for Powered Grounding

With respect to the industry average it can be seen that the ratios for vessel type, with regard to powered grounding, range from a minimum of 0.2 for ferries to a maximum of 1.8 for bulk carriers.

Figure 1.25 presents the ratio of incidents by vessel age based on the industry average for powered groundings, giving due consideration to the number of vessels in each category

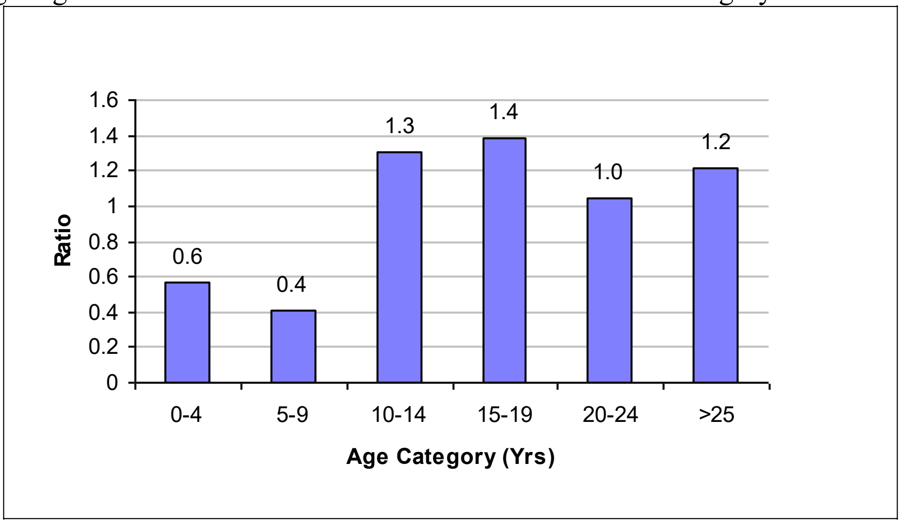

Figure 1.25 Ratio of Incidents by Vessel Age for Powered Grounding

Therefore, vessels under 10 years old are less likely to be involved in a powered grounding compared to the industry average, while those over 10 years old are more likely. As previously discussed this may be due to older vessels being operated by less experienced personnel and to lower than average standards.

Figure 1.26 presents the ratio of incidents by vessel size category based on the industry average for powered grounding giving due consideration to the number of vessels in each category.

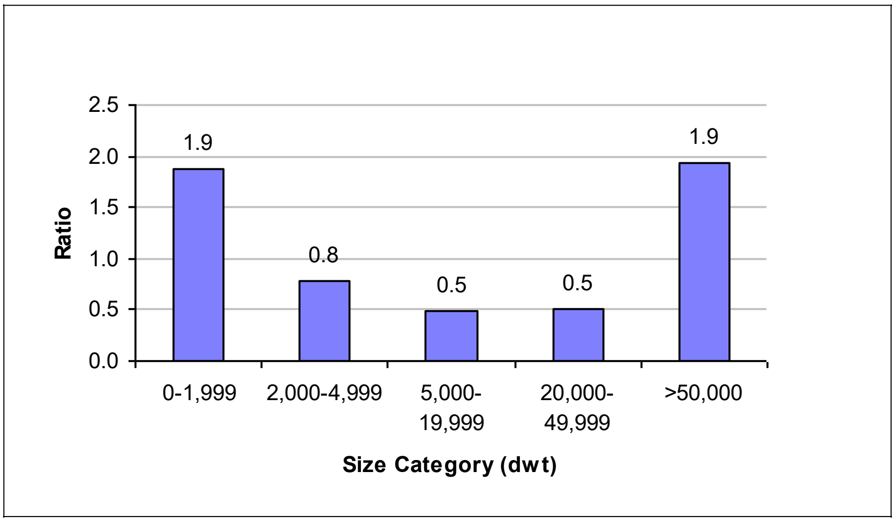

Figure 1.26 Ratio of Incidents by Vessel Size for Powered Grounding

From Figure 1.26 it can be seen that for vessel size the ratios for powered groundings vary from a low of 0.5 to a high of 1.9. It is noted that vessels of less than 1,999 DWT and greater than 50,000 DWT show a high likelihood of grounding with respect to the industry average while vessels which fall into the remaining categories show a lower than average likelihood of grounding. However this does not seem to indicate that there is any underlying trend with regard to vessel size.

1.3.5.1 Environmental Conditions

Figure 1.27 presents the breakdown of reported weather conditions for powered grounding incidents which occurred between 1989 and 1998.

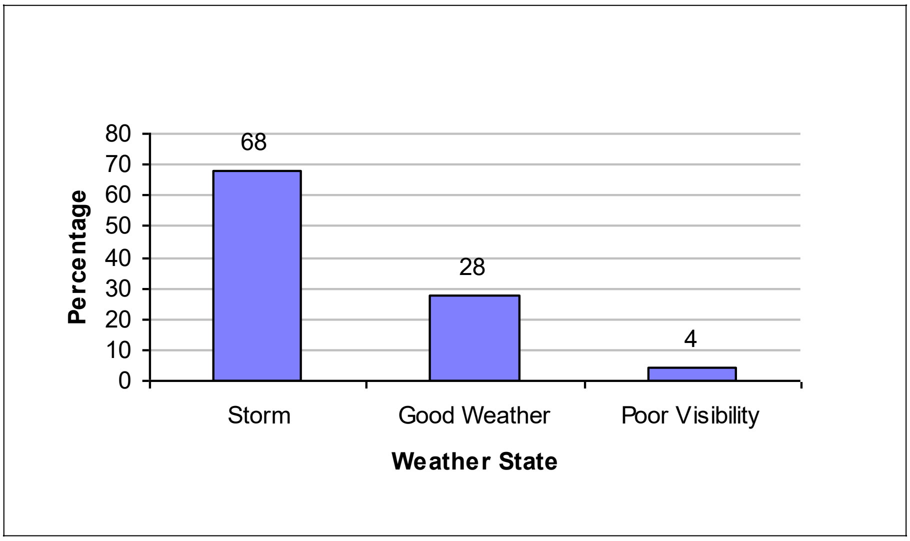

Figure 1.27 Breakdown of Weather Conditions for Powered Grounding Incidents

From the general trend in Figure 1.27 it is apparent that storm conditions significantly increase the likelihood of powered grounding.

1.3.6 Drifting Grounding

Review of the casualty data identified a total of 15 drifting grounding incidents which occurred within the UKCS between 1989 and 1998 This equates to an average 1.5 drifting groundings per annum. The distribution of these incidents by vessel type, age and size are presented in Figure 1.28, Figure 1.29 and Figure 1.30, respectively.

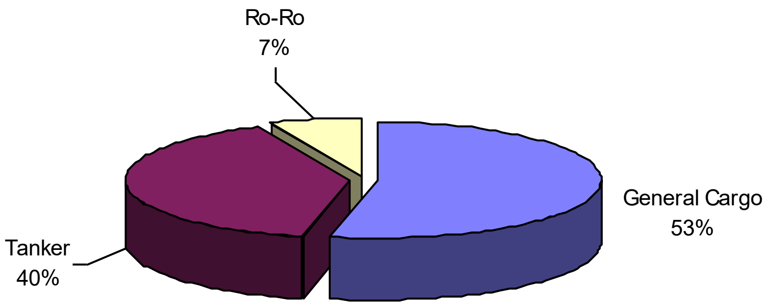

Figure 1.28 Distribution by Vessel Type for Drifting Grounding (1989-1998)

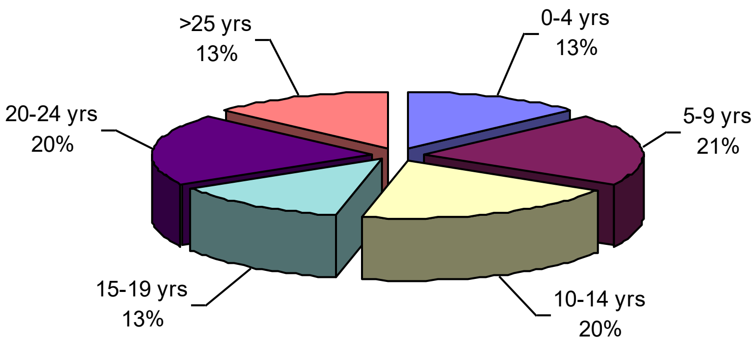

Figure 1.29 Distribution by Vessel Age for Drifting Grounding (1989-1998)

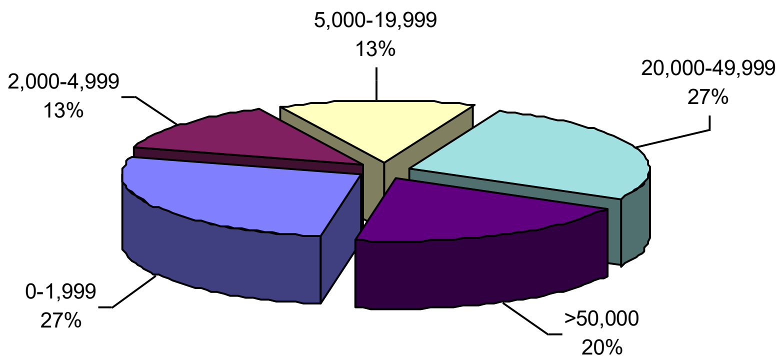

Figure 1.30 Distribution by Vessel Size for Drifting Grounding (1989-1998)

From the casualty statistics and the COAST route database a frequency for drifting grounding per vessel movement was estimated to be 2.0 x 10^{-6}. This value was calculated by dividing the average number of drifting grounding incidents per annum by the total number of movements for ships travelling through the UKCS. Figure 1.31 presents the ratio of incidents by vessel type against the industry average for drifting grounding which has been set as a base value of 1.0. It should be noted that consideration is also given to the number of vessels within each category.

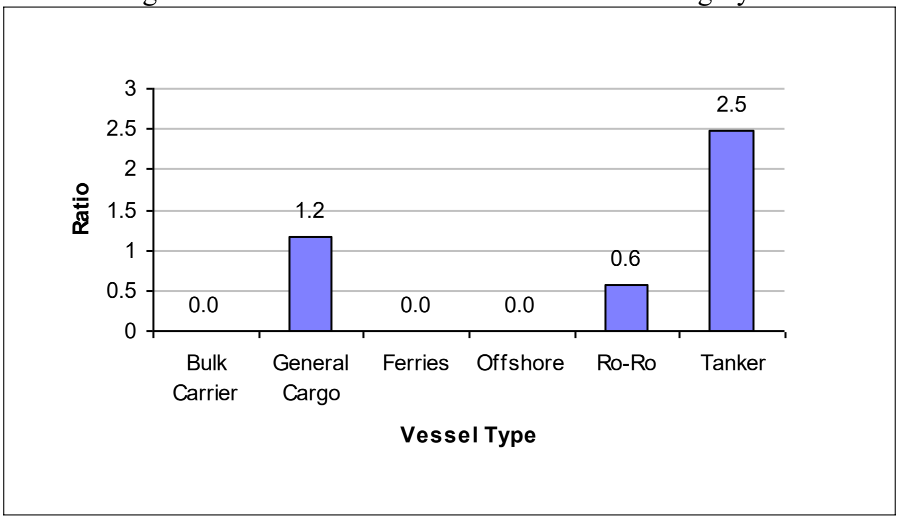

Figure 1.31 Ratio of Incidents by Vessel Type for Drifting Grounding

From the figure above it can be seen that there were only three vessel categories (Bulk Carriers, Offshore Vessels and Tankers) which reported incidents of this nature. With respect to the industry average it can be seen that the ratios with regard to drifting grounding range from a minimum of 0.6 for Ro-Ro's to a maximum of 2.5 for tankers. It is considered that the reason tankers are at greater risk from drifting grounding is a result of their generally large size, which reduces the likelihood of recovery vessels (tugs), being able to recover such vessels from their hazardous course (see Figure 1.33).

Figure 1.32 presents the ratio of incidents by vessel age based on the industry average for drifting groundings giving due consideration to the number of vessel in each age category

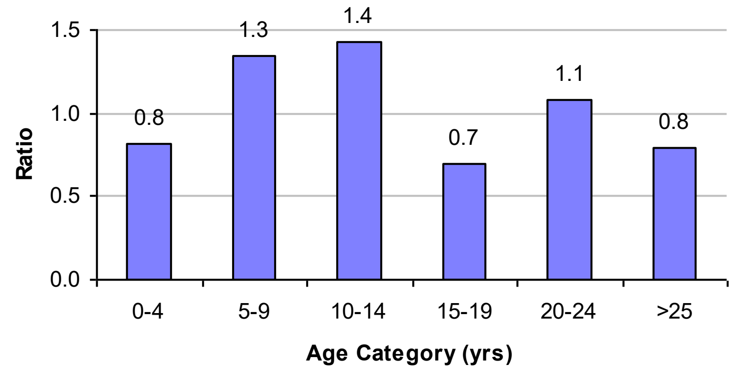

Figure 1.32 Ratio of Incidents by Vessel Age for Drifting Grounding

From Figure 1.32 it can be seen that for vessel age the ratios for drifting groundings with respect to the industry average range from 0.7 to 1.4. There is no apparent trend between the age of vessels and the likelihood of them being involved in a drifting grounding scenario.

Figure 1.33 presents the ratio of incidents by vessel size based on the industry average for drifting groundings giving due consideration to the number of vessel in each size category

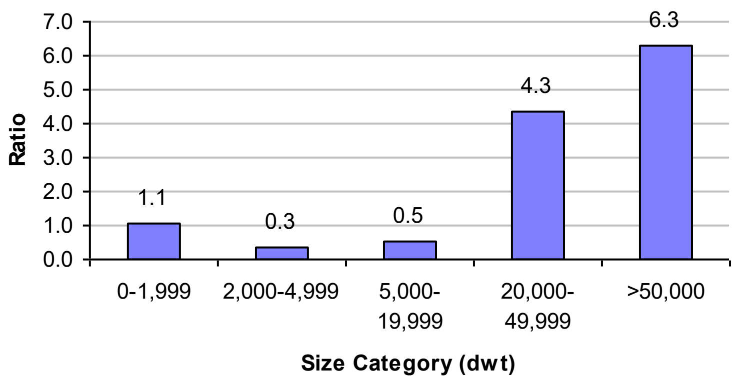

Figure 1.33 Ratio of Incidents by Vessel Size for Drifting Grounding

It can be seen from the figure above that with respect to vessel size the ratios for powered groundings vary from a low of 0.3 to a high of 6.3. It is noted that vessels of greater than 20,000 dwt show a very high ratio compared to the industry average. As discussed previously, it is considered that when large ships are disabled and are drifting towards a hazard, tugs may find it impossible to control due to the large momentum of such vessels.

1.3.6.1 Environmental Conditions

From analysis of the accident data it was found that 89% of the reported drift grounding incidents occurred during rough seas whilst 11% occurred in calm waters suggesting that seastate has an influence on the likelihood of a vessel drifting aground.

This may be due to the fact that during rough seas vessels will drift with a greater velocity towards the shore reducing the time available for tug intervention or for on-board repairs to be carried out. Rough seas will also make the potential for tug assistance less likely due to the difficulty involved in attaching a line to a drifting vessel in these conditions. There have also been problems with some vessels that have suffered engine failure refusing to accept a towline because of potential salvage claims.

1.4 Distribution by Flag

It is generally considered that the vast majority of marine incidents at sea are attributed to human error. There are two main factors which are responsible for these incidents. The first is concerned with the operating skills of the vessel crew, and the second relates to the safety management onboard the vessel which is directed by the shipping company which operate them. It is also considered the frequency of marine incidents, by flag, is directly associated with the level of management by each country over the safety of its registered vessels. Therefore, analysis was performed to determine the frequency of marine incident for each flag state taking in to account the number of movements by vessels of each flag. Based on the results of this analysis, the flags of registration were divided into three risk categories (High, Medium and Low) which are presented in Figure 1.34 to Figure 1.36 (overleaf)

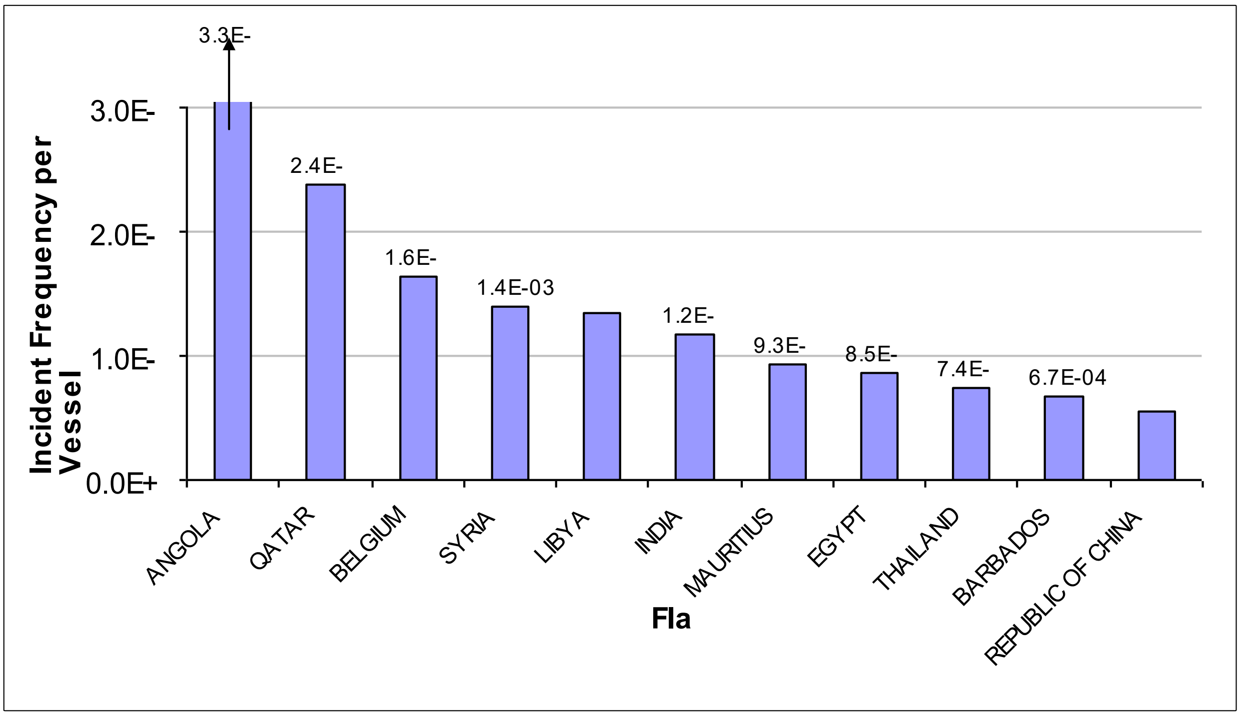

Figure 1.34 **Distribution of High Risk**

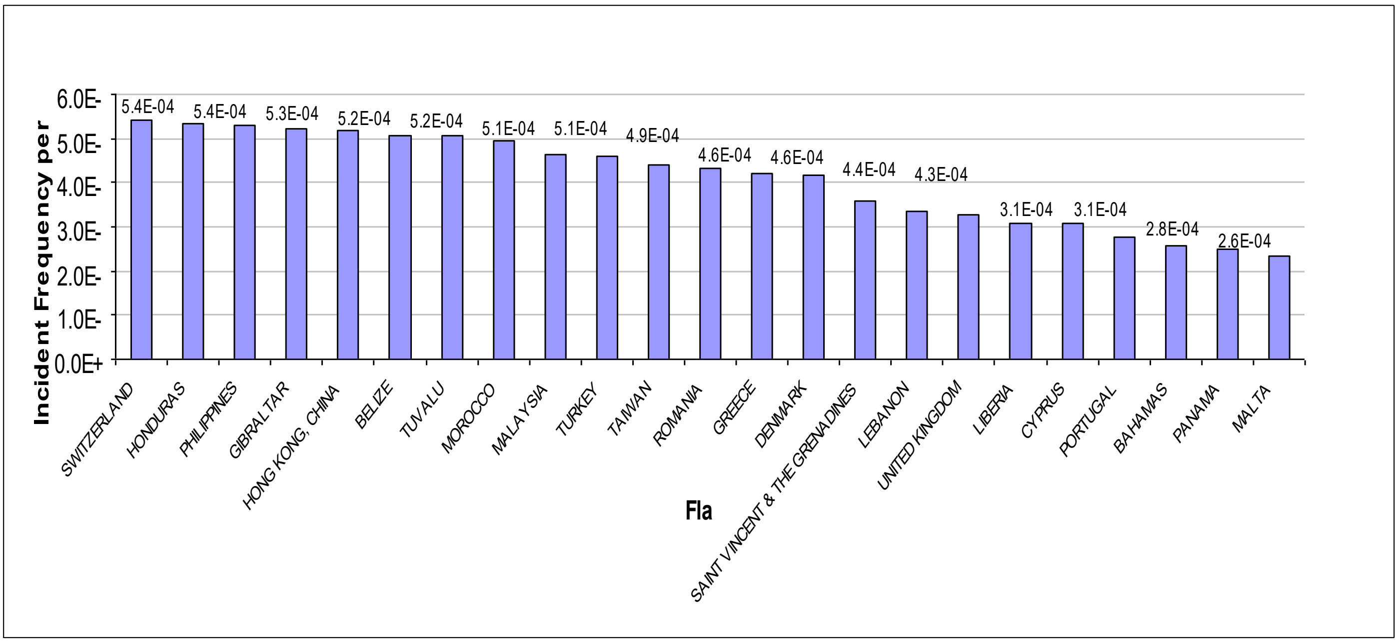

Figure 1.35 Distribution of Medium

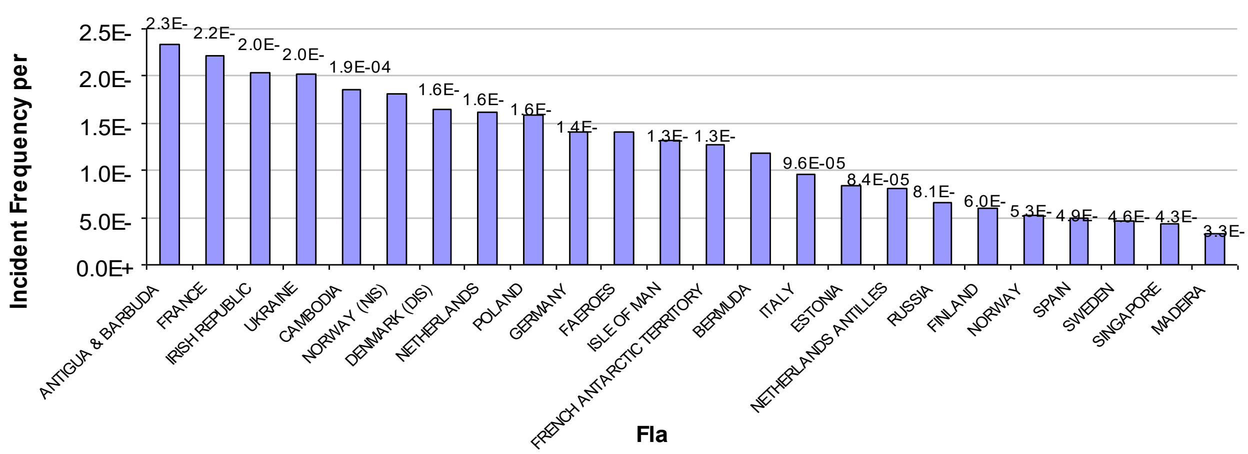

Figure 1.36 Distribution of Low

APPENDIX 3

HISTORICAL OIL SPILL STATISTICS

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1 HISTORICAL OIL SPILL STATISTICS

1.1 Introduction

This appendix presents the historical oil spill statistics for waters around the British Isles which was provided by the Advisory Committee on the Protection of the Sea (ACOPS). For the purpose of this study, data was obtained from ACOPS on oil spills of one tonne and greater which occurred over a 10-year period between January 1989 and December 1998 inclusive (Ref. 1).

1.2 ACOPS Oil Spill Data for the UKCS

Since 1965 ACOPS has compiled statistics and other information on marine oil pollution incidents in the waters around the British Isles. In partnership with the Department of the Environment, a four-page questionnaire was developed and applied in 1978 listing 32 questions and attributes relating to each pollution incident occurring in the open sea, nearshore waters, ports and tidal stretches of rivers. The questionnaire has been circulated to, and completed by, 13 different reporting organisations. In recent years more than 900 returns have been processed thus providing one of the most detailed and comprehensive records of marine oil pollution on a national geographical scale. An integrated and sequential approach was adopted in the statistical treatment of data, which was organised into 14 data fields.

1.3 Historical Oil Spill Data

From the historical oil spill database, it was found that there were a total of 261 reported oil pollution incidents (≥ 1tonne), which occurred within UK waters between 1989 and 1998. This equates to an average of approximately 26 incidents per annum. Table 1.1 presents a breakdown of the annual frequency into spill size categories. Following this, Figure 1.1 and Figure 1.2 present a breakdown of the number of incidents by year and by affected area, respectively.

Table 1.1 Annual Oil Spill Frequencies by Spill Size

Spill Size Category (Tonnes)	Oil Spill Frequency (p.a.)
1 - 5	16.1
5 – 50	8.6
50 – 250	0.9
250 – 500	0.1
500 – 5,000	0.3
≥ 5,000	0.2
TOTAL	26.1

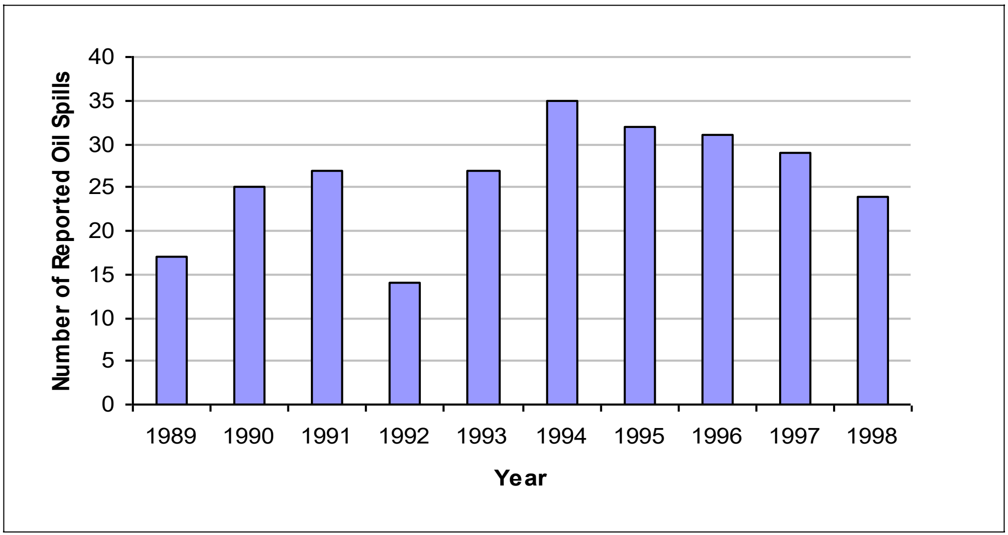

Figure 1.1 Distribution of Reported Oil Pollution Incidents per Annum (1989-1998)

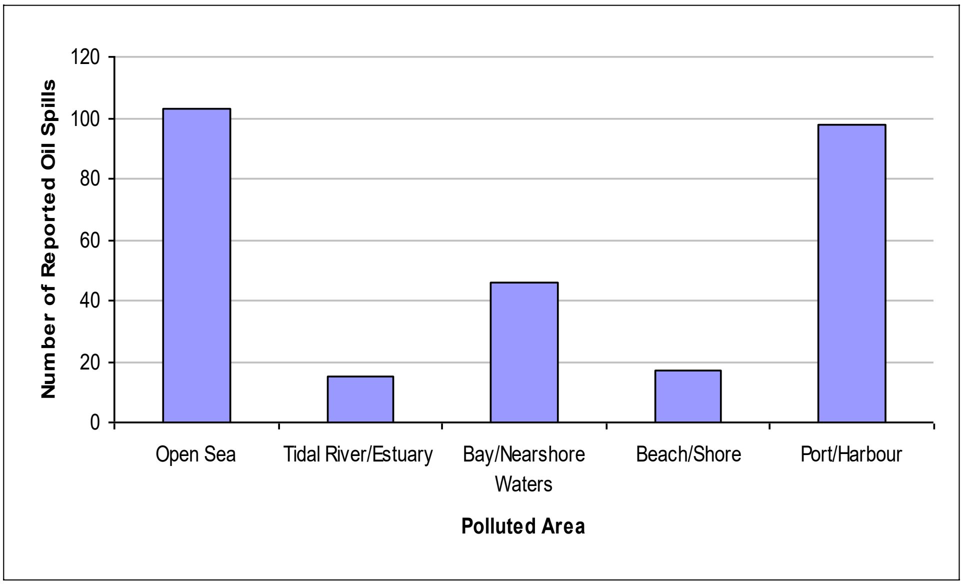

Figure 1.2 Breakdown by Affected Area for Reported Oil Pollution Incidents (1989 – 1998)

Figure 1.3 presents a plot of the reported oil spills which occurred within the boundaries of the ACOPS survey area. It should be noted that the area encompassed by the survey boundaries has been divided into eleven individual regions which are analysed in further detail within the appendix.

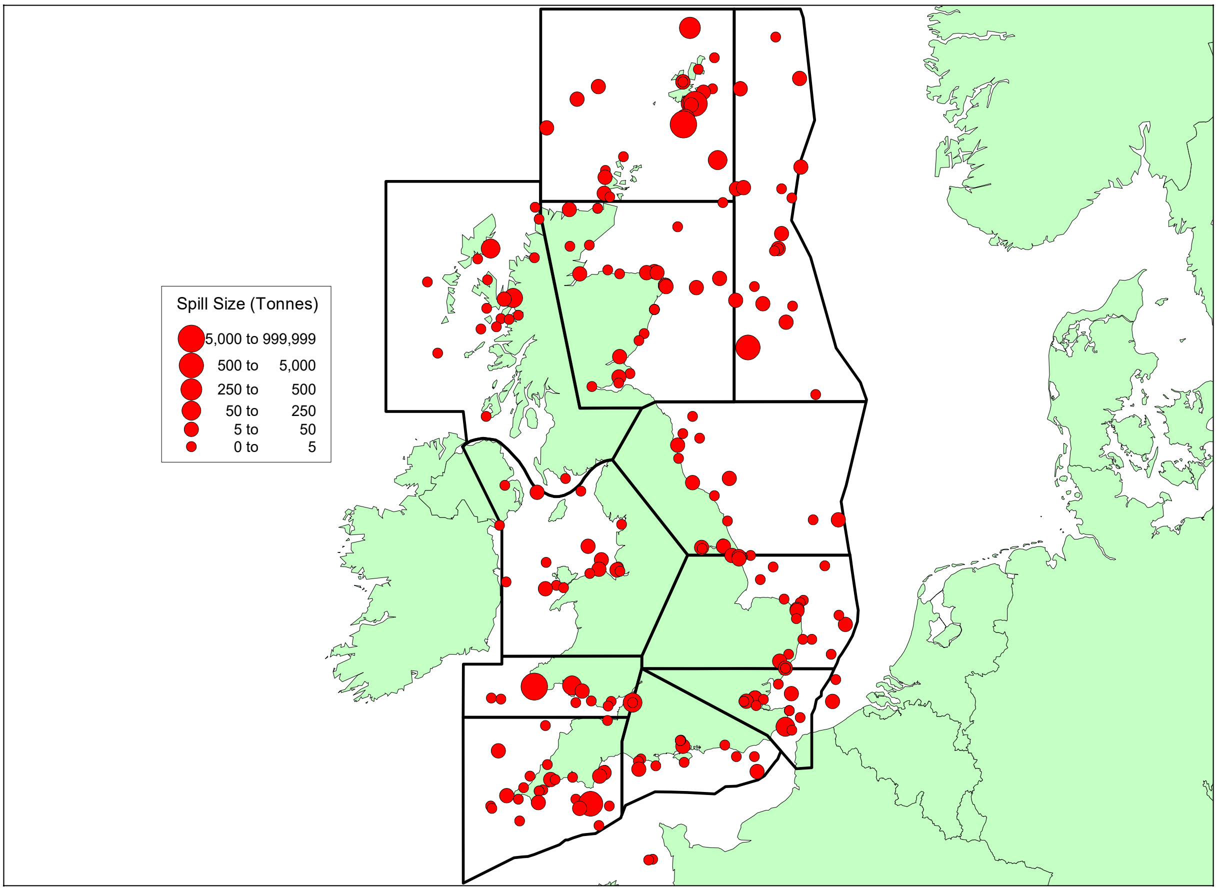

Figure 1.3 Plot of the Reported Oil Spills within UK Waters (1989 – 1998)

The following sub-sections present the analysis undertaken for each of the individual regions as presented in Figure 1.3.

1.3.1 Region 1 - North-East England

Figure 1.4 presents a detailed plot of the 15 reported oil spill incidents which were reported to have occurred within ACOPS region 1 (North-East England). Information on the number of spills per size category is provided within the legend. Following this, Figure 1.5 and Figure 1.6 present a breakdown of these incidents by year and by area affected. It should be noted that an oil spill incident may have affected more than one area (e.g. nearshore waters and beach).

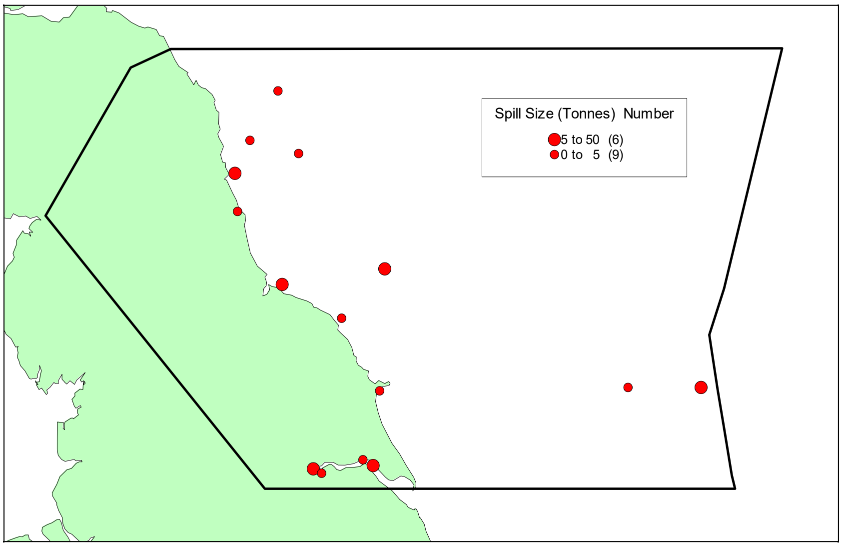

Figure 1.4 Plot of the Reported Oil Spills within North-East England (1989 – 1998)

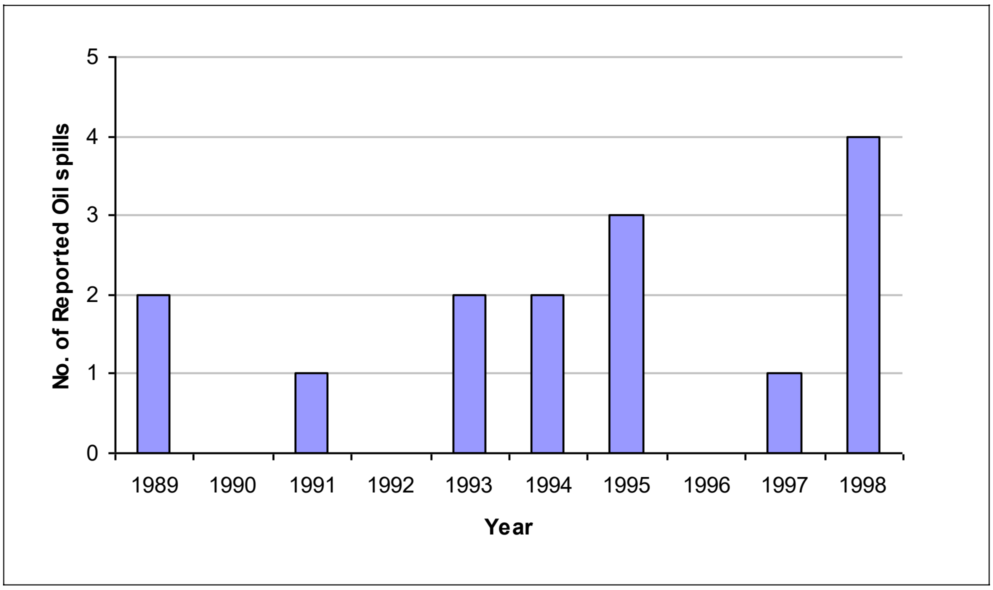

Figure 1.5 Distribution of Reported Oil Spill Incidents per Annum (North-East England)

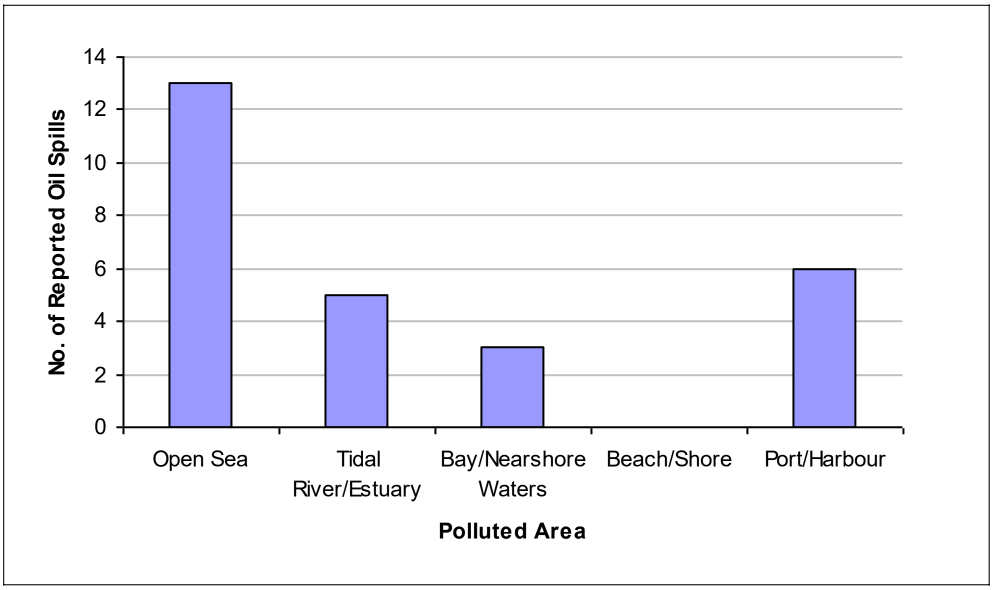

Figure 1.6 Breakdown by Affected Area for Reported Oil Pollution Incidents (North-East England)

1.3.2 Region 2 - Eastern England

Figure 1.7 presents a detailed plot of the 27 reported oil spill incidents which were reported to have occurred within ACOPS region 2 (Eastern England). Information on the number of spills per size category is provided within the legend. Following this, Figure 1.8 and Figure 1.9 present a breakdown of these incidents by year and by area affected.

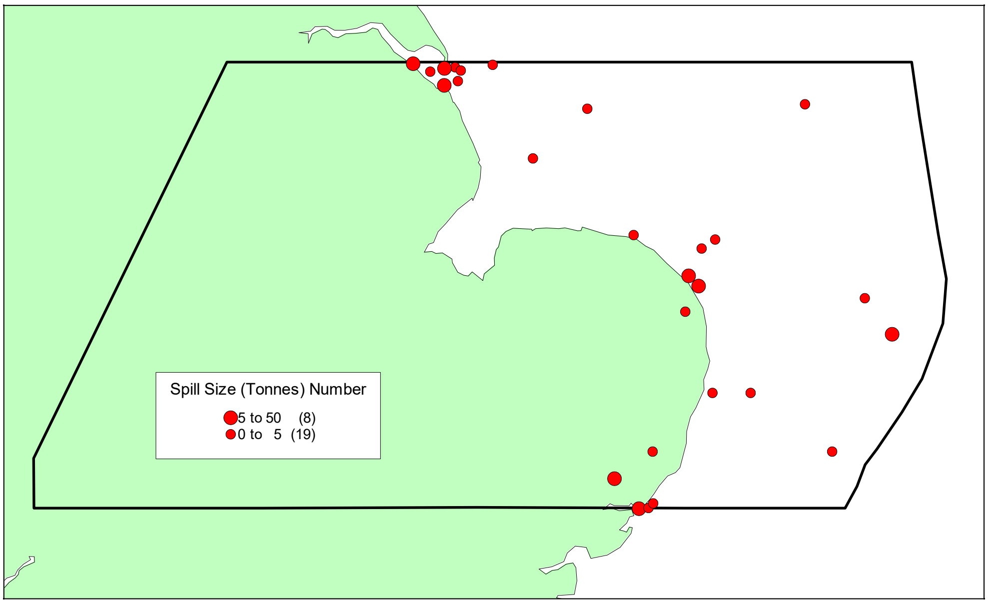

Figure 1.7 Plot of the Reported Oil Spills within Eastern England (1989 – 1998)

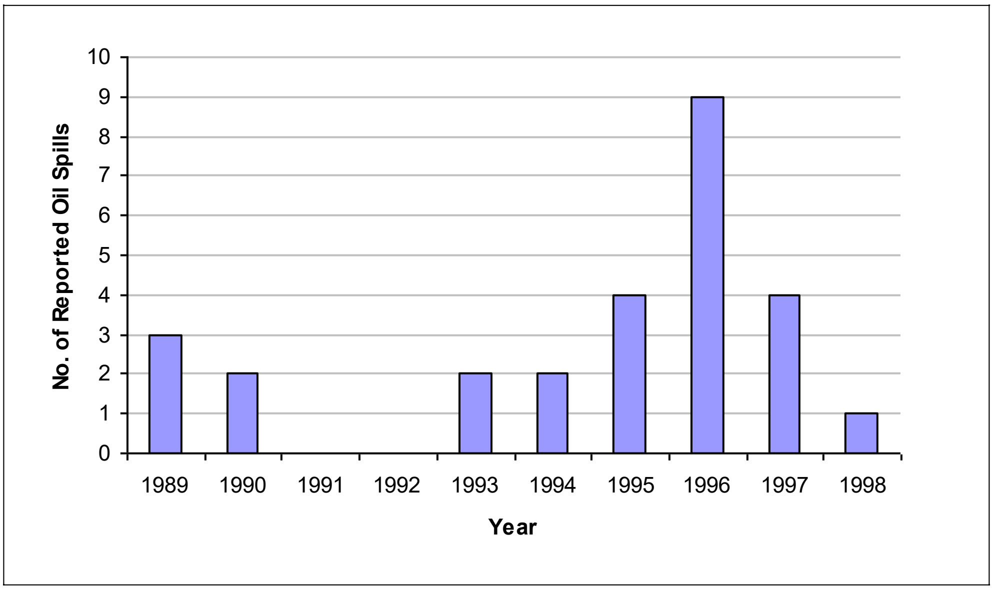

Figure 1.8 Distribution of Reported Oil Spill Incidents per Annum (Eastern England)

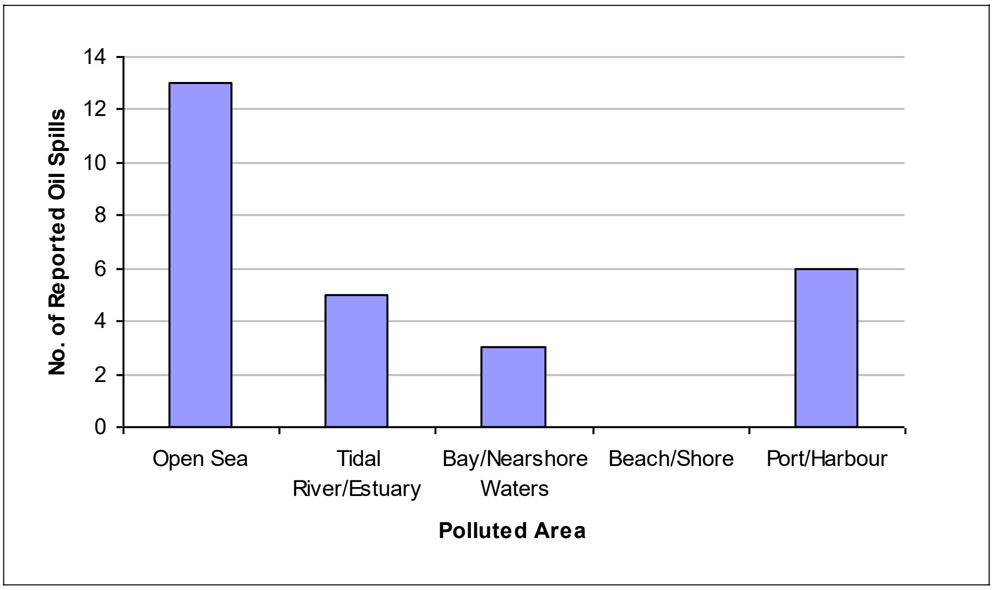

Figure 1.9 Breakdown by Affected Area for Reported Oil Pollution Incidents (Eastern England)

1.3.3 Region 3 - Essex and Kent

Figure 1.10 presents a detailed plot of the 24 reported oil spill incidents which were reported to have occurred within ACOPS region 3 (Essex and Kent). Information on the number of spills per size category is provided within the legend. Following this, Figure 1.11 and Figure 1.12 present a breakdown of these incidents by year and by area affected.

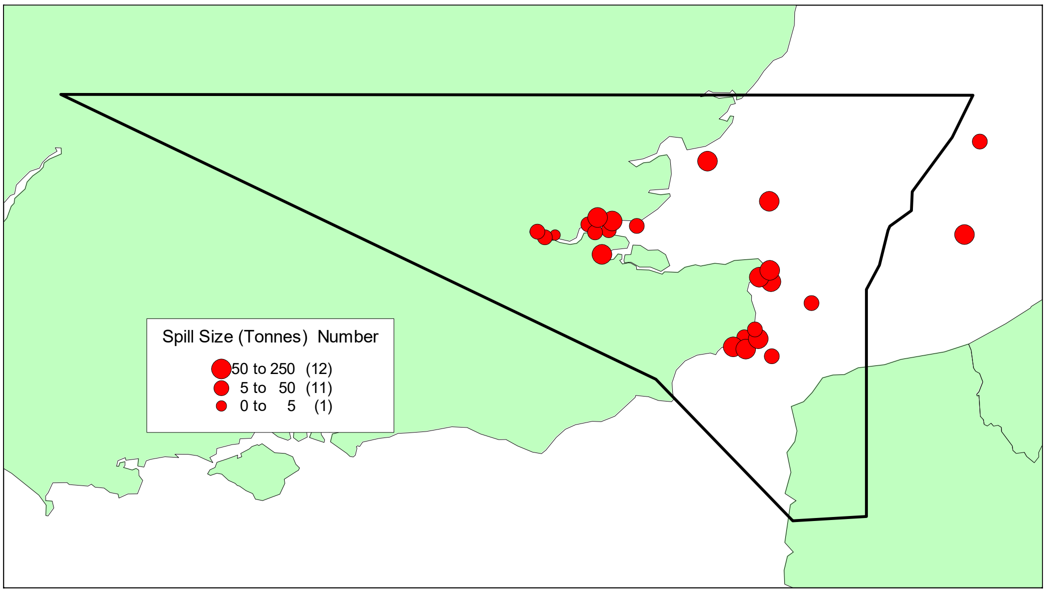

Figure 1.10 Plot of the Reported Oil Spills within Essex and Kent (1989 – 1998) [(1)]

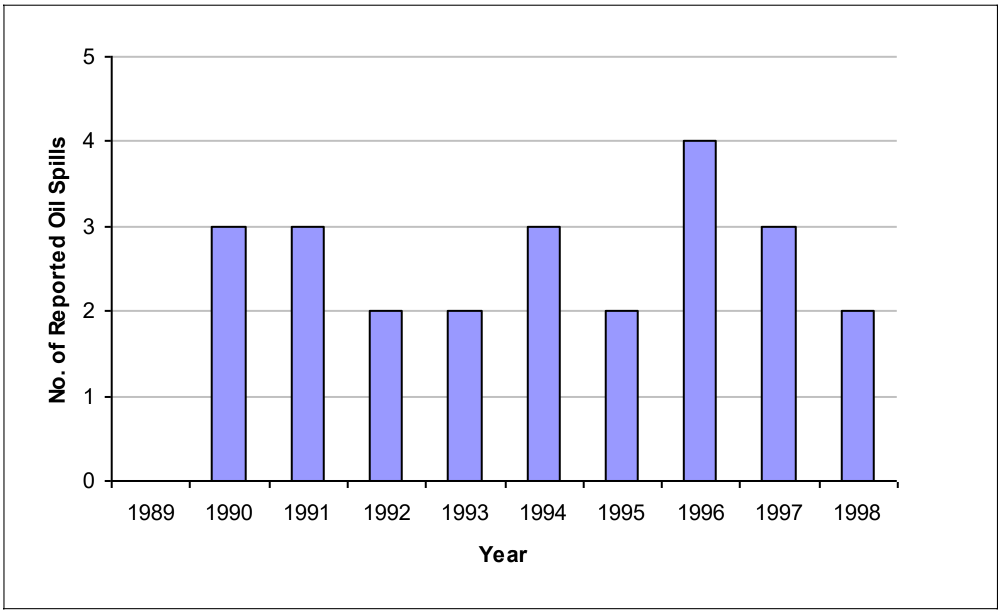

Figure 1.11 Distribution of Reported Oil Spill Incidents per Annum (Essex and Kent)

[(1)] Although two of the reported oil spills occurred outside the regional boundaries these have been included in the data due to the possibility that oil from these spills may drift across the regional boundary thus affecting the area.

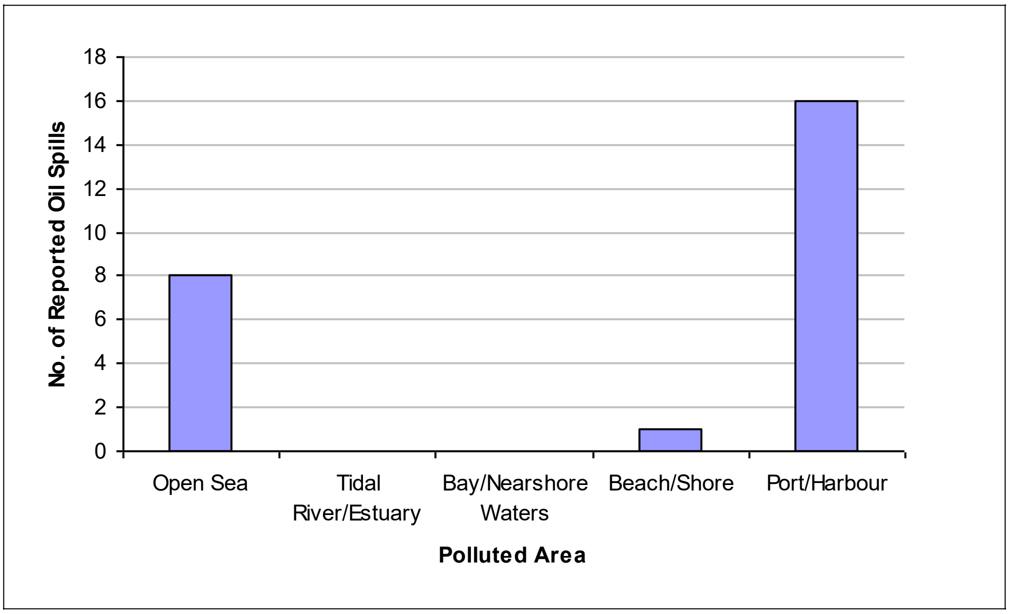

Figure 1.12 Breakdown by Affected Area for Reported Oil Pollution Incidents (Essex and Kent)

1.3.4 Region 4 - Southern England

Figure 1.13 presents a detailed plot of the 15 reported oil spill incidents which were reported to have occurred within ACOPS region 4 (Southern England). Information on the number of spills per size category is provided within the legend. Following this, Figure 1.14 and Figure 1.15 present a breakdown of these incidents by year and by area affected.

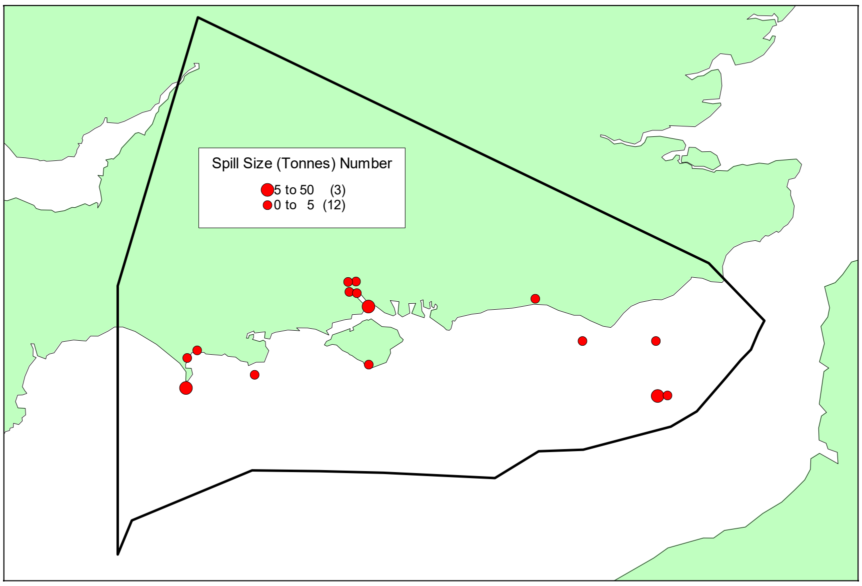

Figure 1.13 Plot of the Reported Oil Spills within Southern England (1989 – 1998)

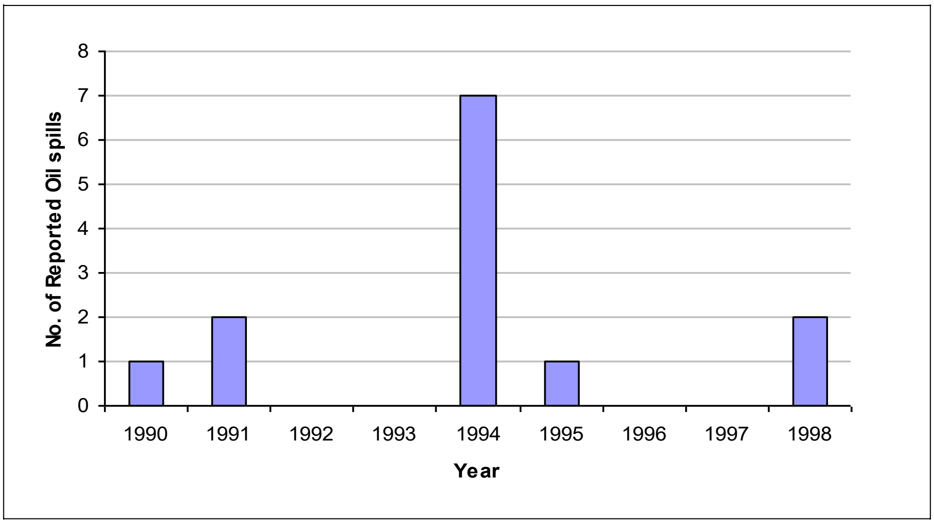

Figure 1.14 Distribution of Reported Oil Spill Incidents per Annum (Southern England)

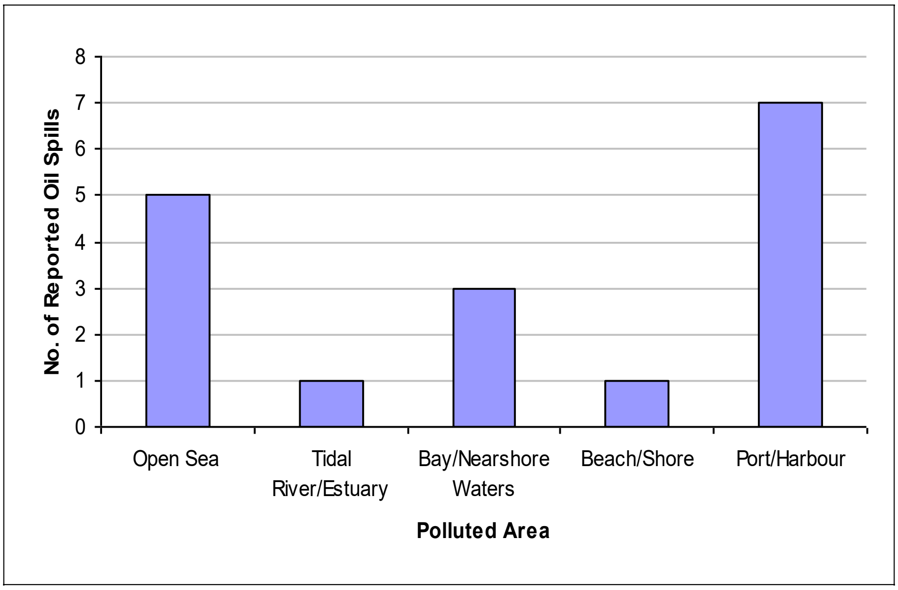

Figure 1.15 Breakdown by Affected Area for Reported Oil Pollution Incidents (Southern England)

1.3.5 Region 5 - South-West England

Figure 1.16 presents a detailed plot of the 30 reported oil spill incidents which were reported to have occurred within ACOPS region 5 (South-West England). Information on the number of spills per size category is provided within the legend. Following this Figure 1.17and Figure 1.18 present a breakdown of these incidents by year and by area affected.

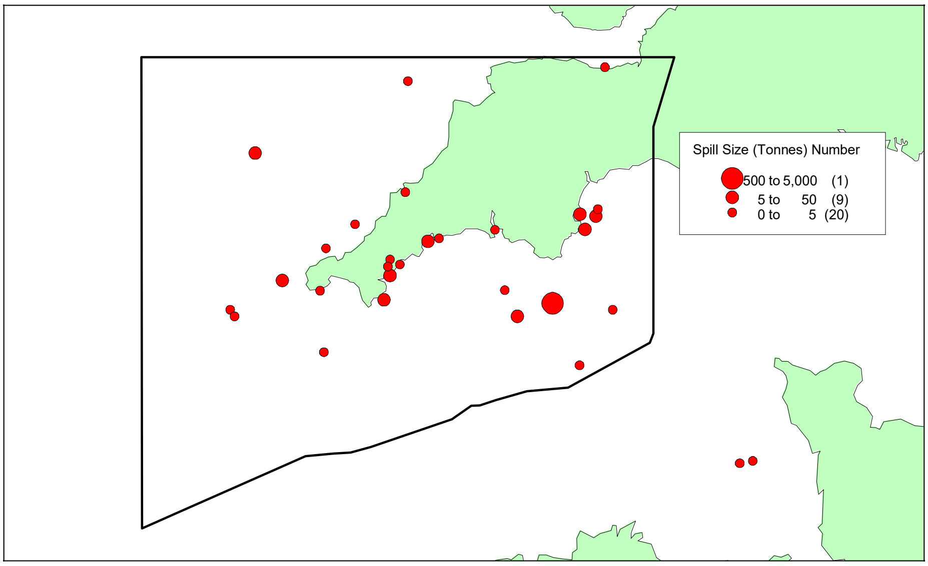

Figure 1.16 Plot of the Reported Oil Spills within South-West England (1989 – 1998) [(2)]

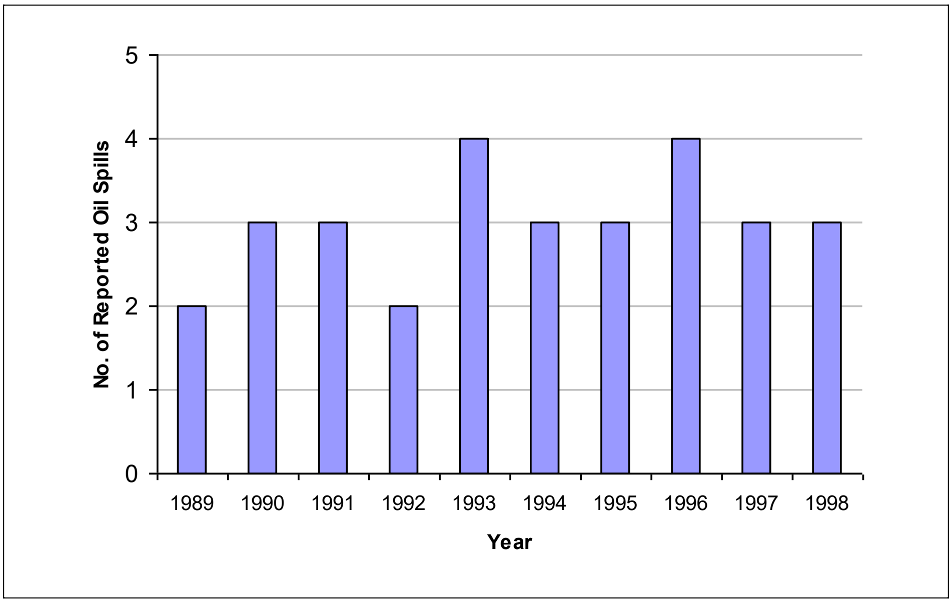

Figure 1.17 Distribution of Reported Oil Spill Incidents per Annum (South-West England)

[(2)] It should be noted that oil spills which occur in the Channel Islands are recorded under region 5 (South-West England)

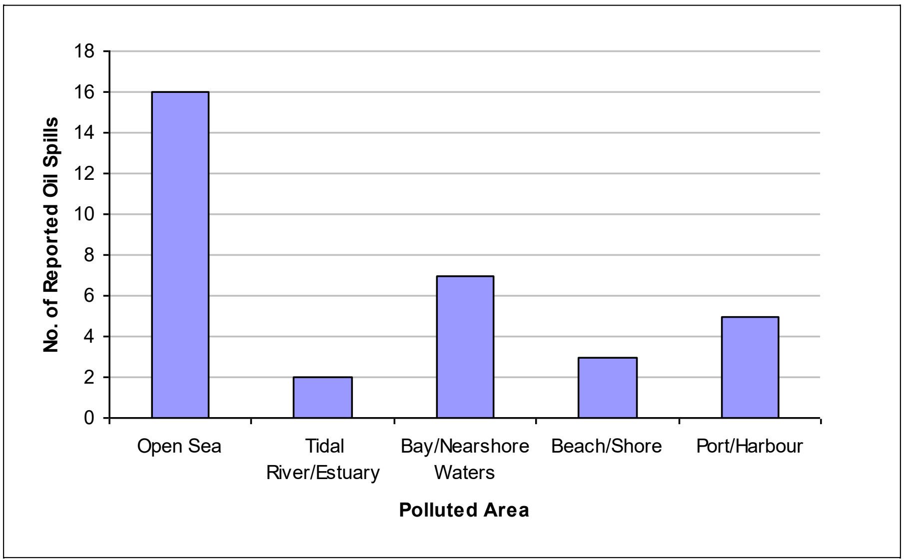

Figure 1.18 Breakdown by Affected Area for Reported Oil Pollution Incidents (South-West England)

1.3.6 Region 6 - Bristol Channel and South Wales

Figure 1.19 presents a detailed plot of the 18 reported oil spill incidents which were reported to have occurred within ACOPS region 6 (Bristol Channel and South Wales). Information on the number of spills per size category is provided within the legend. Following this, Figure 1.20 and Figure 1.21 present a breakdown of these incidents by year and by area affected.

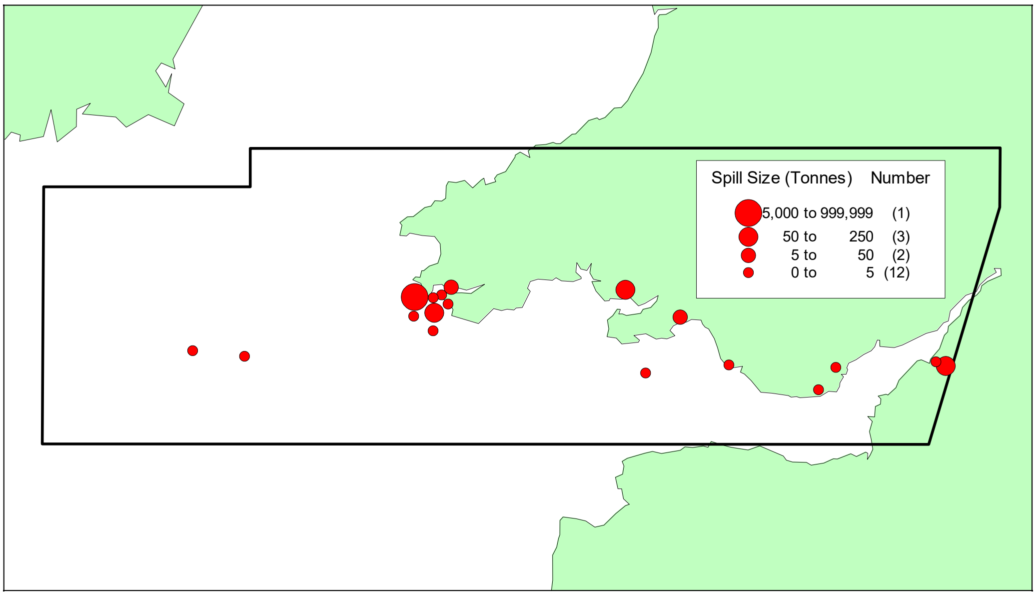

Figure 1.19 Plot of the Reported Oil Spills within the Bristol Channel and South Wales (1989 – 1998)

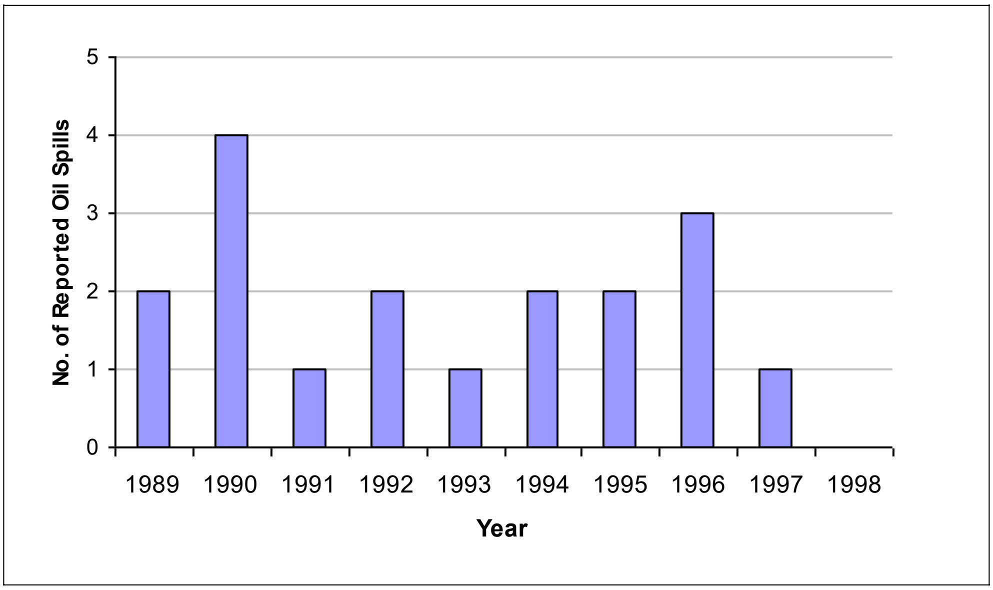

Figure 1.20 Distribution of Reported Oil Spill Incidents per Annum (Bristol Channel and South Wales)

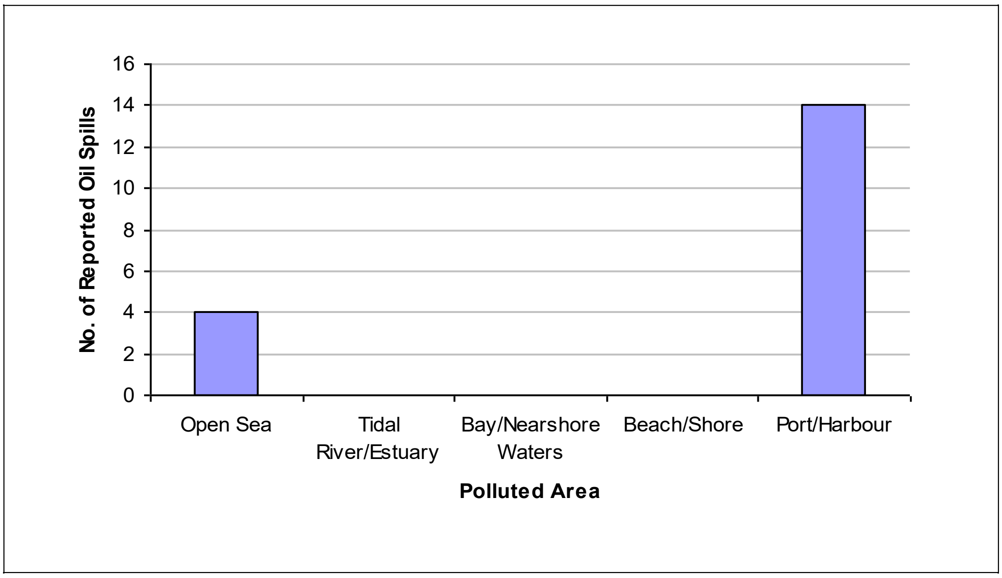

Figure 1.21 Breakdown by Affected Area for Reported Oil Pollution Incidents (Bristol Channel and South Wales)

1.3.7 Region 7 - Irish Sea

Figure 1.22 presents a detailed plot of the 19 reported oil spill incidents which were reported to have occurred within ACOPS region 7 (Irish Sea). Information on the number of spills per size category is provided within the legend. Following this, Figure 1.23 and Figure 1.24 present a breakdown of these incidents by year and by area affected.

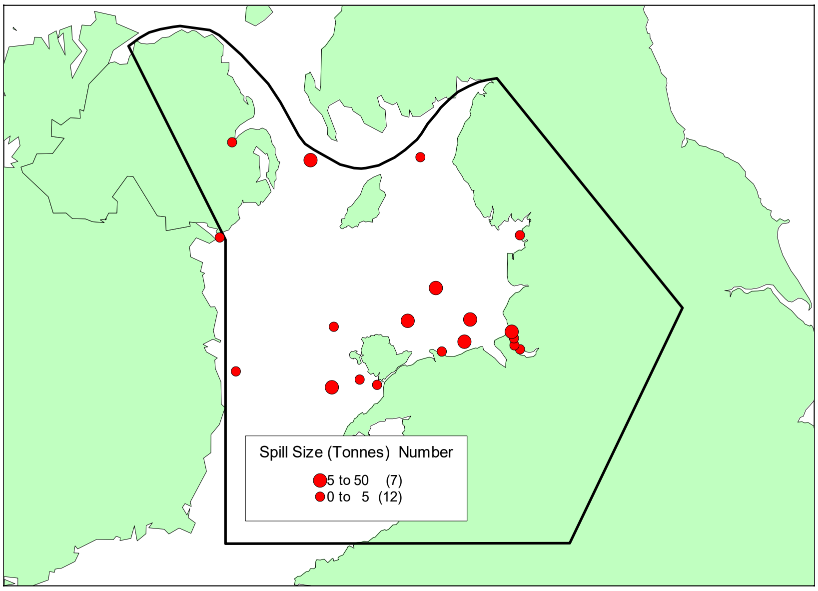

Figure 1.22 Plot of the Reported Oil Spills within Irish Sea (1989 – 1998)

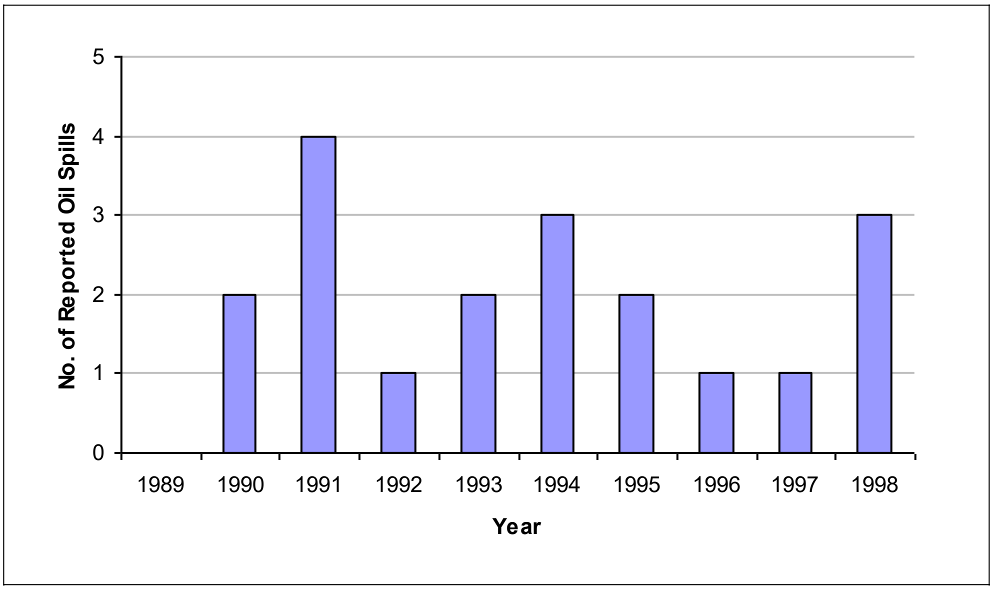

Figure 1.23 Distribution of Reported Oil Spill Incidents per Annum (Irish Sea)

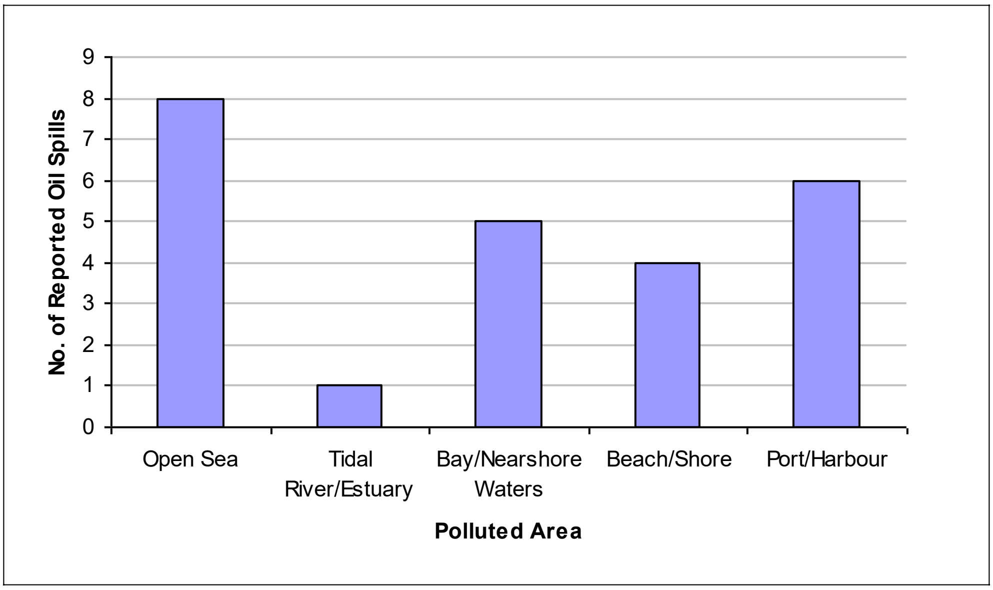

Figure 1.24 Breakdown by Affected Area for Reported Oil Pollution Incidents (Irish Sea)

1.3.8 Region 8 - Western Scotland

Figure 1.25 presents a detailed plot of the 20 reported oil spill incidents which were reported to have occurred within ACOPS region 8 (Western Scotland). Information on the number of spills per size category is provided within the legend. Following this, Figure 1.26 and Figure 1.27 present a breakdown of these incidents by year and by area affected.

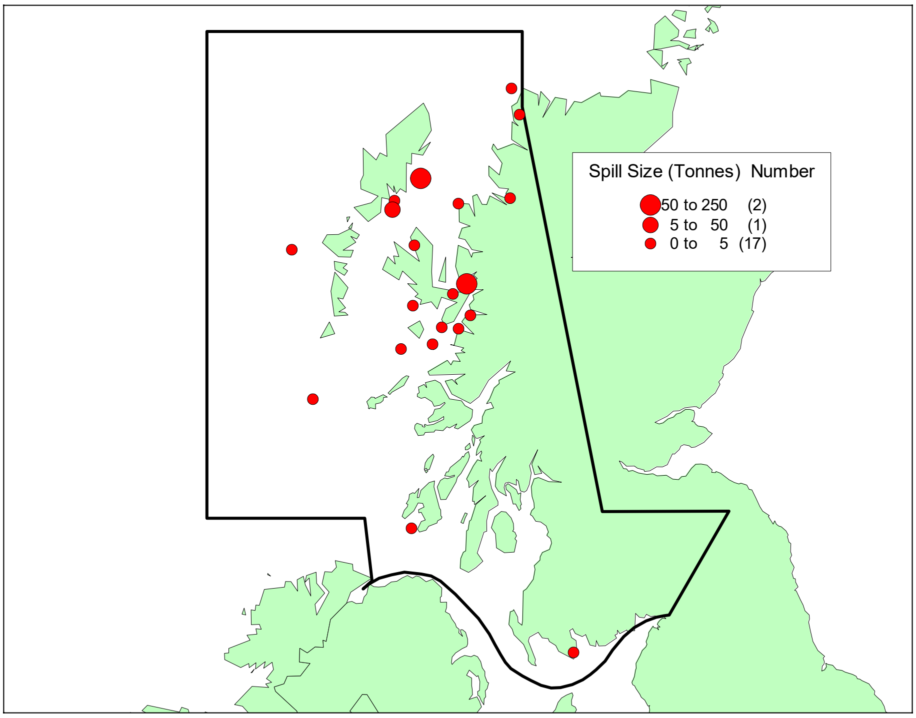

Figure 1.25 Plot of the Reported Oil Spills within Western Scotland (1989 – 1998)

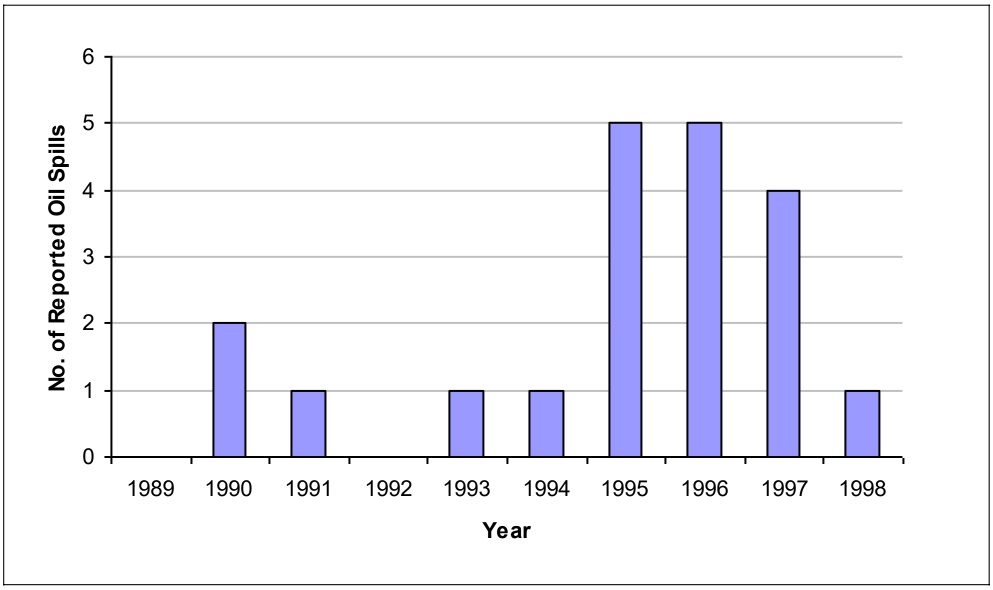

Figure 1.26 Distribution of Reported Oil Spill Incidents per Annum (Western Scotland)

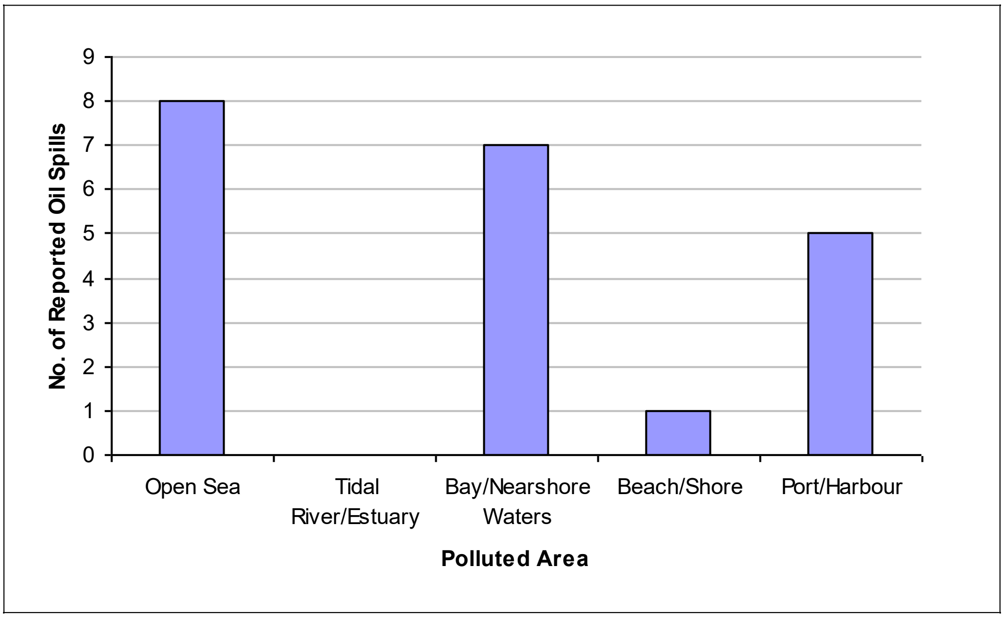

Figure 1.27 Breakdown by Affected Area for Reported Oil Pollution Incidents (Western Scotland)

1.3.9 Region 9 - Orkney and Shetland Islands

Figure 1.28 presents a detailed plot of the 34 reported oil spill incidents which were reported to have occurred within ACOPS region 9 (Orkney and Shetland Islands). Information on the number of spills per size category is provided within the legend. Following this, Figure 1.29 and Figure 1.30 present a breakdown of these incidents by year and by area affected.

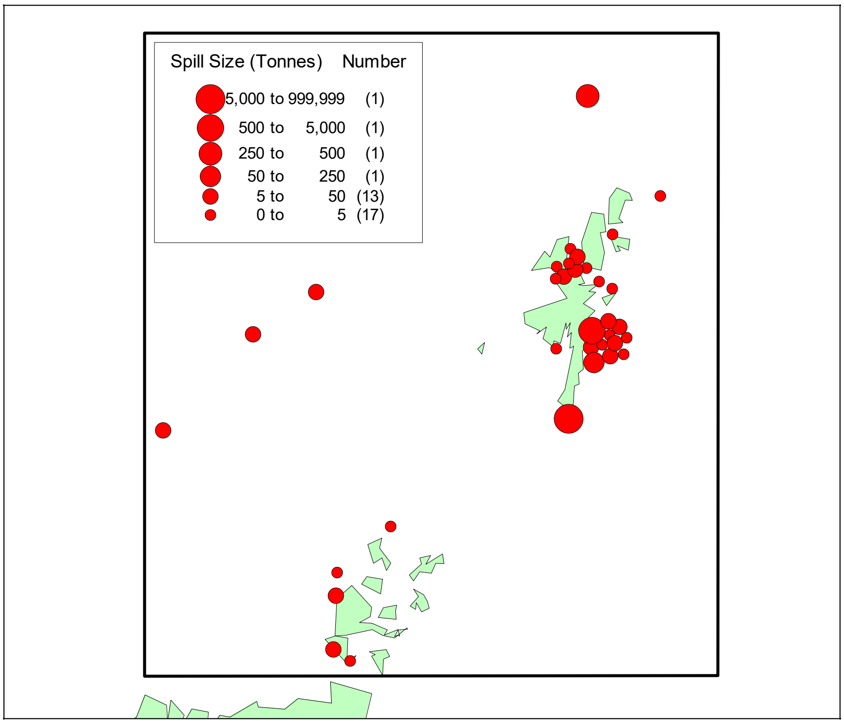

Figure 1.28 **Plot of the Reported Oil Spills within Orkney and Shetland Islands (1989 – 1998)**

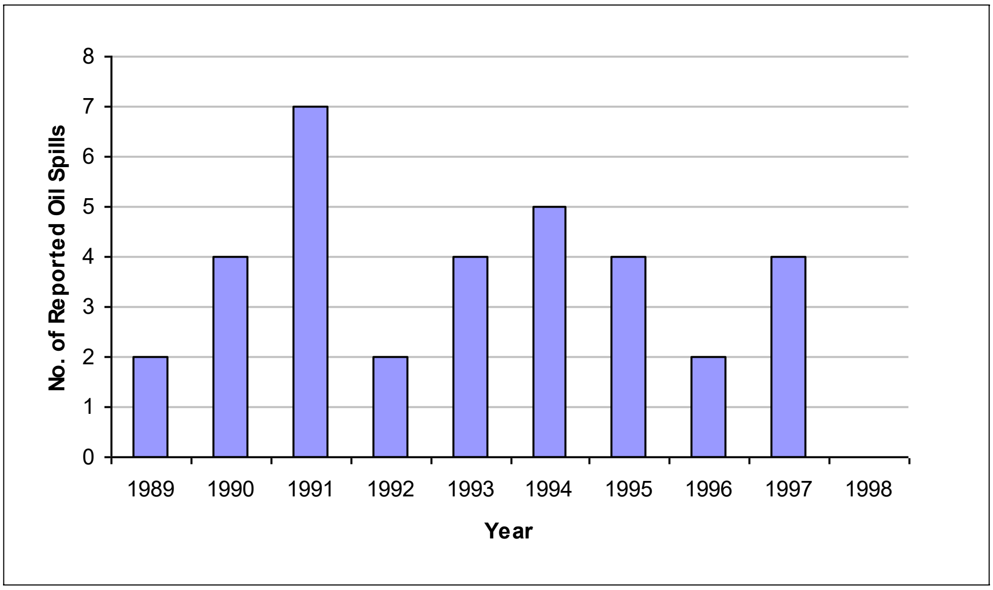

Figure 1.29 **Distribution of Reported Oil Spill Incidents per Annum (Orkney and Shetland Islands)**

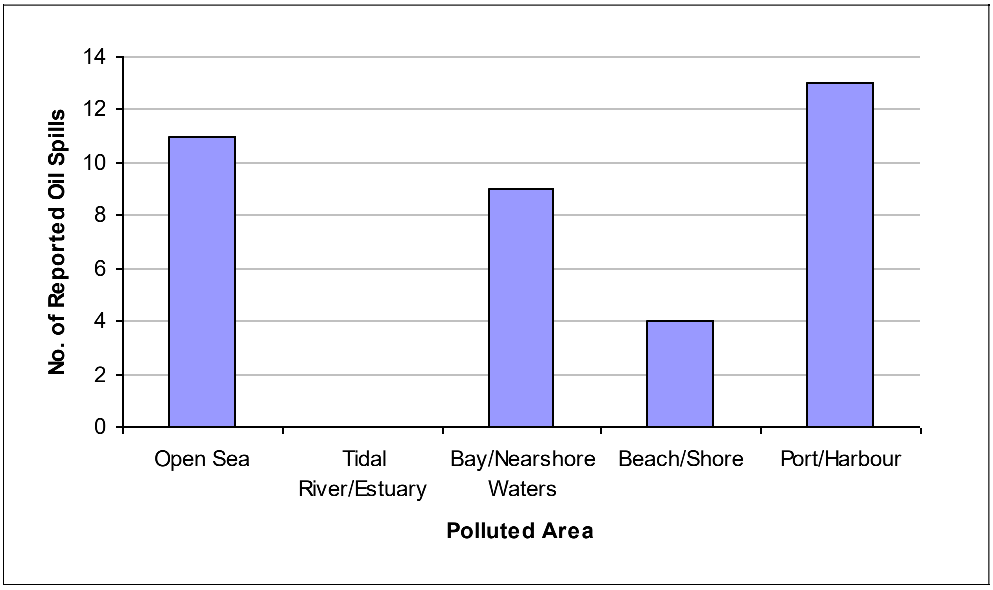

Figure 1.30 Breakdown by Affected Area for Reported Oil Pollution Incidents (Orkney and Shetland Islands)

1.3.10 Region 10 - Eastern Scotland

Figure 1.31 presents a detailed plot of the 39 reported oil spill incidents which were reported to have occurred within ACOPS region 10 (Eastern Scotland). Information on the number of spills per size category is provided within the legend. Following this, Figure 1.32 and Figure 1.33 present a breakdown of these incidents by year and by area affected.

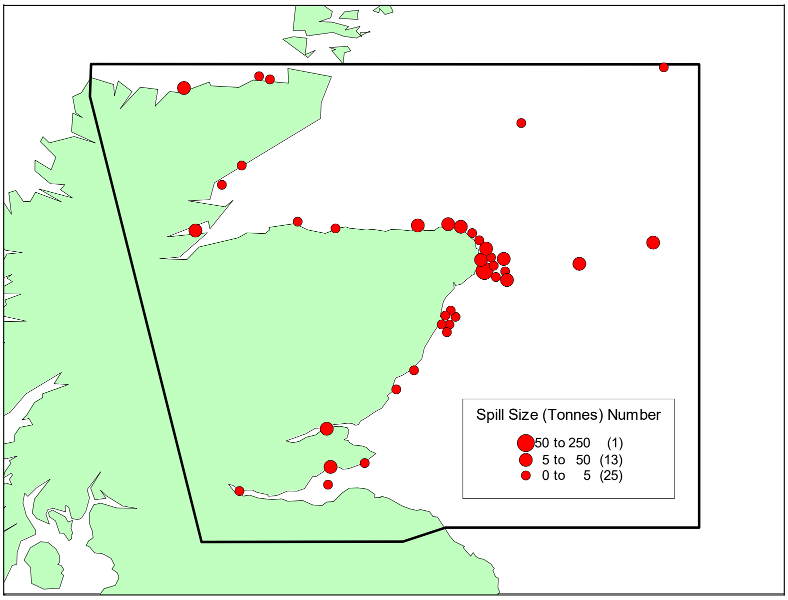

Figure 1.31 Plot of the Reported Oil Spills within Eastern Scotland (1989 – 1998)

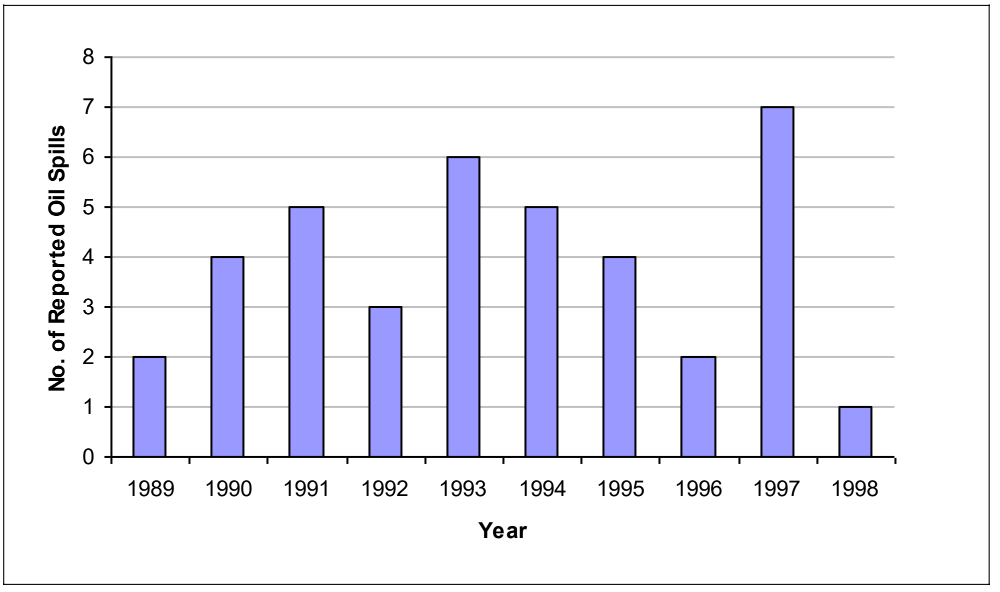

Figure 1.32 Distribution of Reported Oil Spill Incidents per Annum (Eastern Scotland)

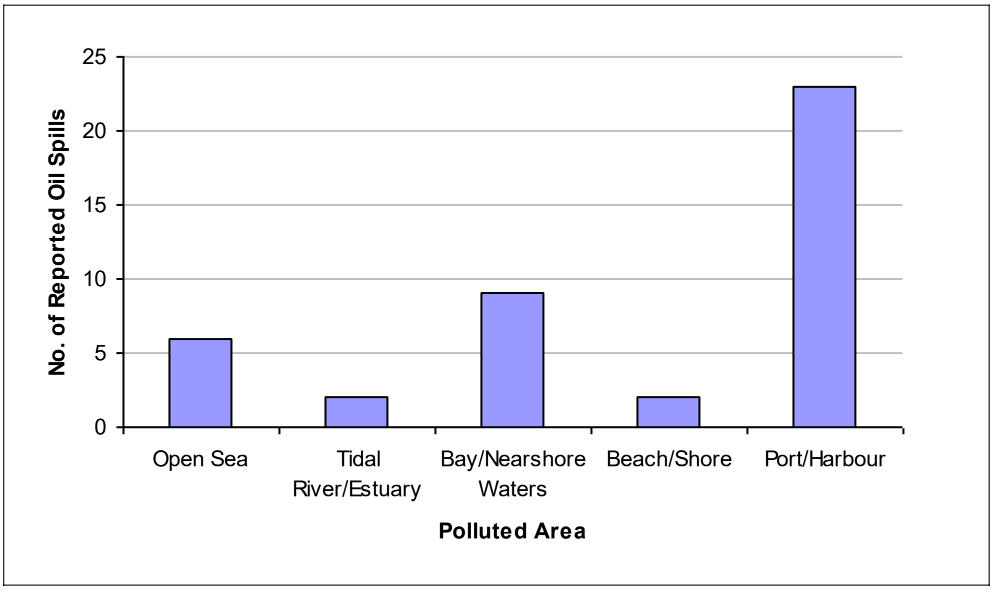

Figure 1.33 Breakdown by Affected Area for Reported Oil Pollution Incidents (Eastern Scotland)

1.3.11 Region 11 - UKCS in the vicinity of offshore installations

Figure 1.34 presents a detailed plot of the 20 reported oil spill incidents which were reported to have occurred within ACOPS region 11 (UKCS offshore installations). Information on the number of spills per size category is provided within the legend. Following this, Figure 1.35 presents a breakdown of these incidents by year. It should be noted that due to the location of the region all recorded spills occurred in open seas.

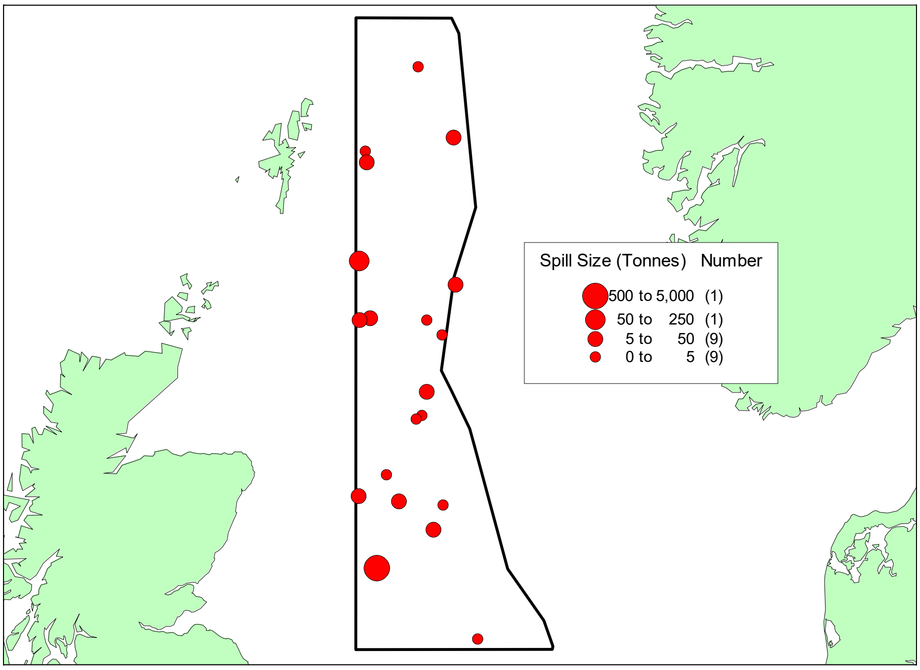

Figure 1.34 Plot of the Reported Oil Spills in the Vicinity of Offshore Installations in the UKCS (1989 – 1998)

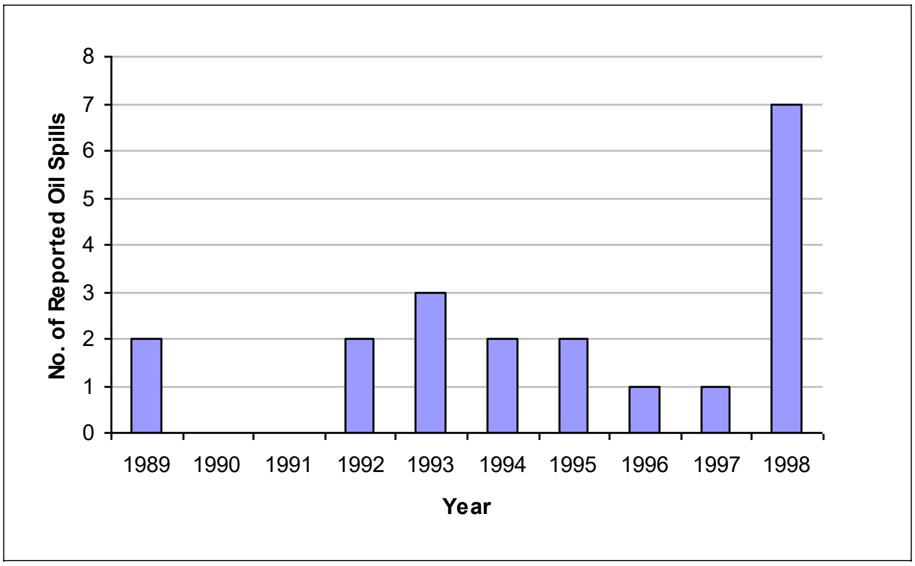

Figure 1.35 Distribution of Reported Oil Spill Incidents per Annum (In the Vicinity of Offshore Installations in the UKCS)

Table 1.2 (overleaf) presents a summary of the historical oil spill data obtained from ACOPS. It should be noted that this data was used to validate the results of the oil pollution risk models.

Table 1.2 Data on Marine Incidents which Resulted in Oil Pollution within the UKCS – January

Incid	Reporting	Year	Date	Location of spill	Type	
1	New Forest DC	1989	10-Jan-89	Fawley to Colshot	Tanker	
	MT Worthy	20				
2	MPCU	1989	1-Feb-89	50 32 N 02 2 W	Merchant	
	MV CAMARET	2				
3	Humberside CC	1989	3-Feb-89	Grimsby docks	Merchant	?
	7.6					
4	Lerwick Harbour Trust	1989	9-Mar-89	Lerwick Harbour	Unknown	?
	1.9					
5	MPCU	1989	30-Mar-89	53 35 N 00 25 E	Merchant	
	MFV SORON VISHOLM	3.9				
6	MPCU	1989	10-Apr-89	Off St Ives	Merchant	
	MV Secil	2				
7	Forth Ports Authority	1989	17-May-89	Firth of Forth	Tanker	?
	3					
8	Shetland Isles Council	1989	20-Jun-89	Sullom Voe	Tanker	

Incid	Reporting	Year	Date	Location of spill	Type	
17	Humberside CC	1989	14-Dec-89	Goole railway bridge Humber	Other	
		BARGE HUMBER		15		
18	Shetlands Islands Council	1990	4-Jan-90	Sullom Voe	Tanker	MT
	Bear G	5.1				
19	Humberside CC	1990	9-Feb-90	53 32 N 00 07 E	Tanker	MT
	TOURAINE	27				
20	MPCU	1990	22-Mar-90	Gerrons bay SW England	Merchant	MTUG
	TITAN	1.5				
21	Shetland Isles Council	1990	26-Mar-90	3 miles offshore	Merchant	MFV
		3.9				
22	NERPB	1990	17-Apr-90	Aberdeen Harbour	Merchant	MV
	Grampian Harrier	1				
23	Western Isles RC/MPCU	1990	25-Apr-90	58 02 N 06 18 W	Merchant	MV
	KONDOR	85				
24	Milford haven PA	1990	25-Apr-90	Millford Haven	Tanker	Coastal
	tanker	1				

Incid	Reporting	Year	Date	Location of spill	Type	
34	Highland Reg Council	1990	12-Oct-90	Uig bay, Isle of Skye	Merchant	
		MFV Glen rinnes		1		
35	Peterhead Harbour Authority	1990	Nov-90	Peterhead Harbour	Merchant	?
		10				
36	Port of London Authority	1990	10-Nov-90	Mobil refinery Coryton	Tanker	
		MV Bonito		20		
37	Suffolk C.C	1990	19-Nov-90	Ipswich docks	Merchant	
		MV Uniforce		11.4		
38	MPCU	1990	27-Nov-90	Barry, No.3 Dock	Merchant	
		Geest boy		4.5		
39	NERPB	1990	1-Dec-90	Aberdeen Harbour	Merchant	
		MV Triton 8		1		
40	Milford haven PA	1990	Dec-90	Milford Haven	Tanker	?
		20				

Incid	Reporting	Year	Date	Location of spill	Type
51	Forth Ports Authority	1991	20-Mar-91	Grangemouth Docks	Tanker
		MT Dona Ovraria		4	
52	Shetland Islands council	1991	21-Apr-91	Sullom Voe	Tanker
		MT Hellespont Ardent		2	
53	MPCU	1991	25-May-91	Longhope Orkney	Merchant
		MFV EBENEZER		1.6	
54	Peterhead Ports Authority	1991	9-Jun-91	Peterhead Bay	Merchant
		MV Balblair		2	
55	MPCU	1991	1-Jul-91	50 00 N 5 4 W	Merchant
		MTUG SEA VIPER		5	
56	Highland R P B	1991	1-Aug-91	Broad bay, Lewis	Merchant ?
		2.2			
57	Port of London Authority	1991	1-Aug-91	C.Jetty Shellhaven	Tanker
		MT Rathkyle		2.6	1.
66	Lerwick Harbour +Others	1991	11-Oct-91	Lerwick Harbour	Merchant

Incid	Reporting	Year	Date	Location of spill	Type	
67	Fife RC+3 others	1991	15-Oct-91	Anstruther Harbour	Merchant	
		MFV Standsure		1.1		
68	Highland RC +3 others	1991	21-Oct-91	Cromarty firth	Merchant	
		MV STAR ALTAIR		8.3		
69	MPCU	1991	6-Dec-91	55 21 N 01 20 W	Merchant	
		MV PROVIDER		3		
70	MPCU+2 Others	1992	25-Feb-92	Torbay 2km SE Corbyn hood	Tanker	
		MV CERRO COLORADO			10	
71	MPCU	1992	28-Feb-92	Roath Dock Cardiff	Tanker	MT
	Oarsman	4				
72	MPCU	1992	4-Mar-92	Dover strait	Unknown ?	
		4.1				
73	MPCU	1992	4-Mar-92	Dover strait	Unknown ?	
		2.3				
74	Fraserburgh+3 Others	1992	10-Apr-92	Fraserburgh Harbour	Merchant	

Incid	Reporting		Year	Date	Location of spill		Type	
84	Shetland Isles CC/MPCU		1993	5-Jan-93	Gorths Ness Shetland		Tanker	
85	GRAMPIAN RC		1993	10-Jan-93 New	Merchant ?			
86	MPCU		1993	16-Feb-93	50 23 N 5 17 W		Merchant	
			MFV LIA		3.9			
87	MPCU		1993	18-Feb-93	57 04 N 5 35 W		Merchant	
			MFV VIKING QUEEN		1			
88	MPCU/CLOVEFORD CC FREJA SEVE		1993 5	28-Feb-93	Redcar cleveland		Tanker	MJ
89	MPCU		1993	2-Mar-93	51 07 N 4 53 W		Tanker	
			MFV CHARTYNE II		2.7			
90	MPCU		1993	9-Mar-93	52 22 N 1 46 E		Merchant	
			RFA Kinkerbury		2.6			
91	Port of Hayshom		1993	13-May-93	Port of Heysham		Merchant	MV
	SP Herald		1					

Incid	Reporting		Year	Date	Location of spill		Type	
100	MPCU		1993	1-Oct-93	55 17 N 00 54 W		Merchant	MV
	EASTBANK		3.6					
101	MPCU		1993	2-Nov-93	51 27 N 4 06 W		Merchant	MFV
	GILSEA		3					
102	MPCU		1993	3-Nov-93	58 55 N 0 14 E		Merchant	MFV
	GLENMORE		6.3					
103	Shetland Isles CC/MPCU		1993	9-Nov-93	60 07 N 01 7W		Merchant	MV
	LUNAHODS 1		15					
104	MPCU/NORFOLK CC		1993	14-Nov-93	52 57 N 1 17 E		Barge	
			CONSTRUCTION BARGE		4.4			
105	Shetland Isles CC/MPCU		1993	15-Nov-93	61 14 N 1 09 W (Lerwick)		Merchant	MV
	BORODINSTOYE POLYE		373					
106	Shetland Isles CC/MPCU		1993	21-Nov-93	60 18 N 00 48 W		Merchant	MFV
	DESTINY		6					
107	MPCU/Kincardine RC		1993	30-Nov-93	56 48 N 2 20 W		Merchant	
			COLURCA		1.1			

Incid	Reporting		Year	Date	Location of spill		Type	
117	MPCU		1994	24-Mar-94	51 28 N 2 32 E		Unknown	
	?		6					
118	MPCU		1994	1-Apr-94	50 40 N 0 31 E		Unknown	
	?		1.2					
119	MPCU		1994	1-Apr-94	58 05 N 3 45 W		Merchant	
			MFV ARNISDALE		2			
120	MPCU		1994	1-Apr-94	53 23 N 3 30 W		Tanker	
			MT HIGHLAND SENTINEL		Tanker	MT Ebella	15	
126	MPCU		1994	22-Jun-94	60 12 N 4 04 W		Merchant	
			MFV ADONIS		20			
127	MPCU		1994	29-Jul-94	55 55 N 02 06 E		Merchant	
			MV GLADNESS		3.6			
128	Hampshire CC +Others		1994	9-Aug-94	Ealing Wharf Southampton		Tanker	
			MT Blackheath		1.6			

Incid	Reporting	Year	Date	Location of spill	Type	
133	MPCU	1994	16-Oct-94	60 23 N 3 31 W	Merchant	MFV
	SEAWARD QUEST		15.2			
134	MPCU	1994	17-Oct-94	54 30 N 5 06W	Merchant	MFV
	THREE SISTERS	7.7				
135	Shetland Isles council /MPCU	1994	31-Oct-94	Ness of Trobistor	Merchant	MV
	PIONERK	600				
136	Bristol port Company	1994	14-Nov-94	Royal Portbury dock (Bristol)	Merchant	MV
	Marine Reliance	3				
137	Port of London Authority	1994	16-Nov-94	Mobil refinery to Southend	Tanker	MT K
	Toulson	5				
138	MPCU	1994	24-Nov-94	50 33 N 4 50 W	Merchant	MFV
	ROTOR JOY	5.4				
139	MPCU	1994	25-Nov-94	52 09 N 2 30 E	Tanker	HT
	ISOKAZE PANAMA		3			1.
148	Orkney Isles council/MPCU	1995	28-Jan-95	West Coast Orkney Mainland	Merchant	MFV

Incid	Reporting		Year	Date	Location of spill		Type	
149	Aberdeen Harbour Board		1995	28-Jan-95	Point low, Aberdeen Harbour		Merchant MV	
	Mikelbaka		5					
150	MPCU		1995	29-Jan-95	60 21 N 0 09 E		Merchant MFV	
	GREEN VALEY		16.7					
151	MPCU		1995	26-Feb-95	57 28 N 0 59 W		Merchant MFV	
	SHARIDALE		8					
152	MPCU		1995	8-Mar-95	51 41 N 5 10 W		Merchant MV	
	UNITED TRADER		5					
153	MPCU/ Highland RC		1995	6-Apr-95	57 19 N 5 43 W		Merchant M TUG	
	FLYING CHILDERS		60					
154	MPCU		1995	21-Apr-95	50 03 N 5 35 W		Merchant MFV	
	MYSTIQUE		4.5			Tanker	MT K Toulson	
161	Shetland Isles council/MPCU		1995	28-Jun-95	Holm Baa whalsay		Merchant MFV	
	ADONIA 2		4					
162	MPCU		1995	30-Jun-95	57 12 N 1 30 E		Unknown ?	
			1.2					

Incid	Reporting		Year	Date	Location of spill		Type	
165	MPCU		1995	27-Aug-95	53 25 N 1 00 E		Merchant	MV
	LAPPONIAN		1					
166	MPCU		1995	9-Sep-95	53 26 N 2 20 E		Merchant	MV
	TERRA NOVA SEA			2.9				
167	En agonny (NRA)		1995	1-Oct-95	River Humber		Merchant	M
	BARGE RIX EAGLE		1.5					
168	Millford haven PA		1995	3-Oct-95	Milford Haven		Tanker	
			Coastal Tanker		2.5			
169	NERPB		1995	14-Oct-95	Torry Quay, Aberdeen Harbour		Merchant	MV
	Barra Supplier		2					
170	MPCU/ Highland RC		1995	20-Oct-95	58 36 N 3 76 W		Merchant	MFV
	SOLON		22.7					
171	MPCU		1995	20-Oct-95	Isle of Scalpay, Off Harris		Merchant	MV
	GOLF STAR		45					
172	Humberside CC		1995	20-Oct-95	River Hull (Tidal)		Unknown	?
			1.2					

Incid	Reporting	Year	Date	Location of spill	Type
182	MPCU	1996	10-Feb-96	Outer Humber Estuary	Merchant MV
	LONEHAM	1.6			
183	MPCU+Others	1996	15-Feb-96	Bristol Channel	Tanker MV Sea
	Empress	72000			
184	SEPA	1996	22-Feb-96	Lossiemouth Harbour	Merchant MFV Unity
	PD14	3.9			
185	En +Heritage Service	1996	23-Feb-96	Belfast Harbour	Merchant MV North
	Trader	1			
186	MPCU	1996	28-Feb-96	57 10 N 6 24 W	Merchant Sovereign
		1.8			
187	Port of London Authority	1996	1-Mar-96	Purfleet deep wharf	Merchant MV Maersk
	Anglia	1			
188	North norfolk DC	1996	7-Mar-96	1 KM off sea polling, Norfolk	Merchant M BARGE
	GEOPOLES 14	11.2			
189	MPCU	1996	10-Apr-96	56 31 N 7 40 W	Merchant MFV
	INTEGRITY III	1.2			

Incid	Reporting	Year	Date	Location of spill	Type	
199	MPCU	1996	15-Aug-96	49 57 N 6 18 W	Merchant	
		MFV FLOMART		1.9		
200	Port of London Authority	1996	1-Sep-96	Sea Reach (Thames)	Unknown	?
		2				
201	SEPA	1996	Oct-96	Isle of Whithorn harbour	Merchant	
		MFV Margarite		1.7		
202	Dover Harbour Board	1996	29-Oct-96	Dover Harbour Eastern Arm	Merchant	
		MV Asian Reefer		5		
203	MPCU	1996	8-Nov-96	57 53 N 6 38 W	Merchant	M
	TUG GW 214	2.1				
204	Norfolk CC/MPCU	1996	11-Nov-96	52 48 N 1 37 E	Merchant	M
	TUG BEVER	12.9				
205	MPCU	1996	17-Dec-96	51 31 N 6 17 W	Merchant	
		MFV CHANTS D'ESPERONCE			3.2	
206	MPCU	1996	17-Dec-96	52 40 N 1 36 E	Merchant	

Incid	Reporting		Year	Date	Location of spill		Type	
216	MPCU		1997	26-Mar-97	49 55 N 6 16 W		Merchant	MV
	CITTA		5					
217	Highland Council +Others		1997	16-Apr-97	Scrabster Harbour		Merchant	Mfv
	Flowing tide		1.5					
218	MPCU		1997	23-Apr-97	57 01 N 6 02 W		Merchant	MFV
	SAPHIRE		1.3					
219	Forth Ports and Others		1997	24-May-97	M3 Anchorage, Off Methill		Merchant	
			Derrick Barge		9			
220	MPCU		1997	21-Jul-97	58 04 N 4 15 W		Merchant	RFA
	Victoria		1					
221	MPCU		1997	13-Aug-97	53 29 N 4 52 W		Unknown	?
			1					
222	Shetland Isles Council/MPCU		1997	30-Aug-97	60 23 N 00 09 E		Merchant	MFV
	AQUARIUS		2.3					
223	MPCU		1997	3-Sep-97	52 09 N 1 24 E		Tanker	
			Whitstar		1			

Incid	Reporting	Year	Date	Location of spill	Type	
233	Fraserburgh	1997	18-Nov-97	Fraserburgh Harbour	Merchant	Dea Mariner
234	MPCU	1997	19-Nov-97	60 08 N 1 08 W	Merchant	MFV
	GREEN LILLY	239				
235	MPCU	1997	29-Nov-97	56 54 N 6 09 W	Merchant	MFV
	KELLY MORONA	4.5				
236	MPCU	1997	9-Dec-97	Falmouth	Merchant	Mv
	Ibin	2				
				Merchant	Mfv Jacoba	
241	MPCU	1998	25-Apr-98	54 42 N 00 08 W	Merchant	HV
	REMA (BL2)	10				
242	MPCU	1998	28-Apr-98	55 36 N 01 05 W	Merchant	MFV
	GOLDEN GIRL	1				
243	MPCU	1998	29-Apr-98	54.02 N 6.07 W	Unknown	?
		1				
244	MPCU	1998	2-Jun-98	58 00 N 1 02 E	Merchant	HV

Incid	Reporting	Year	Date	Location of spill	Type	
249	MPCU	1998	18-Jul-98	61 06 N 1 04 E	Unknown OFF	
	CORMORANT PLATFORM			2		
250	Merseyside Fire Brigade	1998	29-Jul-98	Bromborough Wall, River Mersey	Merchant Mv Rachel	
		1				
251	MPCU	1998	7-Sep-98	59 13 N 1 43 E	Merchant MFV	1
254	Jersey Harbours	1998	25-Sep-98	49 10 N 2 13 W	Merchant MFV	
	MARIE GALLANTE	1.5				
255	MPCU	1998	28-Sep-98	50 03 N 4 06 W	Merchant HMS	
	ALDERNEY	4				
256	MPCU	1998	13-Oct-98	50 40 N 00 3 E	Merchant MFV	
	CATRINA	5				
257	EA+5 Other	1998	15-Oct-98	Broadness, River Thames	Merchant Dredger	

2 REFERENCES

1 Oil spill data sheets received from ACOPS, May 1999

APPENDIX 4

IDENTIFICATION OF SITES SENSITIVE TO MARINE POLLUTION

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1 INTRODUCTION

As a result of the Donaldson Inquiry, it was found that whilst navigational hazards are identified on nautical charts, there is little mention of environmentally sensitive areas. The purpose of this appendix is to identify areas (coastal & sea areas) which are sensitive to marine pollution, which can be used as a basis together with the pollution risks around the UK coastline to establish Marine Environmental High Risk Areas (MEHRA's).

To assess the environmental sensitivity of the coastline and UK waters, the first step taken was to identify all protected or sensitive sites within UK waters. These sites were then classified according to the nature of the site. The sites have been classified based on the following categories:

- Wildlife
- Vulnerability of seabirds to oil pollution
- Fishing
- Amenity and economic benefit of the surrounding community
- Landscape
- Geology

As part of the environmental sensitivity process, JNCC undertook an assessment of in the order of 900 individual sites. This assessment process identified those sites which were potentially sensitive to marine pollution as well as those which were not. Under this assessment process comments were received from JNCC on certain wildlife, geological and landscape designations. Such designations are discussed in each of the corresponding sections of this Appendix.

During the evaluation, various voluntary organisations and sites were identified. These sites, which are documented under Section 8 of this appendix are largely covered by other formal designations and whilst important in their specific nature, the inclusion of such sites may have resulted in 'double counting' thus allocating certain areas a higher 'score', therefore these sites have not been included within the assessment. The specific voluntary organisations and sites in this category include:

- Biogenetic Reserves
- Areas of Special Protection and Wildlife Refuges in Northern Ireland
- Limestone Pavement Orders
- Nature Conservation Review Sites
- Voluntary Marine Nature Reserves
- National trust
- Royal Society for the Protection of Birds Reserves
- Wildfowl and wetlands Trust
- John Muir Trust
- County Wildlife Trust
- Woodland Trust
- Water based leisure Sites

2 WILDLIFE

The following sites were included for their wildlife importance, with the locations outlined in Figure 2.1:

- World Heritage Site of Nature Conservation
- Biosphere Reserve
- Ramsar Site
- Special Protection Area (SPA's)
- Special Area of Conservation (SAC's)
- Site of Special Scientific Interest (SSSI's),
  - Area of Special Scientific Interest (ASSI's) &
  - Area of Scientific Interest (ASI's)
- National Nature Reserve (NNR's)
- Marine Nature Reserve (MNR's)
- Local Nature Reserve (LNR's)
  - Local Authority Nature Reserve (LANR's)
- Marine Consultation Area (MCA's)
- Sensitive Marine Area (SMA's)

The following figure presents a geographical overview of the location of these sites around the UK coastline.

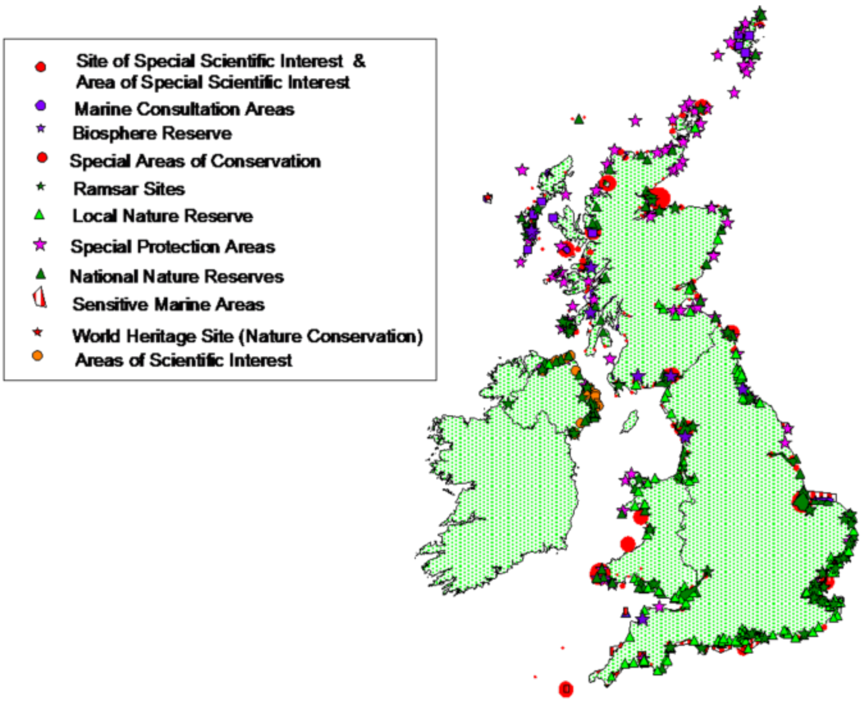

Figure 2.1 Sites Designated for their Wildlife Importance

Of the sites included for their wildlife importance, sites under the following designations were reviewed by JNCC to assess if they were sensitive to Marine Pollution:

- World Heritage Site of Nature Conservation Importance
- Biosphere Reserve
- Wetlands of International Importance (Ramsar Sites)
- Special Protection Areas (SPA's)
- Special Areas of Conservation (SAC's)
- Sites and Areas of Special Scientific Interest (SSSI's & ASSI's)
- National Nature Reserves (NNR)
- Marine Nature Reserves (MNR)

~~Each~~All ~~-~~of the Wildlife designations included in the evaluation of environmental sensitivity are discussed in the following paragraphs.

2.1.1 World Heritage Site of Nature Conservation Importance (WHS's)

World Heritage Sites are designated under the Convention concerning the protection of the world cultural and natural heritage (World Heritage Convention). World Heritage sites are **unique** examples of natural beauty often **representing** a major stage of the earth's evolutionary **history**, they are of exceptional interest and universal value. Sites are nominated by the state within which they are situated, with the nominations being considered by the World Heritage Committee. Sites that are accepted are then placed on the World Heritage list and categorised as either 'natural' and 'cultural', only **natural** sites have been included in this evaluation.

Such natural sites have been further divided into those designated for their nature conservation importance and those designated for their geological importance. Only one site, St Kilda in the Scottish Western Isles has been designated as a World Heritage Site that is important for nature conservation. This site has been identified by JNCC as being sensitive to marine pollution and is identified in Figure 2.2.

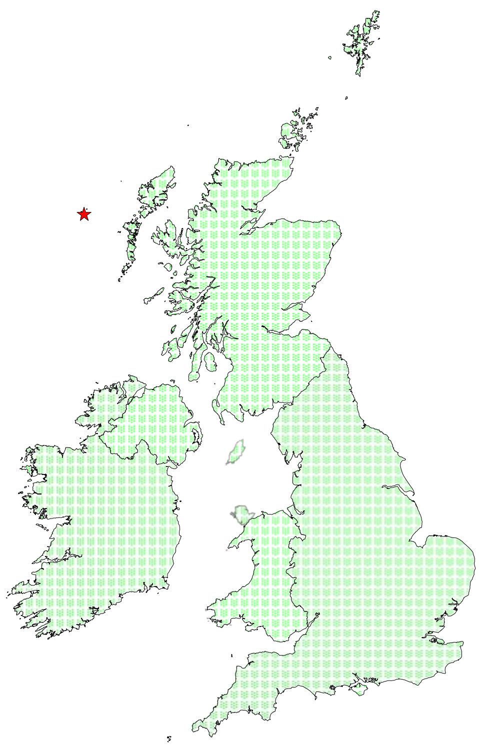

Figure 2.2 World Heritage Site of Nature Conservation Identified by JNCC as being Sensitive to Marine Pollution.

Source: JNCC Coastal Directories Series (1998) (Ref. 1), World Heritage List (1999), JNCC Sensitive List (1999).

2.1.2 Biosphere Reserve

The Biosphere Reserve is an international designation introduced by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) in 1970 with criteria and guidelines for the selection of sites produced in 1974.

They are protected areas of land and coastal environment **representative** of significant examples of biomes throughout the world. They have a **unique** value as benchmarks or standards for the measurement and **monitoring** of long term changes in the biosphere as a whole. They provide a base for **education** and **research**. They are chosen to conserve examples of areas which are characteristic of the world's **natural** regions. They must also be areas where people are important components of everyday life. Their needs must be met whilst also conserving the area's natural processes and wildlife.

There are a total of 12 biosphere reserves in the UK, four of which are in England, with the rest being in Scotland. Only sites declared as National Nature Reserves are nominated for Biosphere Reserve status, and are therefore also Sites of Special Scientific Interest. No Sites have been identified by JNCC as not being sensitive to Marine Pollution, therefore all 12 sites are identified in Figure 2.3.

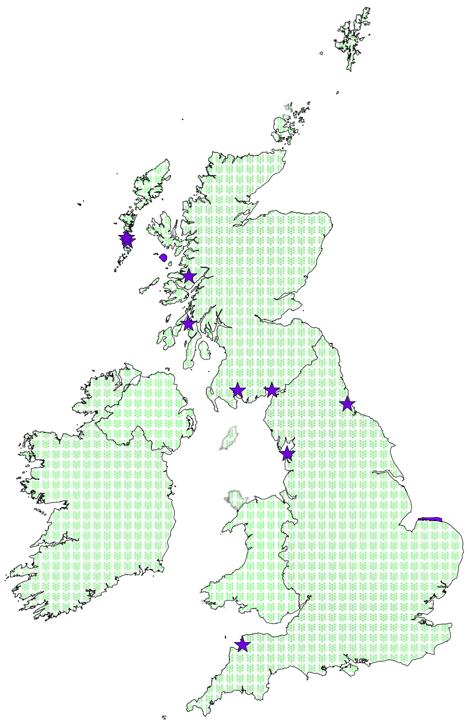

Figure 2.3 Biosphere Reserves Identified by JNCC as being Sensitive to Marine Pollution

Source: Scottish Natural Heritage (1998), Digest of Environmental Statistics (1998)

2.1.3 Wetlands of International Importance (Ramsar Sites)

Ramsar sites are designated under the Convention on Wetlands of International Importance, which was signed in the Iranian town of Ramsar in 1971.

Wetlands of international importance are designated as Ramsars in order to safeguard wetland habitats and species including those that contain large numbers of wildfowl. All Ramsar sites are primarily designated as SSSI's, particular sites are then designated Ramsars because they **represent natural** areas with **unique** populations of waterfowl including migratory birds, important plant and animal assemblages and wetland interest.

All Ramsar Sites are also Sites of Special Scientific Interest. There are currently 125 classified Ramsar sites in the UK covering a total area of 602,255 hectares, sites in coastal areas are identified in Figure 2.4. Most of the sites are identified as single points, however some of the larger sites have been shown as a solid coloured area. Of the Ramsar sites listed only one, Magilligan in Northern Ireland has been identified by JNCC as not being sensitive to marine pollution.

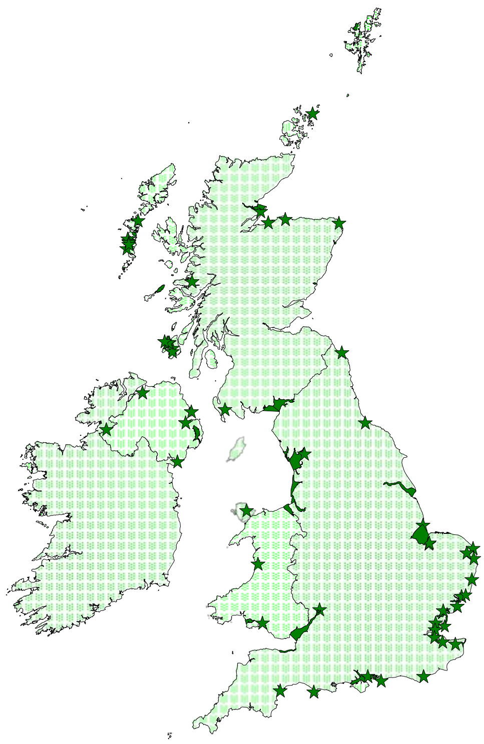

Figure 2.4 Ramsar Sites Identified by JNCC as being Sensitive to Marine Pollution

Source: Scottish Natural Heritage (1998), JNCC (1999), World Conservation Monitoring Centre (1999)

2.1.4 Special Protection Area (SPA's)

Special Protection areas were introduced, by the UK government as a result of the 1979 European Community Directive on the Conservation of Wild Birds (the Birds Directive). This designation is implemented in Northern Ireland through the provisions of the Nature Conservation and Amenity Lands (Northern Ireland) Order 1985.

The aim of the SPA designation is to safeguard rare or **vulnerable** bird species, as well as regularly occurring migratory birds and protect their habitats. SPA sites are **representative** of **unique natural** bird habitats. SPA's, together with SAC's will form a European-wide network of sites known as Natura 2000. The main aim of the network is to maintain the relevant species and habitats as a favourable conservation status.

All SPA's have first to be notified as Sites of Special Scientific Interest and some have also been declared as National Nature Reserves. Some sites, such as in Northern Ireland are still awaiting formal designation and are classed as proposed SPA's, however these have also been included in the designation since they have the same protection as SPA's until such times as they are formally designated or rejected.

There are 207 designated Special Protection Areas in the UK, with six proposed sites giving a total of 213 SPA's as detailed in Figure 2.5, either in the form of a site point, or in the case of larger sites, as a solid coloured area. Only one Special Protection Area, Magilligan in Northern Ireland, was identified by JNCC as not being sensitive to marine pollution.

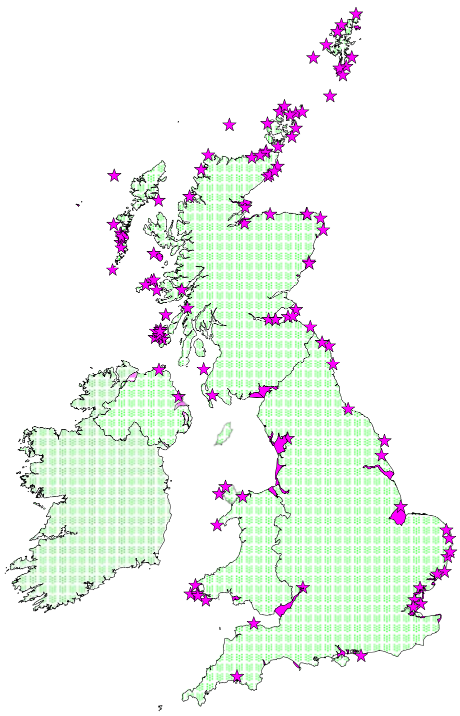

Figure 2.5 Special Protection Areas Identified by JNCC as being Sensitive to Marine Pollution

Source: JNCC (1998)

2.1.5 Special Area of Conservation (SAC's)

Special Areas of Conservation are designated under the 1992 EC Directive on the conservation of habitats and wild flora and fauna (Habitats and Species Directive). In Northern Ireland the Directive will be implemented through the Conservation (Natural Habitats, etc.) Regulations 1994. At this time no sites have been formally designated, however a list of candidate special areas of conservation was drawn up and finalised in 1998, member states have until June 2004 to designate selected sites as SAC's.

Special Areas of Conservation are identified as **outstanding** examples of selected habitat types or areas important for the continuing well-being or **survival** of selected non-bird species. Such habitats include coastal estuaries and sand dune systems. The directive states that SAC's are to be afforded absolute protection subject to 'imperative reasons of overriding public interest, including those of a social or **economic** nature'. SAC's, together with SPA's will form a European-wide network of sites known as Natura 2000. The main aim of the network is to maintain the relevant species and habitats as a favourable conservation status.

There are currently no Special Areas of Conservation in the United Kingdom, although there are 327 candidates awaiting formal designation, covering over 1.5 million hectares. Since the candidates have the same protection as SAC's until formal designation, they are given the same status as SAC's.

SAC Candidates that are sensitive to Marine Pollution were identified by the JNCC, and are shown geographically in Figure 2.6. Only one Special Area of Conservation, Magilligan in Northern Ireland, was identified by JNCC as not being sensitive to marine pollution.

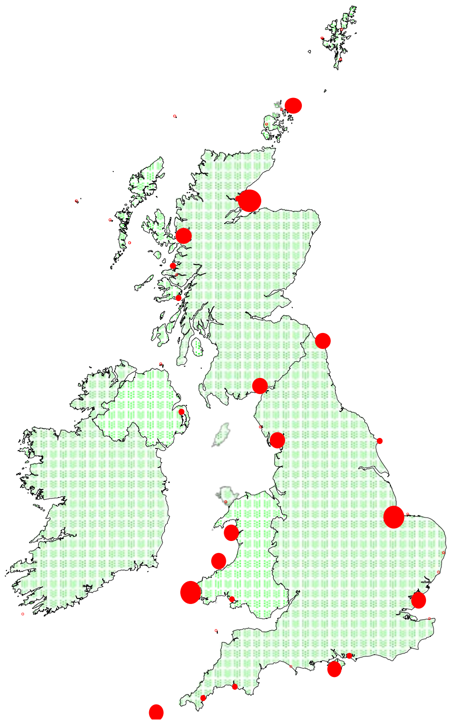

Figure 2.6 Special Areas of Conservation Identified by JNCC as being Sensitive to Marine Pollution

Source: JNCC List of Sensitive Sites (1999)

2.1.6 Site of Special Scientific Interest & Areas of Special Scientific Interest (SSSI's & ASSI's)

Sites of Special Scientific Interest (SSSI) are defined in the Wildlife and Countryside Act 1981. The equivalent Northern Ireland designations are Areas of Special Scientific Interest (ASSI), as notified under the Nature Conservation and Amenity Lands (Northern Ireland) Order 1985 (as amended, 1989). However, the designation of sites in Northern Ireland is still underway and it is intended that this will be complete by the year 2001. Potential Areas of Special Scientific Interest are designated as Areas of Scientific Interest (ASI) under The Amenity Lands Act (Northern Ireland) 1965

All of the sites are designated for their special **nature** conservation interest. **Representing unique** areas of land or water that are of special interest by reason of their flora, fauna, geological features or landforms of special interest. In order to designate SSSI's certain 'areas of search' are **surveyed** and **assessed** against scientific guidelines to determine whether land is of special interest. SSSI's also provide an excellent base for **educational** purposes.

SSSI's provide the basis for other national and international designations e.g. NNRs and SACs. Extensive parts of the coast are included within the SSSI designation but this only applies to land above the low water mark. Sites of Special Scientific Interest in the UK and Areas of Special Scientific Interest in Northern Ireland identified by JNCC as being sensitive to marine pollution are identified in Figure 2.7. Potential Areas of Special Scientific Interest, i.e. Areas of Scientific Interest were identified in JNCC's Coastal Directories Series and are also included in this figure. A Number of Sites & Areas of Special Scientific Interest (totalling 242 locations) were specified by JNCC as being insensitive to marine pollution. The locations of such sites are outlined in Figure 2.8.

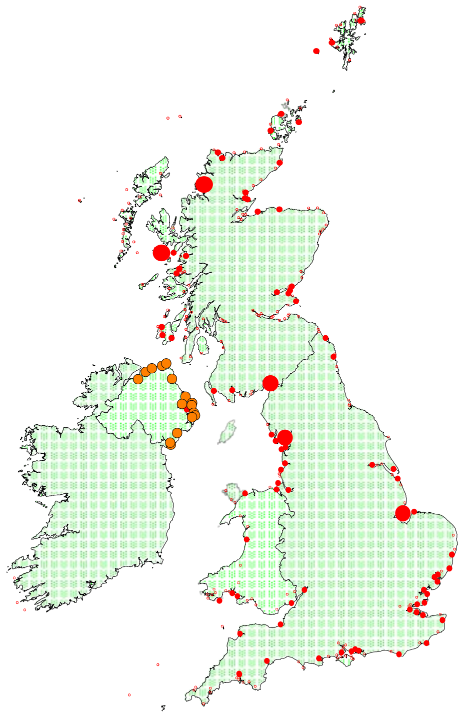

Figure 2.7 Sites and Areas of Special Scientific Interest and Areas of Scientific Interest Identified by JNCC as being Sensitive to Marine Pollution.

Source: JNCC List of Sensitive Sites (1999), JNCC Coastal Directories Series (1998)

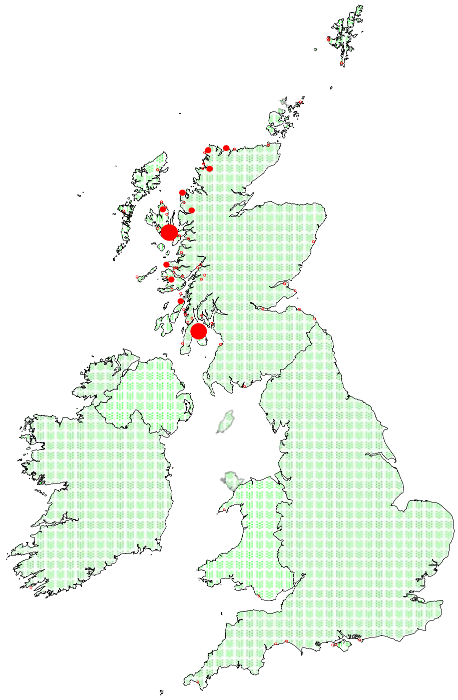

Figure 2.8 Sites & Areas of Special Scientific Interest Identified by JNCC as Not being Sensitive to Marine Pollution.

2.1.7 National Nature Reserves (NNR's)

National Nature Reserves were introduced as a result of the National Parks and Access to the Countryside Act 1949. National Nature Reserves **represent** some of the most important **natural** and semi-natural ecosystems and earth science features. They are managed to conserve their flora, fauna, features of geological, physiographical or other scientific or special interest. They provide an important **educational** base and are used for **research**, study, **survey** and management trials. They are exemplars for positive land management where conservation and enhancement of the natural heritage is the prime aim

All NNRs are firstly designated as Sites of Special Scientific Interest. There are 118 National Nature Reserves spread throughout the UK, some of the sites have a coastal frontage or are offshore islands, the locations of which are given in Figure 2.9 with the larger sites being identified by diagonally striped areas. Thirty five National Nature Reserves were identified by JNCC as not being sensitive to marine pollution. Such sites are largely located inland, as shown in Figure 2.10.

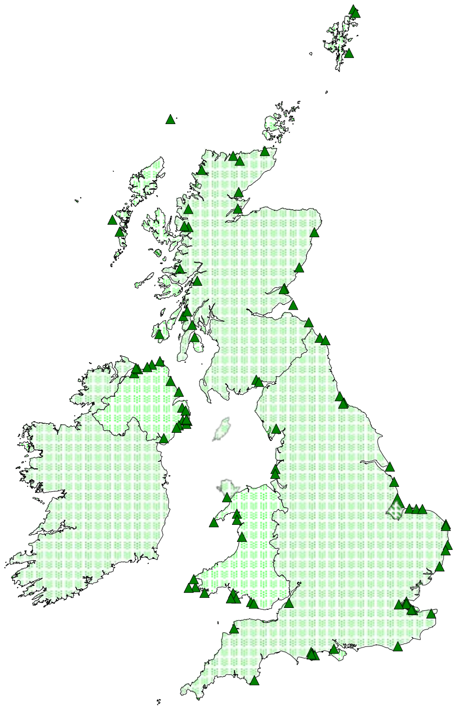

Figure 2.9 National Nature Reserves Identified by JNCC as being Sensitive to Marine Pollution

Source: Scottish Natural Heritage (1998), English Nature (1998), Countryside Council for Wales (1996), World Conservation Monitoring Centre (1999)

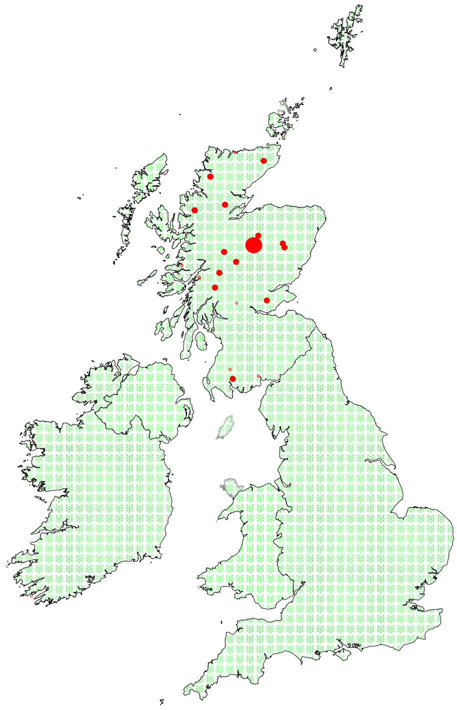

Figure 2.10 National Nature Reserves Identified by JNCC as Not Sensitive to Marine Pollution

2.1.8 Marine Nature Reserves (MNR's)

Provision is made in the Wildlife and Countryside Act 1981 to designate marine areas in order to conserve their marine flora and fauna. This is the only statutory designation that specifically relates to marine areas below the low water mark. Marine Nature Reserves are a way of conserving especially important marine habitats and wildlife, and other **unique** features along the shore or on the seabed. They provide public enjoyment and **education** as well as being a base for study, **research**, and **monitoring** of the physical system.

There are only three Marine Nature Reserves designated to date, these can be found in Northern Ireland, South West Wales and Devon. The total area protected by MNR's is 20,200 ha and are shown in Figure 2.11. The larger site, Strangford Lough in County Down is represented by a diagonally striped area, whereas the smaller sites are identified by points only. All of the Marine Nature Reserves identified in this evaluation were identified by JNCC as being sensitive to marine pollution.

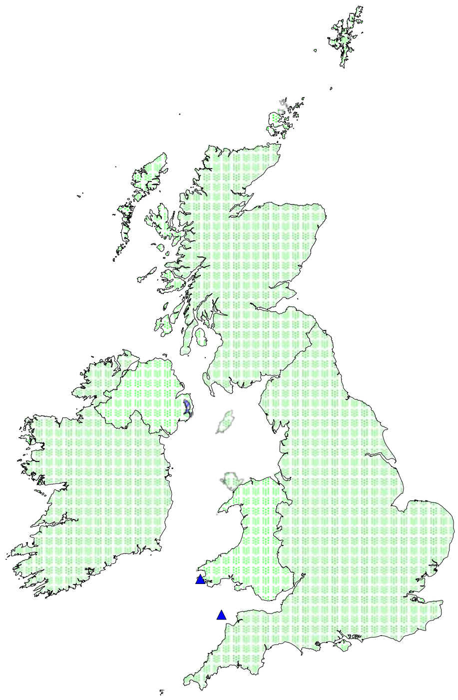

Figure 2.11 Marine Nature Reserves Identified by JNCC as Sensitive to Marine Pollution

Source: JNCC (1998), World Conservation Monitoring Centre (1999)

2.1.9 Local Nature Reserves (LNR's) and Local Authority Nature Reserves (LANR's Northern Ireland)

Local Nature Reserves are declared and managed by local authorities under the National Parks and Access to the Countryside act, 1949. Local Authority Nature Reserves are the Northern Ireland equivalent of Local Nature Reserves designated in Great Britain.

The Reserves are provided for the same purposes as NNRs and may be designated for their study and research value, their preservation value, or both. They are concerned with matters relating to flora and fauna and the physical conditions in which they live, as well as geological and physiographical features of special interest in the area. They **represent** areas that are 'special' in the local context, and have a high value for education and informal enjoyment.

Local Nature Reserves are only found in England, Scotland and Wales, where there are a total of 248 designated sites, those including coastal areas are identified in Figure 2.12. Local and Local Authority Nature Reserves were not reviewed by JNCC in terms of sensitivity to marine pollution.

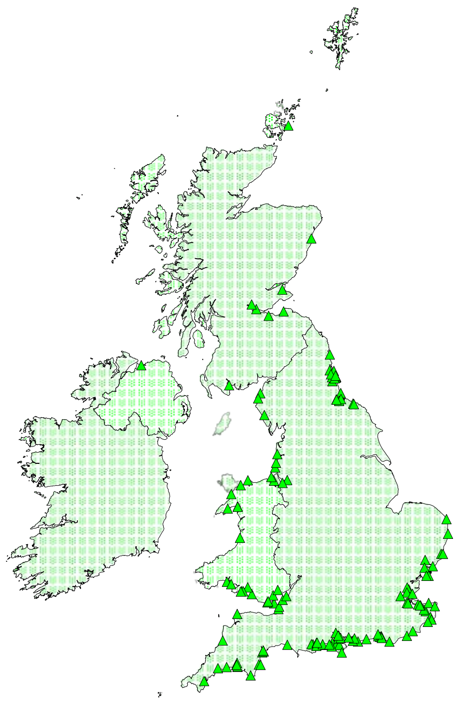

Figure 2.12 Local and Local Authority Nature Reserves

Source: Scottish Natural Heritage (1998), English Nature (1998), Countryside Council for Wales (1998), JNCC (1998).

2.1.10 Marine Consultation Areas (MCA's)

Marine Consultation Areas are non-statutory areas introduced in 1986 by Scottish Natural Heritage. The areas are considered to deserve particular **distinction** in respect of the quality and **sensitivity** of the marine environment within them. They are areas in which SNH wish to be consulted on **developments**, in particular fish farms, which are likely to have an impact on the marine environment.

There are 28 sites, all in Scotland, either on the West Coast or the Islands, and one in the Scottish Borders, all located in Figure 2.13. Marine Consultation Areas were not reviewed by JNCC in terms of sensitivity to marine pollution.

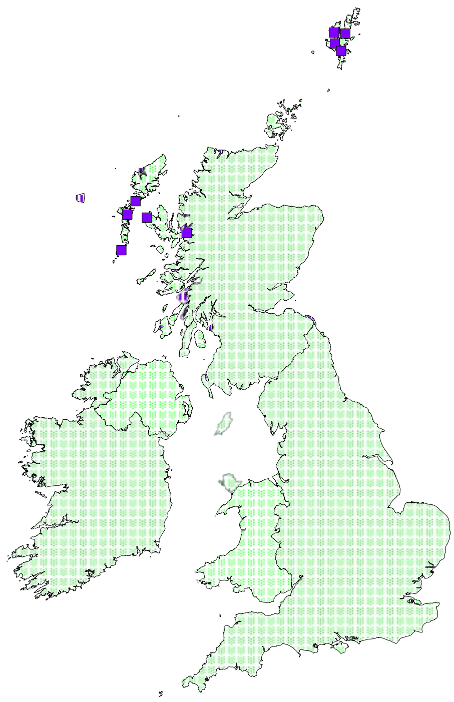

Figure 2.13 Marine Consultation Areas

Source: Scottish Natural Heritage (1998)

2.1.11 Sensitive Marine Areas (SMA's)

Sensitive Marine Areas are non-statutory marine areas that are nationally important and notable for their **natural** marine animal and plant communities or which provide ecological support to adjacent statutory sites.

There a total of 27 areas around the coast of England, most of the Sensitive Marine Areas are widespread, and have been represented in Figure 2.14 as vertically stripped areas rather than single points. Sensitive Marine Areas were not reviewed by JNCC in terms of sensitivity to marine pollution.

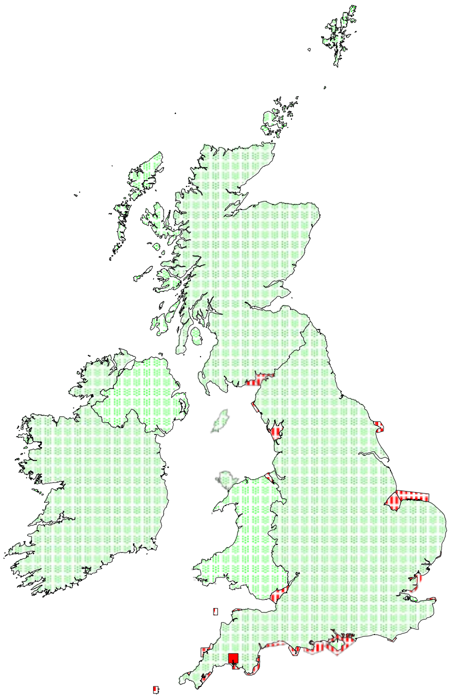

Figure 2.14 Sensitive Marine Areas

Source: JNCC (1998)

3 VULNERABILITY OF SEABIRDS TO OIL POLLUTION

Seabirds have been surveyed systematically off Britain's coasts for 20 years. The results of these surveys have been compiled into a series of atlases that describe these distributions an a monthly basis. Further information has been gained on the location of concentrations of nearshore seabirds (primarily duck) in other surveys. The results of these surveys have been used by JNCC to create a set of maps of seabird vulnerability to oil pollution that are available in both electronic and printed format. These maps rate UK's seat into four categories of vulnerability, running from very high to low. The majority of nearshore areas of the UK hold concentrations of birds that are very highly vulnerable at some stage of the year; and this criterion aims to identify those sites at highest vulnerability for a substantial part of the year. Whilst the vulnerability varies from month to month for different areas, an annual summary has been applied in this assessment. The following figure presents areas of sea holding concentrations of seabirds, at highest vulnerability to oil pollution for 70% or more of the year.

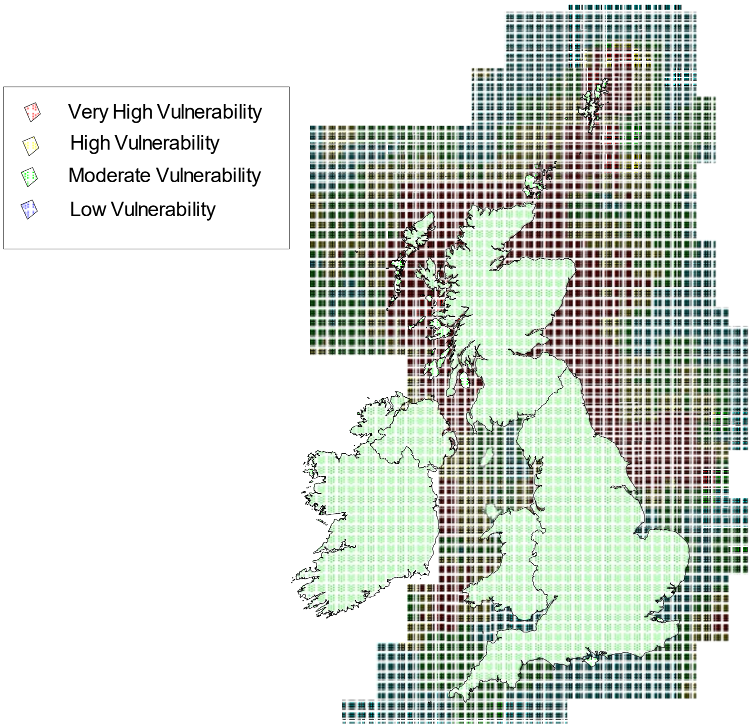

Figure 3.1 Ranking of Sea Areas Based on Vulnerability of Birds to Oil Pollution.

Source: JNCC (1999)

4 FISHING AREAS SENSITIVE TO MARINE POLLUTION

In the event of a marine pollution incident taking place in UK waters, then fishing can be affected in terms of production areas as well as breeding grounds. In the sensitivity assessment, the following categories have been included:

- Fish farms,
- Nephrops fishing areas,
- Shrimp fishing areas,
- Shellfish bivalve mollusc production areas; and
- Shellfish waters

The following figure presents a geographical overview of each category considered in the assessment, with the following subsections presenting each dataset.

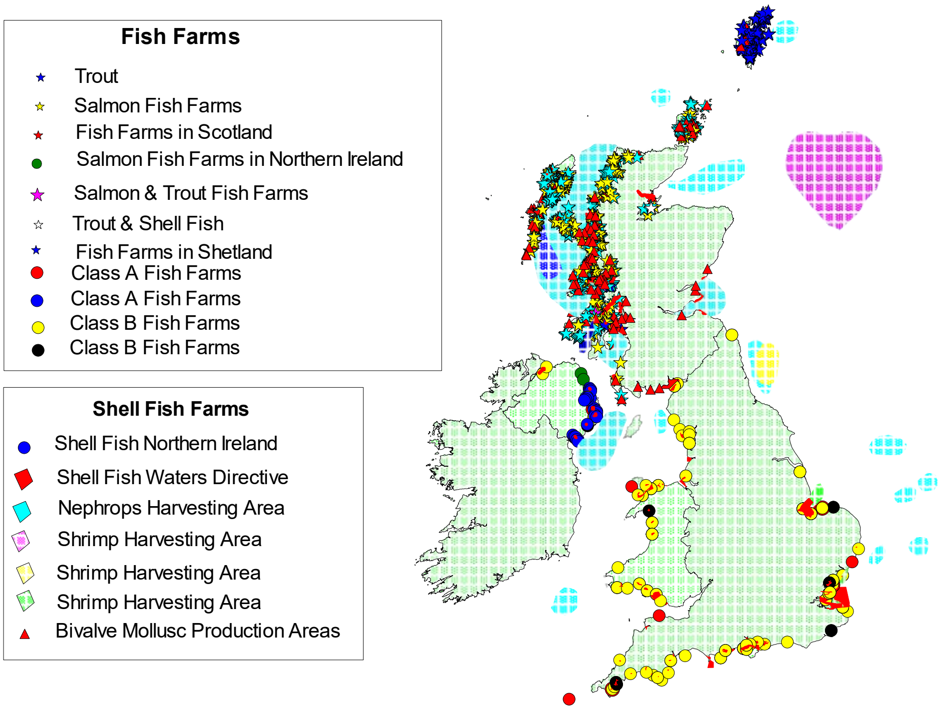

Figure 4.1 All Sensitive Fishing Sites on the UKCS Considered in MEHRAS Evaluation

Source: The Centre for Environment Fisheries and Aquiculture Science; CFAS (1999), DETR (1999), Fisheries Research Services (1999), Aberdeen Marine Laboratory (1999), DETR Northern Ireland (1999), Ministry of Agriculture Fisheries & Food (1998), Scottish Office (1999) UKDMAP (1981-1991) (Ref. 2)

4.1 Fish Farms

Figure 4.2 presents the location of fish farms in Scotland and Northern Ireland. These consist mainly of salmon, trout and shellfish farms.

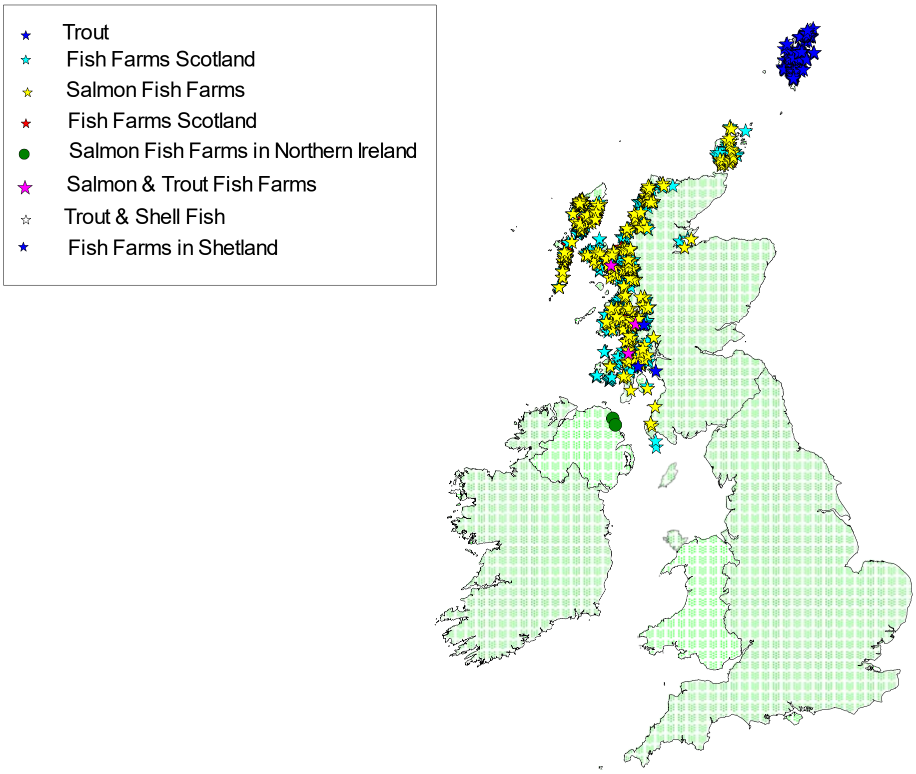

Figure 4.2 Location of Fish Farms in Scotland & Northern Ireland

Source: The Centre for Environment Fisheries and Aquiculture Science; CFAS (1999), Fisheries Research Services (1999), Aberdeen Marine Laboratory (1999), Department of Agriculture Northern Ireland (1998), Ministry of Agriculture Fisheries & Food (1998), UKDMAP (1991).

Due to the large number of fish farms present in certain areas these have been represented by density as presented in Figure 4.3 rather than individual fish farm sites. The categories used within the fish farm density figure are outlined in Table 4.1.

Table 4.1 Fish Farm Density

Category	Number of Fish Farms in Cell	Percentage of Cells in Category
High	More than 13 fish farms per cell	10
Medium	Between 5 and 13 fish farms per cell	40
Low	Between 1 and 5 fish farms per cell	50

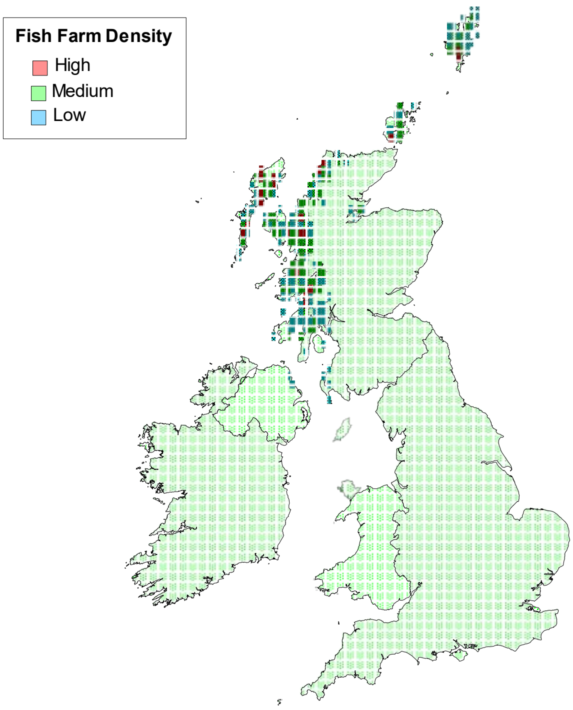

Figure 4.3 Fish Farm Density

Source: The Centre for Environment Fisheries and Aquiculture Science; CFAS (1999), DETR (1999), Fisheries Research Services (1999), Aberdeen Marine Laboratory (1999), Department of Agriculture Northern Ireland (1998), Ministry of Agriculture Fisheries & Food (1998), Scottish Office (1999) UKDMAP (1991)

4.2 Nephrops Fishing Areas

Nephrops fishing areas which have been included in the assessment are presented in Figure 4.4. The source of this data is the 1997 version of the UKDMAP database. It is acknowledged that the source of this data contained within the database dates to 1981.

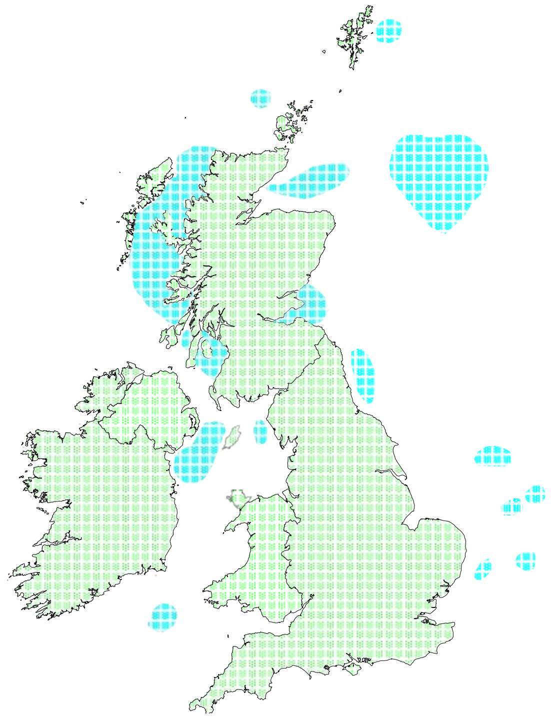

Figure 4.4 Nephrops Fishing Area

Source: UKDMAP (1981)

4.3 Shrimp Fishing Area

Shrimp fishing areas which have been included in the assessment are presented in Figure 4.5. The source of this data is the 1997 version of the UKDMAP database. It is acknowledged that the source of this data contained within the database dates to 1981.

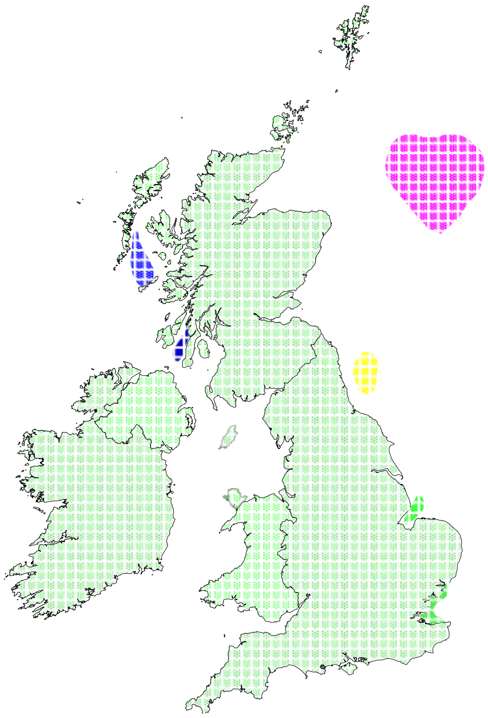

Figure 4.5 Shrimp Fishing Area

Source: UKDMAP (1981)

4.4 Shellfish & Bi-Valve Mollusc Production Areas

Shellfish production areas consist of the following:

- Class A Shell Fish Production Areas
- Class B Shell Fish Production Areas
- Bi-valve Mollusc Production Areas in Scotland and
- Shell Fish Production Areas in Northern Ireland

4.4.1 Shellfish Production Areas – England, Wales and Northern Ireland

Figure 4.6 presents the location of the different categories of shellfish production areas in the England, Wales and Northern Ireland.

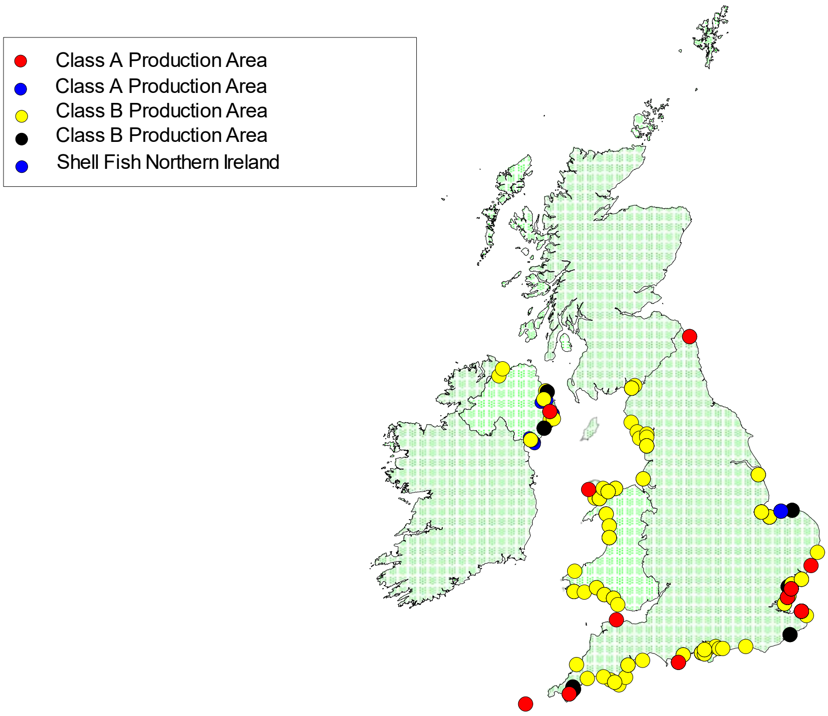

Figure 4.6 Shellfish Production Areas

Source: The Centre for Environment Fisheries and Aquiculture Science; CFAS (1999), DETR (1999), Fisheries Research Services (1999), Aberdeen Marine Laboratory (1999), Department of Agriculture Northern Ireland (1998), Ministry of Agriculture Fisheries & Food (1998), Scottish Office (1999) UKDMAP (1996)

4.4.2 Bivalve Mollusc Production Areas

The EC shellfish Directive lays down the health conditions for the production and the placing on the market of live Bivalve Molluscs which includes oysters, mussels, scallops and razor fish. Under the directive the competent authority of the member state must establish the location and fix the boundaries of production areas according to the degree of contamination by faecal indicator bacteria present in samples of mollusc flesh. The production areas are classified according to the categories outlined in Table 4.2.

Table 4.2 Definition of Bi-Valve Mollusc Production Criteria

Category	Criteria	Production requirements
Category A	Less than 300 faecal coliforms per 100g flesh	May go direct for human consumption if end product standard met
Category B	Less than 6,000 faecal coliforms per 100g flesh in 90% of samples	Must be depurated, heat treated or relayed to meet category A requirements
Category C	Less than 60,000 faecal coliforms per 100g flesh	Must be relaid for a long period (at least two months) whether or not combined with purification, or after intensive purification to meet Category A or B
Other Area	Above 60,000 faecal coliforms	Unsuitable for production

There are 153 production sites in the UK all of which are in Scottish waters as outlined in Figure 4.7.

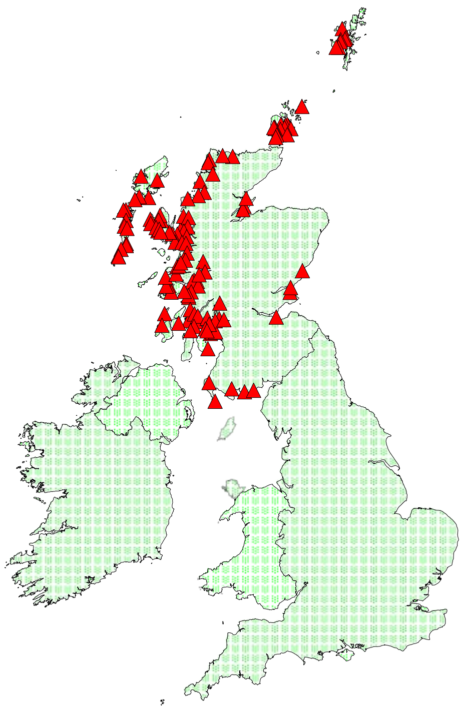

Figure 4.7 Bivalve Mollusc Production Areas

Source: Marine Laboratory Aberdeen (1999)

It should be noted that whilst for presentation purposes, the locations of the bi-valve mollusc production areas are represented by symbols on Figure 4.7, these are included as detailed areas within the GIS, an example of which is presented in Figure 4.8.

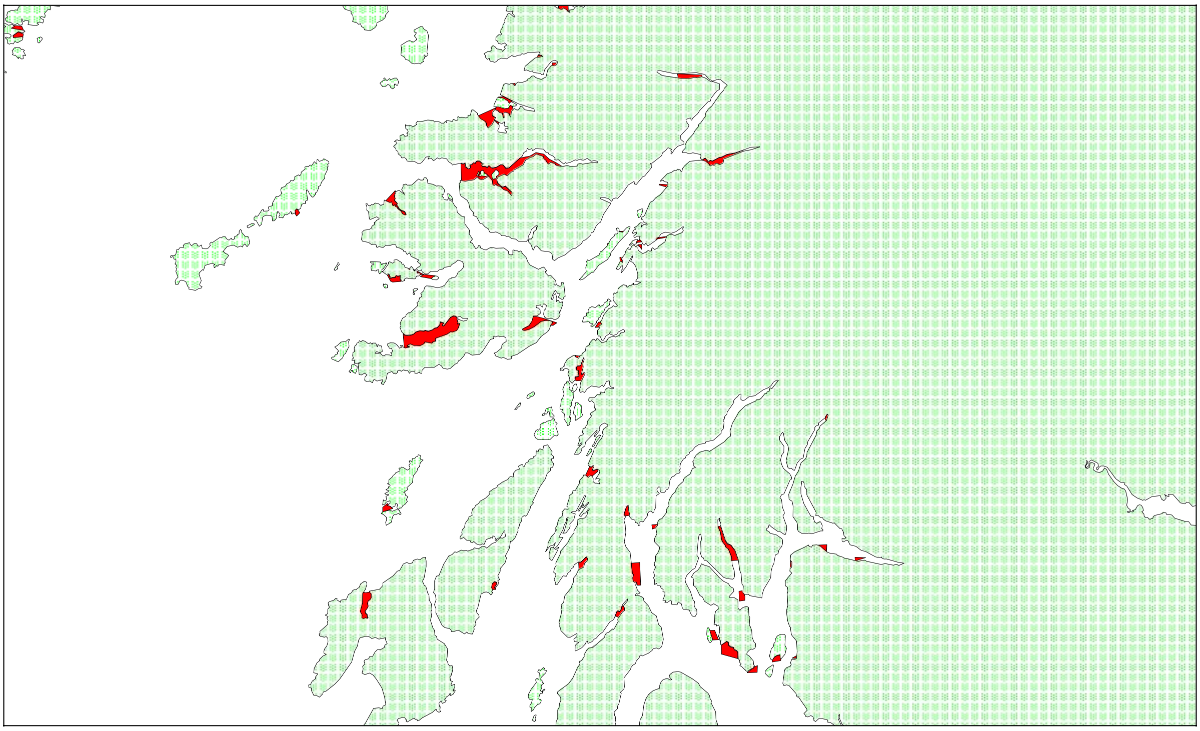

Figure 4.8 Areas of Bivalve Mollusc Production in Argyll & Bute Scotland

4.5 Shellfish Waters Directive

The Shellfish Waters Directive was introduced in 1979 and is administered by the DETR. This was later updated by the introduction of the Shellfish Hygiene Directive in 1997. Under the Shellfish Waters Directive the primary concern is the well-being of the shellfish population as an indicator of water quality, but there are obviously public health implications. The Production areas are classified to denote the level of treatment which must be given to shellfish caught within the area. The classifications and production requirements are outlined in Table 4.3.

Table 4.3 Shellfish Waters Area Classification - Definitions

Area Classification	Production requirements
Class A areas	Shellfish can be gathered for direct human consumption.
Class B areas	Shellfish must be purified, relayed (followed by purification where necessary) or heat treated by an approved method.
Class C areas	Shellfish must be relayed for at least two months (followed by purification where necessary) or heat treated by an approved method.
Prohibited areas	Shellfish harvesting is prohibited from areas where shellfish exceed the limits of Class C.

Shellfish waters production areas are spread throughout the whole of the United Kingdom Continental Shelf with 93 production areas in England, 26 areas in Wales, 8 sites in Northern Ireland and 21 sites in Scotland.

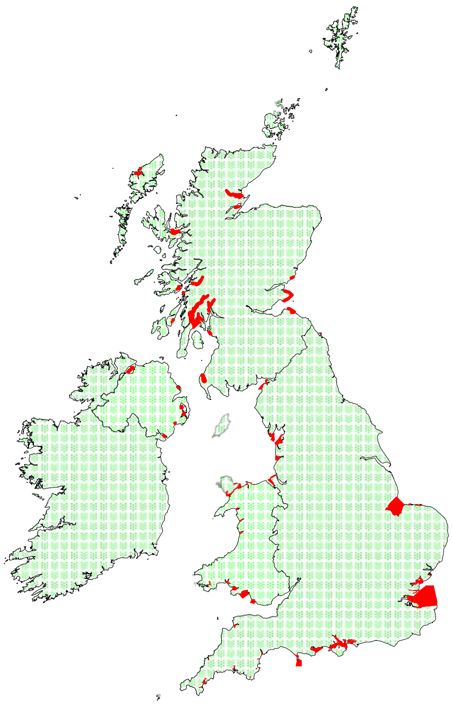

Figure 4.9 Shellfish Waters Designations

Source: Environment Agency Wales (1999), DETR Northern Ireland (1999), Scottish Office (1999), DETR (1999).

The locations of the shellfish water production areas are represented on Figure 4.9 as detailed areas within the GIS, however a more detailed picture is presented in Figure 4.10.

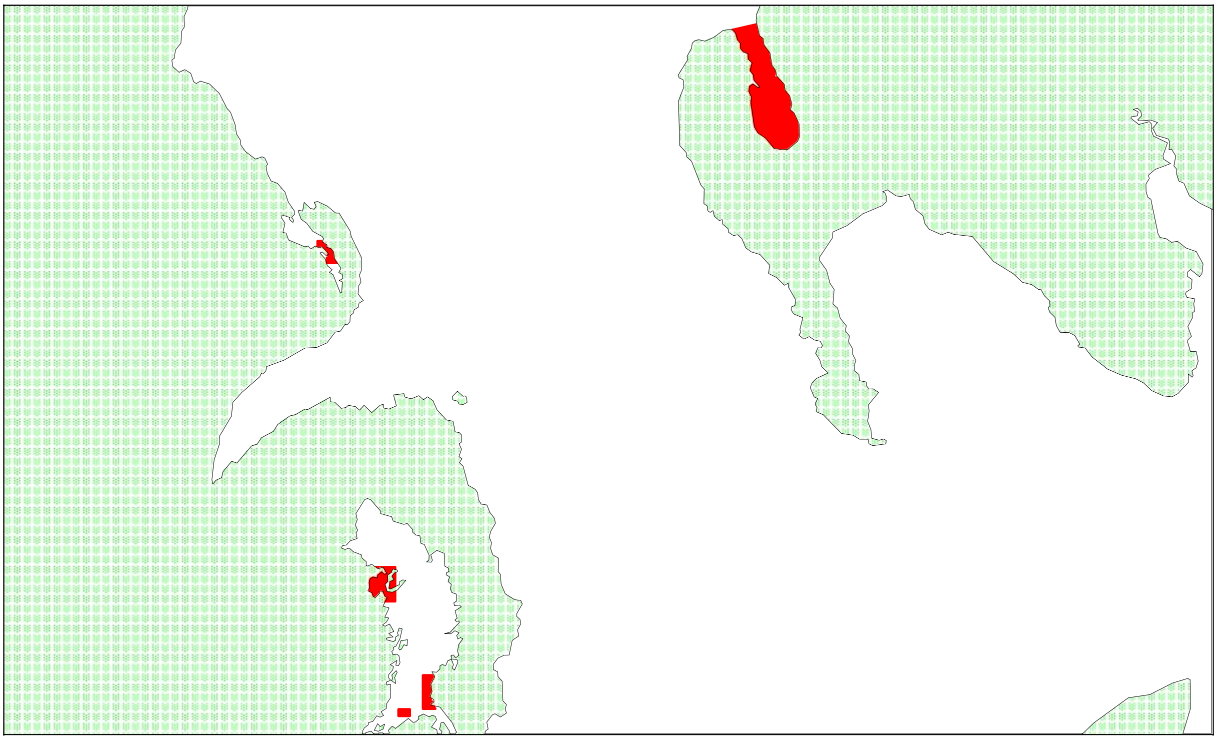

Figure 4.10 Shellfish waters production areas

5 AMENITY/ECONOMY

In the event of a marine pollution incident taking place at any location around the UK coastline, then this could have a detrimental effect on the local economy e.g. a polluted beach could deter tourists from visiting an area which gains significant economic benefit from this amenity. The following figure presents a geographical overview of the range of designations that identify most closely with amenity and economy and have been considered in the determination of MEHRA's.

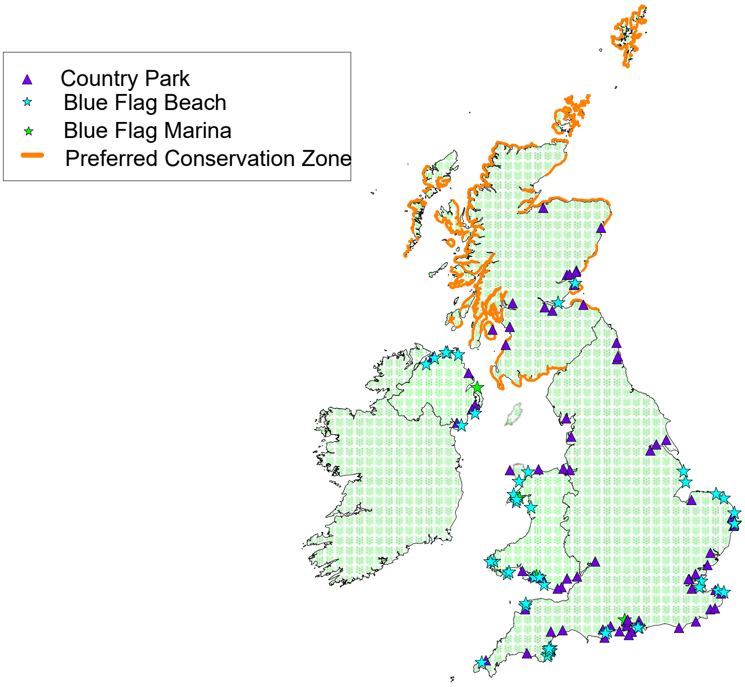

Figure 5.1 Location of Sites that Cover Amenity and Economic Designations

5.1 Country Parks (CP's)

Country Parks are statutorily declared and managed by local authorities under the Countryside Act 1968. They are primarily intended for **recreation** and leisure opportunities, are close to population centres and do not necessarily have any nature conservation interest. Nevertheless, many are in areas of semi-natural habitat and so form a valuable network of locations at which informal recreation and the natural environment co-exist.

There are 104 Country parks spread throughout the UK, 68 of which are coastal as identified in Figure 5.2. All Country Parks have been marked as points due to their rather small area.

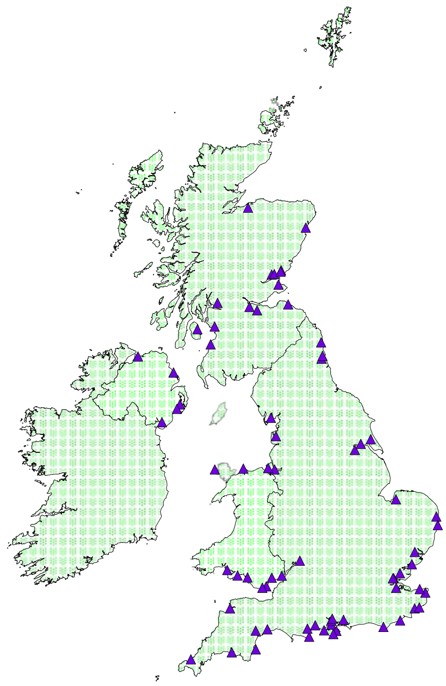

Figure 5.2 Country Parks

Source: Natural Heritage Directorate (1999), Scottish Natural Heritage (1998), and English Nature (1998)

5.2 Blue Flag Beaches

The European Blue Flag is awarded by the Foundation for Environmental Education in Europe (FEEE) to beaches across Europe that meet strict criteria for both water quality and environmental management based on the water quality directive. Its aim is to promote environmental protection internationally. The FEEE is working on its extension outside Europe, along with the United Nations Environmental Programme and the World Tourism Organisation.

The European Blue Flag award for beaches is based on 26 specific criteria covering four aspects of management: water management, general environment, environmental education & information and safety & services.

Blue Flag Beaches are **recreational** areas that, due to tourism have an **economic benefit** to the surrounding area. They are a source of environmental **education** to the public, by providing information on protected sites or species in the vicinity of the beach. Forty five of the UK's beaches have passed the criteria to achieve Blue Flag status, most are in England, Wales and Northern Ireland, with only two being in Scotland. Figure 5.3 presents a geographical overview of the Blue Flag beaches which have been included in the assessment.

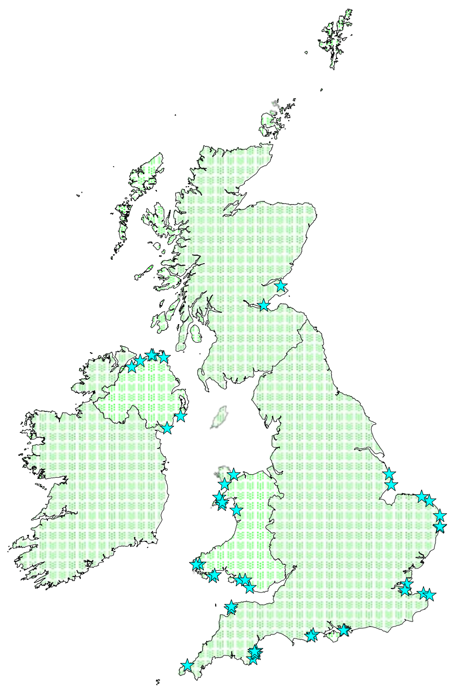

Figure 5.3 Blue Flag Beaches

Source: Foundation for Environmental Education in Europe (1998)

5.3 Blue Flag Marinas

The European Blue Flag is awarded by the Foundation for Environmental Education in Europe (FEEE) to marinas across Europe that meet strict criteria for both water quality and environmental management based on the water quality directive. Its aim is to promote environmental protection internationally. The FEEE is working on its extension outside Europe, along with the United Nations Environmental Programme and the World Tourism Organisation. The European Blue Flag award for marinas is based on 16 specific criteria covering four aspects of management: water management, general environment, environmental education & information and safety & services.

Blue Flag Marinas consist of pontoons or jetties for the mooring of **recreational** craft, and as a result have an **economic benefit** on the surrounding area. Six marinas have been classified as Blue Flag marinas, none of which are in Scotland. Figure 5.4 presents a geographical overview of the Blue Flag marinas which have been included in the assessment.

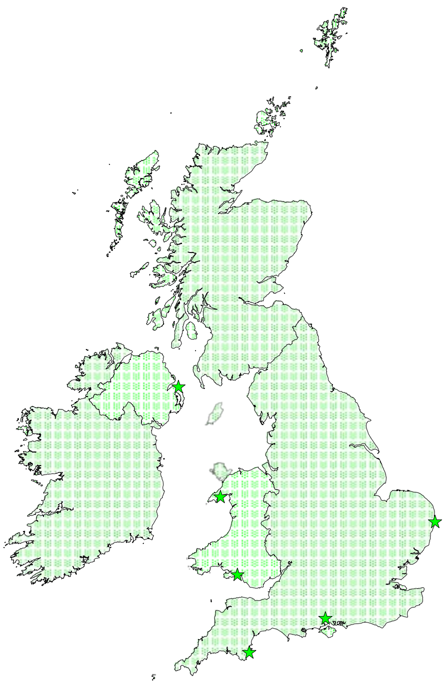

Figure 5.4 Blue Flag Marinas

Source: Foundation for Environmental Education in Europe (1998)

5.4 Preferred Conservation Zones (PCZ's)

Preferred Conservation Zones are non-statutory coastal areas in Scotland of particular national, scenic, environmental or ecological importance, in which major new oil and gas related developments would in general be inappropriate or would have a socio-**economic** impact on a small community, and would only be justified in exceptional circumstances.

They are areas with a distinctive aesthetic appeal, **heritage** and character, where tourism and **recreation** take priority over major industrial processes. They are **unique** areas where the local inhabitants are **dependent** on the **natural** state of the area.

There are 22 PCZ's on the Scottish mainland and numerous PCZ's around the islands. These are outlined in Figure 5.5.

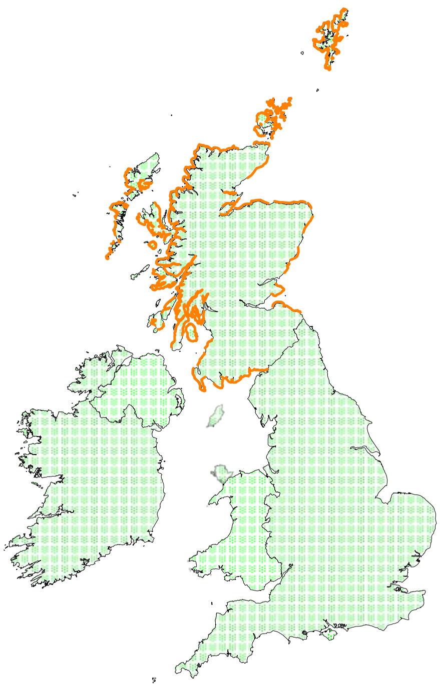

Figure 5.5 Preferred Conservation Zones

Source: JNCC (1998)

6 LANDSCAPE

In the event of a marine pollution incident taking place in proximity to the UK coastline, then there are a number of landscape features which could be affected. The following are the designations that have been considered as representing the landscape and included within the evaluation:

- Environmentally Sensitive Areas (ESA's)
- Heritage Coasts
- Regional Landscape Designations (RLD)
- National Parks (NP)
- Areas of Outstanding Natural Beauty (AONB's)
- National Scenic Areas (NSA)

Figure 6.1 presents a geographical overview of the different landscape designations, which have been considered in the evaluation. Each of these designations is presented in the subsequent sections which follow the figure.

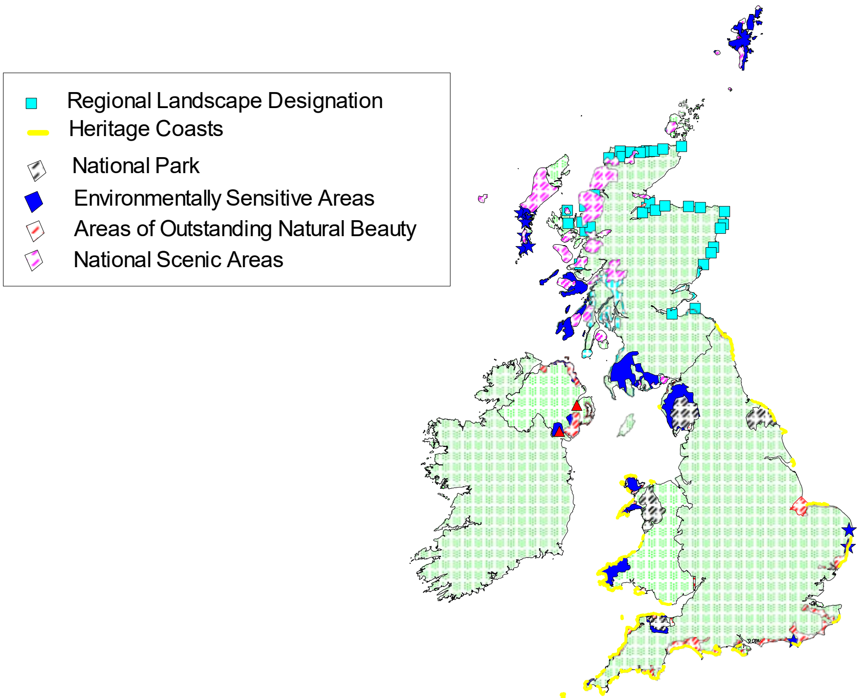

Figure 6.1 Landscape Designations

6.1 Environmentally Sensitive Areas (ESA's)

Environmentally Sensitive Areas were originally designated by the Secretary of State under the 1986 Agriculture Act to encourage landowners to manage their land in order to safeguard and enhance its nature conservation, landscape, **historical** and cultural interest. The aim is to encourage environmentally sensitive farming, thus preventing damage hat might result from certain types of agricultural intensification.

Although initially designated for farming, ESA's may also cover coastal and fresh water areas such as the Western Isles and County Antrim coast. There are currently 28 ESA's throughout the UK that incorporate coastal areas the locations of which are given in Figure 6.2, some are identified as points, whereas the larger sites are shown as a solid colour.

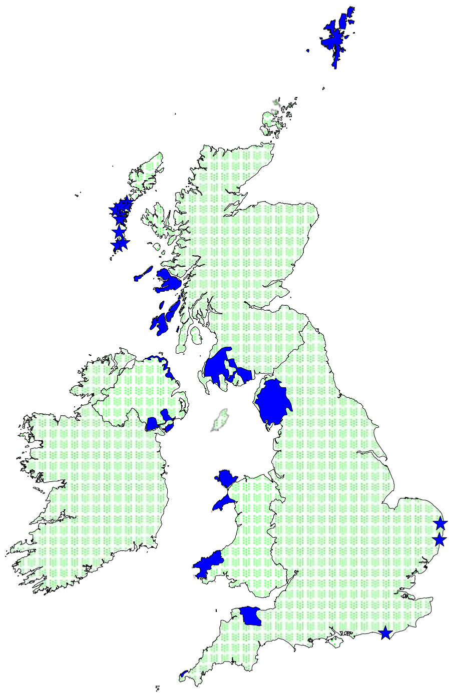

Figure 6.2 Environmentally Sensitive Areas

Source: JNCC (1998)

6.2 Heritage Coasts

Heritage Coasts are non-statutory, the identification of which are agreed between the local authority and the Countryside Commission (England), or the Countryside Council for Wales. They were identified in response to widespread concern about the loss of **unspoiled** coastlines to insensitive developments, including caravan sites, industry and urban expansion. They are selected for being **representative** of coastline with exceptionally fine scenic quality, substantially undeveloped and containing features of special significance and interest. They are **unique** areas of the coast that are valuable for **research**, **monitoring** and **education**.

Heritage Coasts are only designated in England and Wales, with 32% (1027 km) of English coastline and about one-third of Welsh coastline (500 km) being defined as Heritage Coast. Figure 6.3 presents a geographical overview of the heritage coasts which have been included in the assessment.

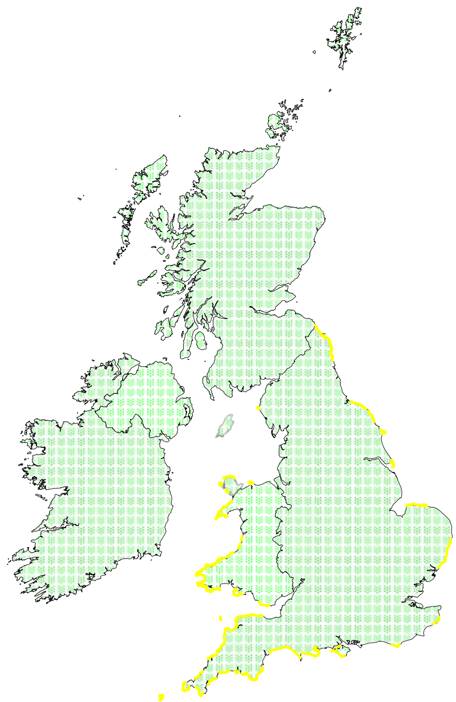

Figure 6.3 Heritage Coasts

Source: Countryside Commission (1999), JNCC Coastal Directories Series (1998)

6.3 Regional Landscape Designations (RLD's)

Regional Landscape Designations were identified in 1974 to provide a mechanism whereby Scottish planning authorities can identify sites where there should be a strong presumption against development. It is recognised that these scenic areas have **considerable unexploited** potential for tourism and therefore for benefiting local economies.

Regional landscape designations vary in title, scale and objectives from one planning authority to another, and there are now five different types of RLD. These include Areas of Great Landscape Value (AGLV), Highland Areas of Regional Landscape Significance (ARLS), Areas of Scenic Value (ASV), Regional Scenic areas (RSA) and Regional Scenic Coasts (RSC).

There are 64 coastal Regional Landscape Designations (see Figure 6.4), all of which are in Scotland, the larger Regional Landscape Designations are shown as vertically stripped areas.

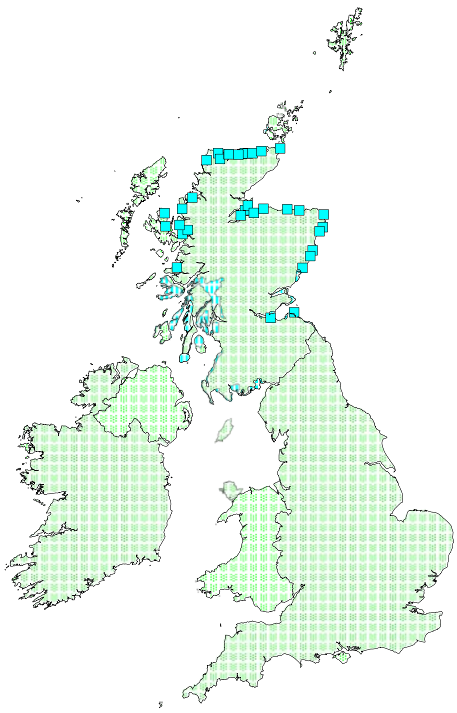

Figure 6.4 Regional Landscape Designation

Source: JNCC Coastal Directories Series (1998)

6.4 National Parks (NP's)

The purpose of National Parks is to preserve and enhance the most beautiful, dramatic and spectacular expanses of countryside in England and Wales (Countryside Commission 1993). National parks are **unique** in that they contain the best of the countryside. They are **recreational** areas, thus bringing an **economic benefit** to the surrounding area, on which the local community may be **dependent**.

There are ten National Parks in the UK, although only four of the parks include coastal areas, as shown in Figure 6.5. There are no National Parks in Scotland or Northern Ireland.

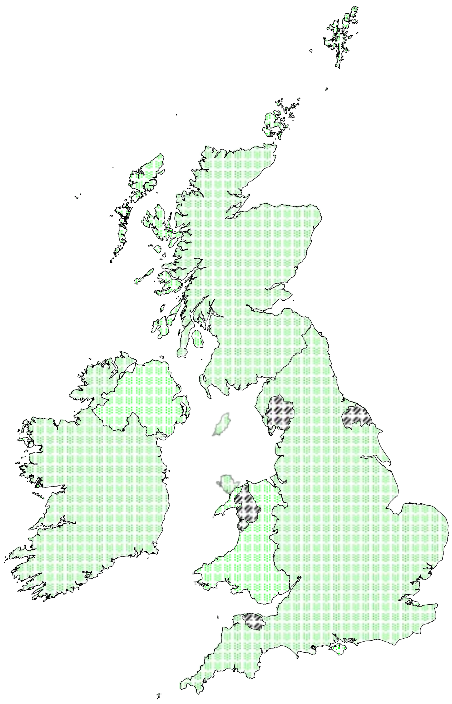

Figure 6.5 National Parks

Source: World Conservation Monitoring Centre (1999), Digest of Environmental Statistics (1998)

6.5 Areas of Outstanding Natural Beauty (AONB's)

Areas of Outstanding Natural Beauty are statutorily designated by the Department of the Environment. The designations are intended to conserve and enhance the area's natural beauty, its amenities, wildlife, historic objects or **natural** phenomena, to promote its **enjoyment by the public** and to provide and maintain public access. People living within an area of outstanding natural beauty are **dependant** on the area for the **economic benefit** that tourism brings.

There are a total of 48 AONB's in Wales, Northern Ireland and England as presented in Figure 6.6. There are no AONB's in Scotland, although National Scenic Areas are the nearest equivalent.

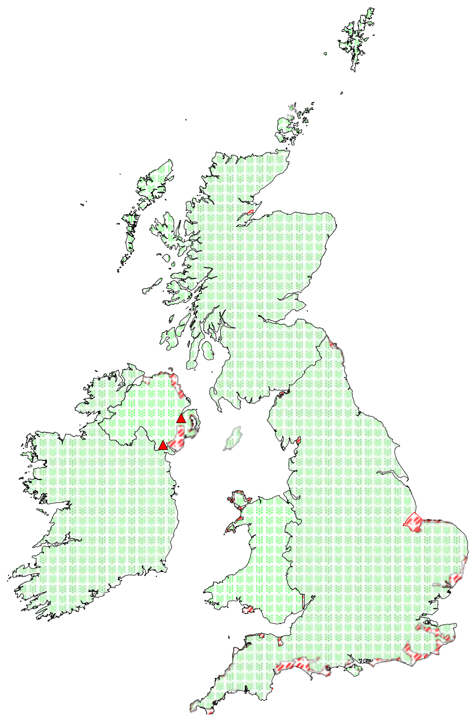

Figure 6.6 Areas of Outstanding Natural Beauty

Source: World Conservation Monitoring Centre (1999), Countryside Council for Wales (1999), Natural Heritage Directorate (1999).

6.6 National Scenic Areas (NSA's)

National Scenic Areas were identified by the Countryside Commission for Scotland in 1978 and are defined as areas of "national scenic significance... of unsurpassed attractiveness which must be conserved as part of our national heritage". They are identified by Scottish Natural Heritage as being **representative** of the country's most **unique**, **natural** sites of **historic** value.

This designation only applies to Scotland, where there are 46 named sites covering over 1 million hectares, 26 of the areas include sections of the Scottish Coastline, as shown in Figure 6.7.

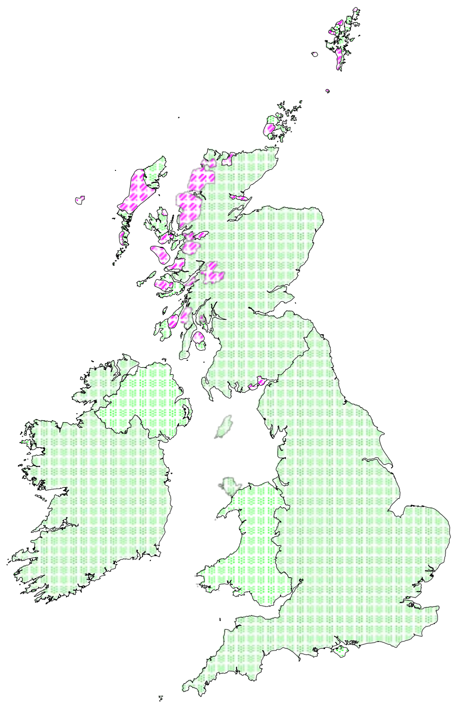

Figure 6.7 National Scenic Areas

Source: Scottish Natural Heritage (1998), World Conservation Monitoring Centre (1999).

7 GEOLOGICAL

There are a number of sites around the UK coastline which have been designated based on their geological importance. A marine pollution incident could have an effect on such sites and they have therefore been considered in the evaluation. Figure 7.1 presents a geographical overview of these sites which have been considered in the evaluation. Each of these designations is presented in the subsequent sections which follow the figure.

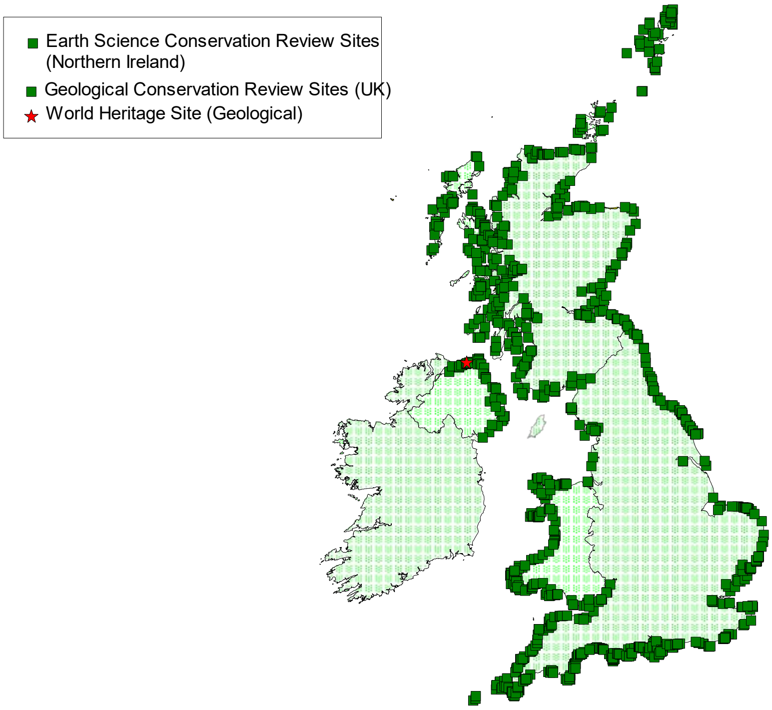

Figure 7.1 Sites of Geological Importance

7.1 World Heritage Site (Geological)

World Heritage Sites are designated under the Convention concerning the protection of the world cultural and natural heritage (World Heritage Convention), adopted in 1972 by the General Conference of the United Nations Educational, Scientific and Cultural Organisation (UNESCO) and ratified by the UK Government in 1984. They are divided into two categories, 'natural' and 'cultural'. Sites selected for designation must have continuing strict legal protection. They are thus already under the protection of domestic legislation.

One site in the UK has been accorded the status of World Heritage Site (natural) of geological importance - the Giant's Causeway, on the North Antrim coast of Northern Ireland. This outstanding geological, scenic and coastal habitat site was selected as a prime example of the earth's evolutionary history during the Tertiary era and because it contains superlative natural features.

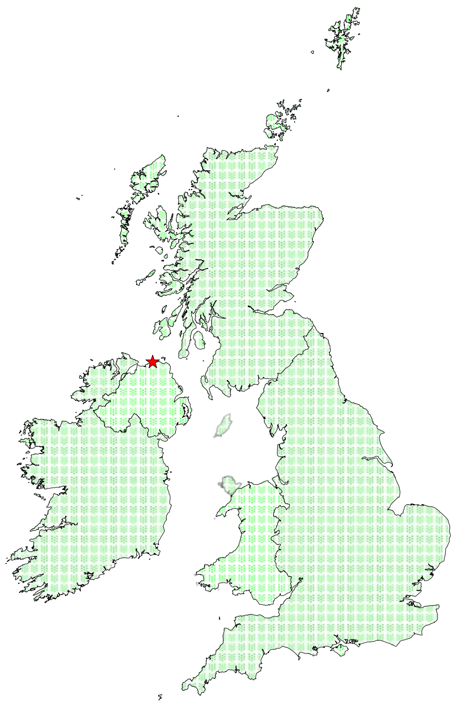

Figure 7.2 World Heritage Site of Geological Importance

Source: Digest of Environmental Statistics (1998), JNCC Coastal Directories Series (1998), JNCC Sensitive List (1999)

7.2 Geological and Earth Science Conservation Review Sites (GCR's & ESCR's)

Geological Conservation Review sites are non-statutory sites identified as having national or international importance for earth science, the Northern Ireland equivalent are called Earth Science Conservation Review sites.

The sites are **unique natural** areas that **represent** examples of geology, palaeontology, mineralogy or geomorphology. They have **educational** purposes and are often used as areas of **research** and **monitoring**. GCR sites are the earth science equivalent of NCRs.

There are 1100 sites spread throughout the Scotland, Wales, England and Northern Ireland. The sites which are within a coastal area have been identified in Figure 7.3.

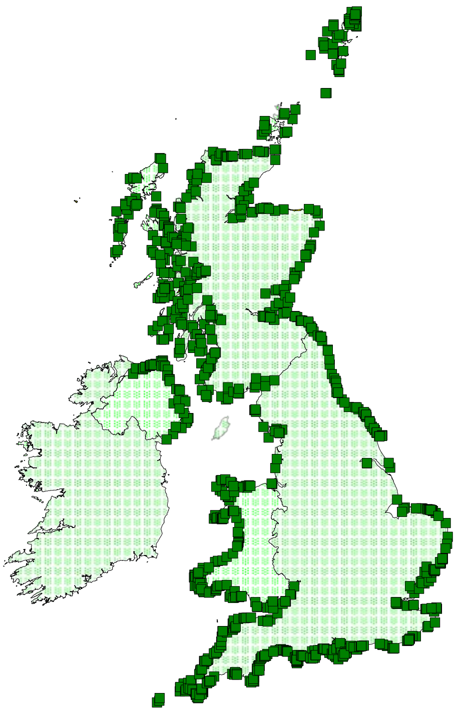

Figure 7.3 Geological and Earth Science Conservation Review Sites

Source: JNCC Coastal Directories Series (1998)

8 OTHER DESIGNATIONS CONSIDERED BUT NOT INCLUDED

This section presents designations which whilst being identified in the assessment have not been included in the final evaluation process. The vast majority of these designations are voluntary, whereas the focus of the assessment was mainly on formal designations. It was noted through a number of comparisons that a large proportion of these sites are already covered by other designations and their inclusion may lead to double counting for certain areas. The designations identified and mapped are presented as follows:

- Biogenetic Reserves
- Areas of Special Protection (AoSP)
- Limestone Pavement Orders (LPO)
- Nature Conservation Review Sites (NCR)
- Voluntary Marine Nature Reserves (VMNR)
- National Trust Sites (NT)
- RSPB Reserves (RSPB)
- Wildfowl and Wetlands Trust Sites (WWT)
- John Muir Trust Sites (JMT)
- County Wildlife (WT)
- Woodland Trust (WT2)
- Water based leisure

A geographical overview of these sites is presented in Figure 8.1, with each designation being presented on an individual basis in the sub-sections, which follow the figure.

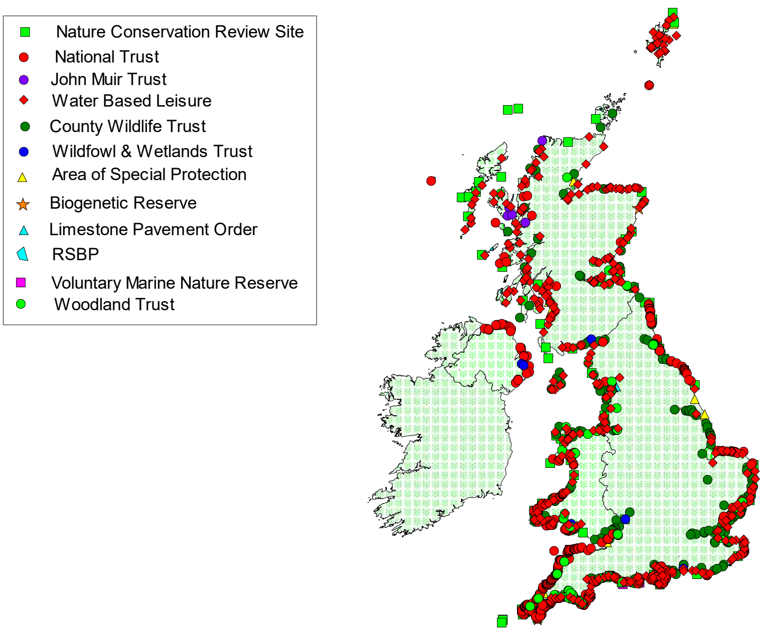

Figure 8.1 Designations Considered but Not Included in the MEHRA's Evaluation

8.1 Biogenetic Reserves

Biogenetic Reserves are classified mostly for their heathland interest. It was decided by JNCC that since the heathland will not be compromised due to marine pollution, these sites do not require to be protected by such a designation as being a MEHRA. Therefore these sites were not considered during the evaluation of potential MEHRA sites.

The location of these sites are presented in Figure 8.2.

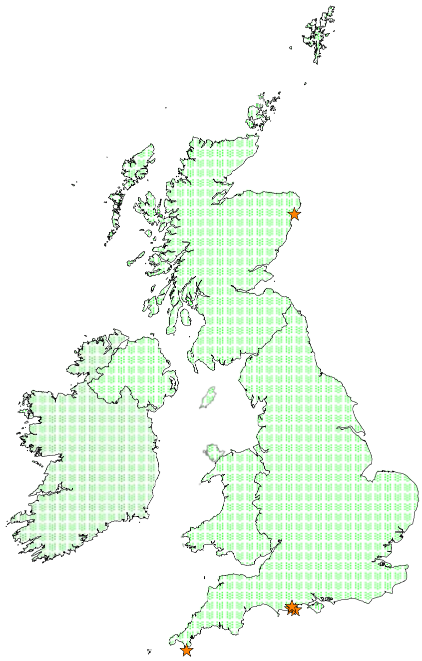

Figure 8.2 Biogenetic Reserves Considered in the Evaluation of Potential MEHRA's locations

Source: Scottish Natural Heritage (1998), Digest of Environmental Statistics (1998).

8.2 Areas of Special Protection (AoSP) & Wildlife Refuges (WR NI)

Areas of Special Protection were originally designated under the Protection of Birds Acts (1967). They were then amended under the Wildlife and Countryside Act 1981, although only six have been designated since then. Designation aims to prevent the disturbance and destruction of the birds for which the area was identified, by making it unlawful to damage or destroy either the birds or their nests and in some cases by prohibiting or restricting access to the site. Areas of special protection are **unique representing natural** bird habitats.

There are 38 AoSP's in the United Kingdom, distributed between Scotland, England and Wales, there are none in Northern Ireland, although Wildlife Refuges are a near equivalent. The Areas of Special Protection that are coastal are identified in Figure 8.3 with larger areas being shaded.

The statutory provision of an area as a 'Wildlife Refuge' is a protection mechanism under The Wildlife Order 1985. It was intended that this provision would replace that of Bird Sanctuary, established under the Wild Birds Protection Act 1931, extending its scope to all forms of wildlife. It is the nearest equivalent to the 'Area of Special Protection' in Great Britain

There are several coastal Bird Sanctuaries in Northern Ireland but as yet no Wildlife Refuges have been established, although there are tentative plans for some.

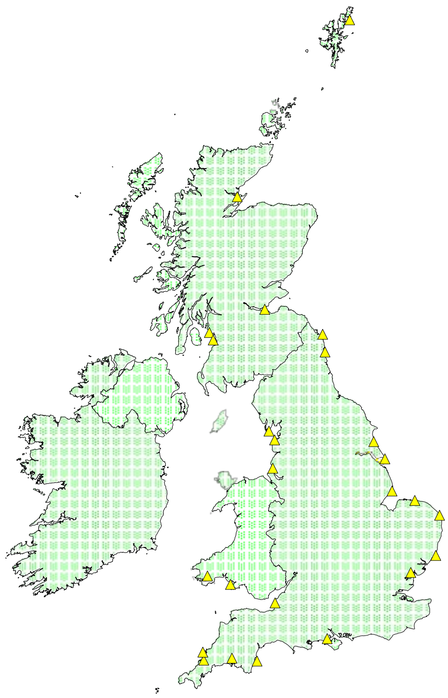

Figure 8.3 Areas of Special Protection

Source: Department of the Environment Transport and the Regions (1999)

8.3 Limestone Pavement Orders (LPO)

Limestone Pavement Orders provide statutory protection for limestone pavements under the Wildlife and Countryside Act 1981. They have also been given further protection under the European Habitats and Species Directive 1992, which recognises them as a priority habitat.

Limestone pavements are of interest for, and are subsequently designated for, their **unique** and **vulnerable** plant assemblages, geological and gemorphological features or landscape attributes, most notably their glaciogenic landforms. Figure 8.4 presents LPO's in the UK.

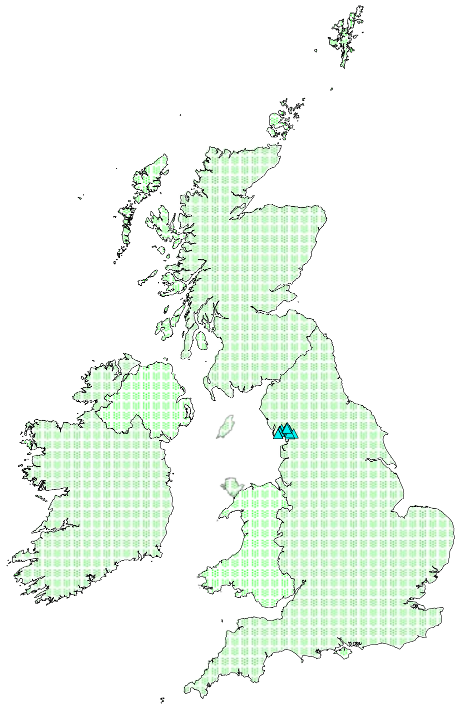

Figure 8.4 Limestone Pavement Orders in the UK

Source: JNCC Coastal Directories Series (1999)

8.4 Nature Conservation Review Sites UK & Northern Ireland (NCR's)

A Nature Conservation review (Ref. 3) was carried out in 1979 to identify British sites that may qualify for declaration as National Nature Reserves. Sites that were identified during this study, but were not accepted as National Nature Reserves are known as Nature Conservation Review sites.

Nature Conservation Review sites are non-statutory sites that are identified as having the **best representative** examples of wildlife & vegetative habitats, whilst supporting nationally and internationally important bird populations. For some coastal sites, for example estuaries, all sites that were above a critical standard of nature conservation importance were selected. Nature conservation Review sites are **natural** areas that are also used for **research**, **monitoring** and **education**

There are a total of 953 sites identified as Nature Conservation Review sites, 149 of which (approximately 360,000 ha) are coastal. The site locations are outlined in Figure 8.5, with the larger sites identified by vertically stripped areas.

The Nature Conservation Review did not extend to Northern Ireland. The passing of the Nature Conservation and Amenity Lands Order in 1985 for the first time gave the Department the legal framework to start a systematic survey of habitats to locate all sites of potential interest for nature conservation. This exercise is still incomplete and is likely to continue until the end of the century.

There are no such sites to date, although it is expected that the designations will be made around 2000.

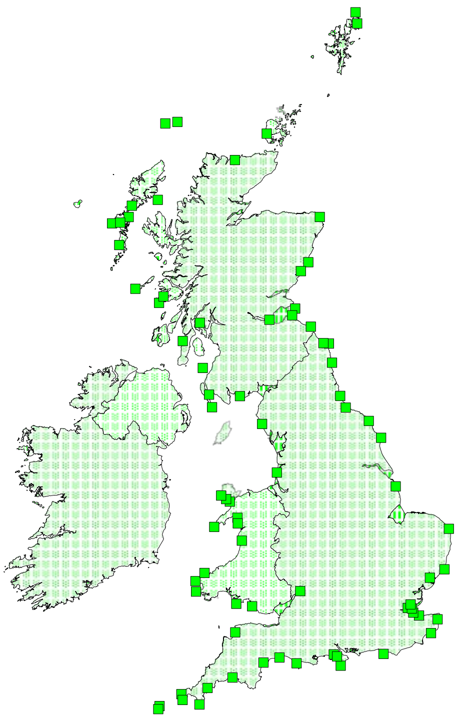

Figure 8.5 Nature Conservation Review Sites

Source: A Nature Conservation Review, Ratcliffe (1979)

8.5 Voluntary Marine Nature Reserves (VMNR's)

Voluntary Marine Nature Reserves may be set up by representatives of the users of an area (whether sub-tidal or shoreline) in order to initiate management of that area. The reserves serve a variety of purposes, including conservation of, and **research** into marine biologically important areas, **monitoring** of the marine environment and **educational** purposes.

There are 13 Voluntary Marine Nature Reserves in the UK, with only one in Scotland, and the rest around the Western Approaches. These Marine Nature Reserves cover a relatively small area, therefore each site is represented by a single point.

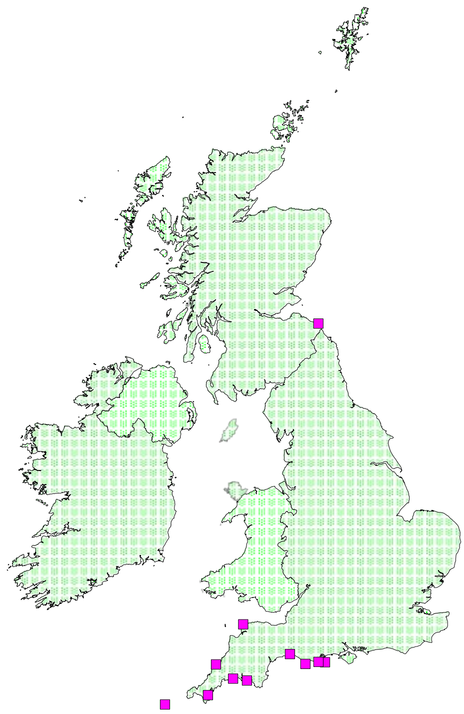

Figure 8.6 Voluntary Marine Nature Reserves

Source: JNCC Coastal Directories Series (1998)

8.6 National Trust (NT) & National Trust (Scotland)

The National Trust is an independent charity with statutory powers to protect property under an Act of Parliament (1907). Their primary aim is to protect large areas of **unique** landscape and countryside, including areas of **historical** value. As well as building and gardens the National Trust owns several islands, areas of foreshore and seabed. A total of 850 km of coast in England, Wales and Northern Ireland is now owned or managed by the National Trust (National Trust 1993).

There are 363 National Trust sites on the coastline around England, Wales and Northern Ireland. These are shown in Figure 8.7.

The National Trust for Scotland is a charitable organisation, established under the National Trust for Scotland Order Confirmation Act 1935. Their aim is to promote the permanent preservation of Scotland's heritage of fine buildings, beautiful landscape and **historic** places, and to encourage public enjoyment of them. There are 17 areas of the Scottish coastline in its care.

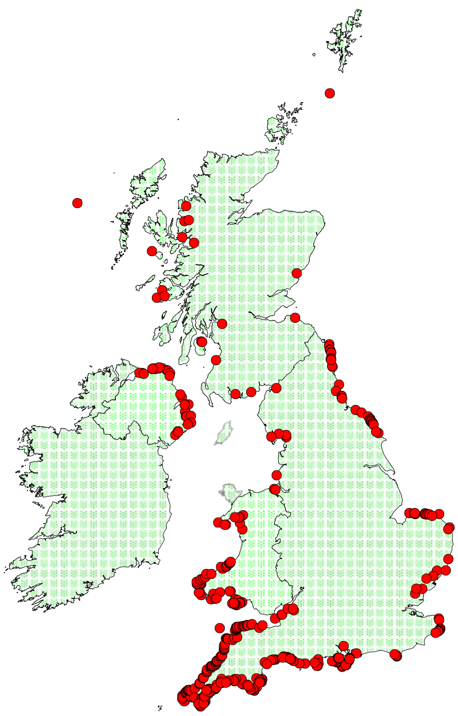

Figure 8.7 National Trust Sites

Source: National Trust (1999), JNCC Coastal Directories Series (1998)

8.7 Royal Society for the Protection of Birds (RSPB)

The RSPB Coastal sites while recognised as being open to damage due to marine pollution, are designated by other legislation. Most of the sites as well as being RSPB reserves are also SSSI's, Nature Reserves or have some other designation which have already been included in the assessment.

It was noted that if RSPB sites were included along with these other designations, then these sites would receive a higher environmental 'score' as they would have been counted more than once for the same site. Due to this it was decided that the RSPB sites should not have a separate designation whilst evaluating the sensitivity of the coastline to marine pollution. Figure 8.8 presents RSPB reserves around the UK coastline.

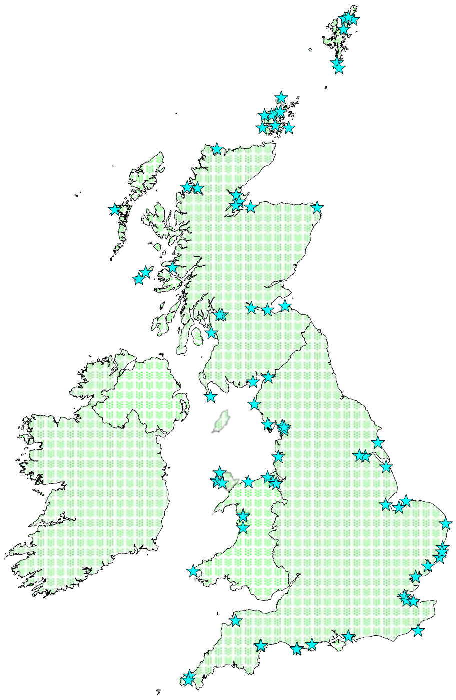

Figure 8.8 RSPB Coastal Sites

Source: RSPB (1999)

It should be noted that whilst for presentation purposes, the locations of RSPB sites are represented by symbols as in on Figure 8.8, these are included as detailed areas within the GIS, an example of which is presented in Figure 8.9.

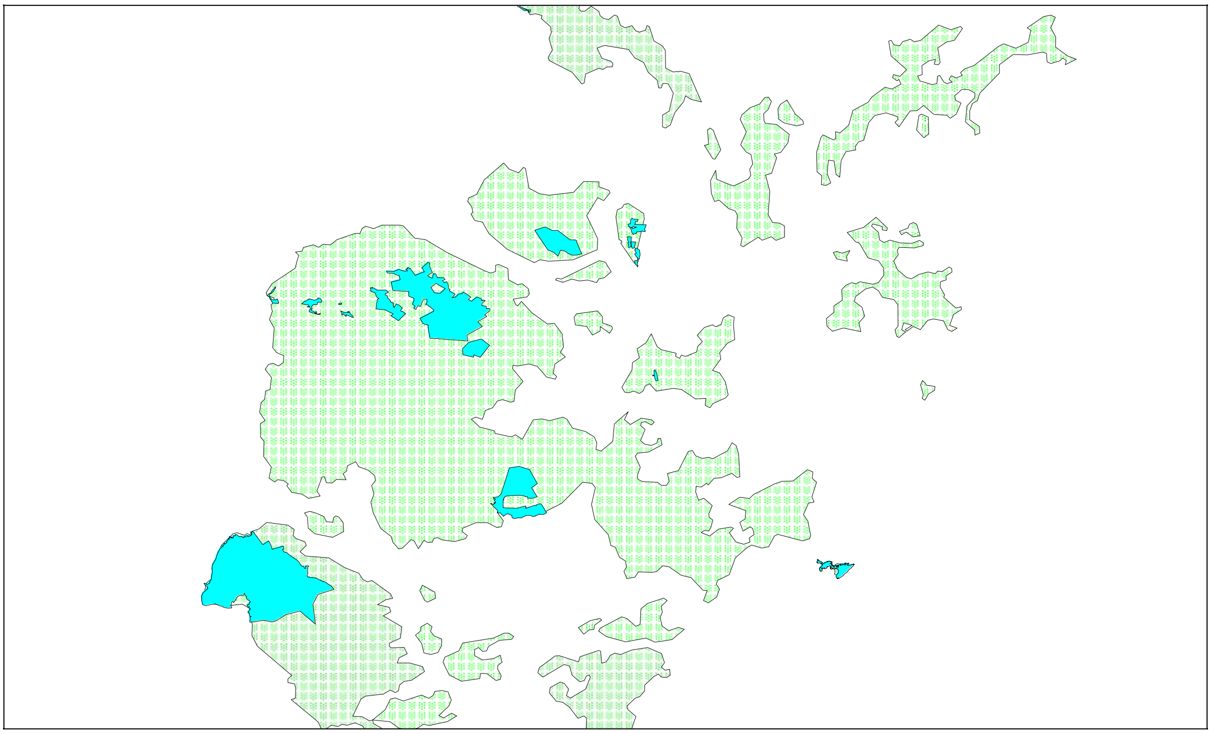

Figure 8.9 RSPB Nature Reserve Sites in the Orkney Islands

Source: RSPB (1999)

8.8 Wildfowl & Wetlands Trust (WWT)

The Wildfowl & Wetlands Trust (formerly the Wildfowl Trust) has established non-statutory reserves in a number of key wintering areas for migrant wildfowl. The level of protection afforded to such sites is high, since the land is either owned or held on long-term leases. The sites **represent natural** wildfowl habitats that may also be in a **vulnerable** state. The sites are also important for **educational** purposes.

There are a total of seven coastal WWT sites covering 1,200 ha in Great Britain. These are presented in Figure 8.10.

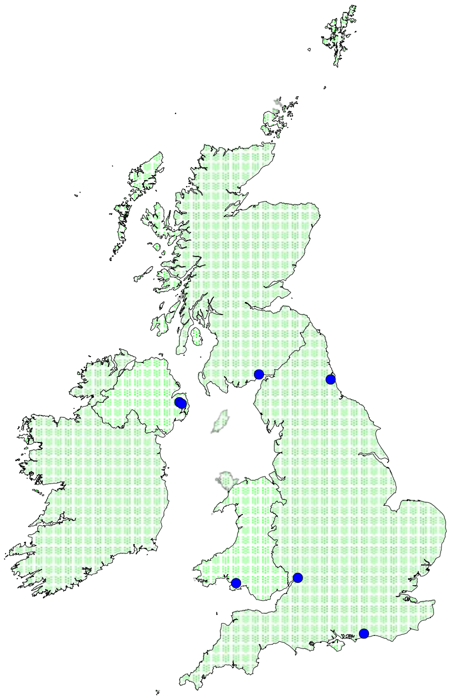

Figure 8.10 Wildfowl & Wetlands Trust

Source: JNCC Coastal Directories Series (1998)

8.9 John Muir Trust

The John Muir Trust was formed in 1983 to protect and conserve **wild** places and to increase awareness and **understanding** of the value of such places. The Trust is interested in all the many aspects of wild landscapes - the animal, bird, plant and human communities that share them and believe that the interests of local people and conservation can and must go hand in hand.

The Trust owns and manages five areas totalling 18,000 hectares in the North West Highlands the Isle of Skye in Scotland (see Figure 8.11). There are no sites elsewhere in the UK.

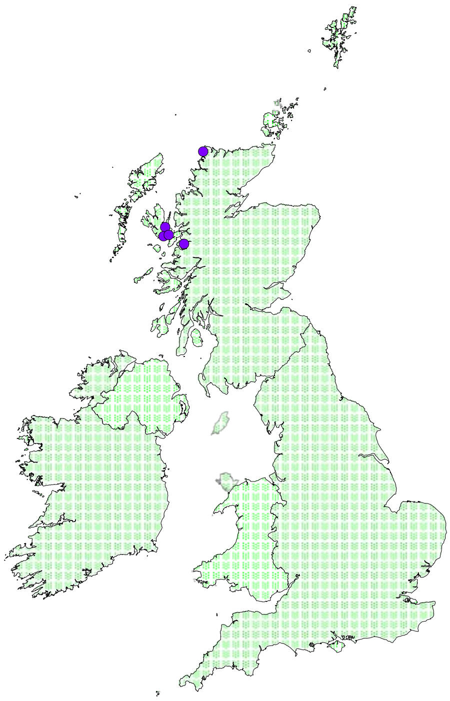

Figure 8.11 John Muir Trust Locations

Source: John Muir Trust (1999)

8.10 County Wildlife Trust (WT)

The Wildlife Trusts were established to promote non-statutory **nature** conservation at a local level. There is usually one trust covering a whole county or group of county's, although both Scotland and the Isle of Man each have a single Trust.

The trust own, lease and manage over 1,800 nature reserves, covering more than 52,000 ha throughout the UK. 245 of the reserves are located in coastal areas, covering a total of almost 25,000 hectares. The location of the sites are presented in Figure 8.12.

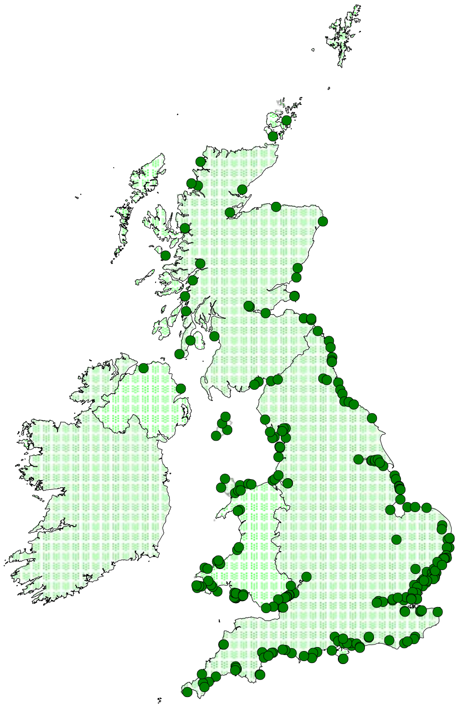

Figure 8.12 Location of County Wildlife Trust Sites

Source: JNCC Coastal Directories Series (1998)

8.11 Woodland Trust (WT 2)

The Woodland Trust was established in 1972 with the aim of conserving, restoring and re-establishing trees (particularly broad-leaved), woodland plants and wildlife in the United Kingdom. The sites consist of ancient woodland, semi-**natural** ancient woodland (land which has never been cleared or replanted by man), and small urban and village woods. Some of the sites are woodland SSSI's, **representing** the best examples of UK Wildlife habitats.

The Woodland Trust owns many woodlands throughout the country, including 63 that are near the coast. The location of which are presented in Figure 8.13.

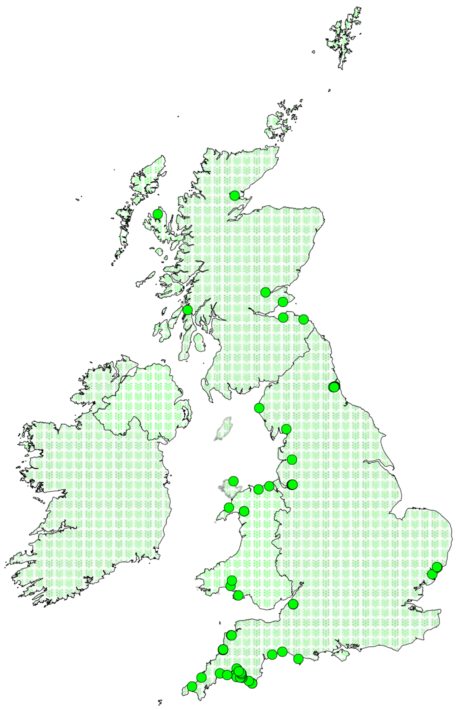

Figure 8.13 Location of Woodland Trust Sites

Source: JNCC Coastal Directories Series (1998)

8.12 Water Based Leisure

Water based activities provide **recreation** and therefore are of **economic benefit** to the local community. The areas surrounding these locations are largely **dependent** on the income from the activities available and any loss of this would be of great harm to the area.

There are 327 recreational water based leisure sites in the UK, they include tourist attractions such as beaches and marinas, estuaries and harbours, but also include more rural coastal areas such as the Western Isles of Scotland. The location of these sites are presented in Figure 8.14.

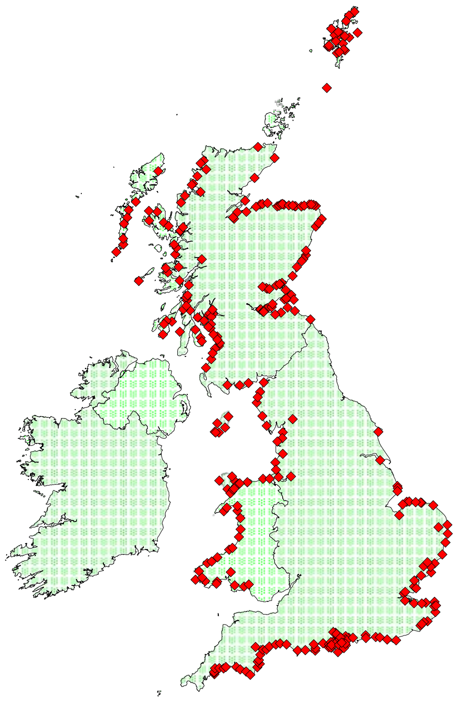

Figure 8.14 Water Based Leisure Sites

Source: JNCC Coastal Directories Series (1998)

9 REFRENCES

1 "Coasts and Seas of the United Kingdom", Coastal Directories Electronic Platform (Phase 1), JNCC, 1999

2 UKDMAP for Windows (Beta Release), 1997.

3 "A Nature Conservation Review", Ratcliffe, 1979.

APPENDIX 5

PERSISTENCE OF OIL ON THE UK COASTLINE

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1 INTRODUCTION

One factor which has not been considered in the assessment of MEHRA's is the likely persistence of a spill at different coastal locations as this will to some extent determine the level of environmental damage likely to result. This has not been carried out due to the amount of work required to integrate this into the assessment with any real confidence. This appendix presents an overview of the persistence of oil, the factors which influence it, as well as the classification of the UK coastline, which could be used as a starting point should a further evaluation consider what effect persistence has on the sensitivity of different parts of the UK coastline.

2 FATE OF OIL AT SEA

In general there are eight main processes that cause oil to weather, namely:

- Spreading
- Evaporation
- Dispersion
- Emulsification
- Dissolution
- Oxidation
- Sedimentation/Sinking
- Biodegradation
- Combined Processes

A brief description of each is presented within the following sections.

2.1.1 Spreading

Once spilled at sea, oil will spread within the environment, initially to form a single slick. The rate at which this occurs is dependent on a number of factors including temperature, sea state, wind conditions and viscosity of the oil. Slicks can spread quickly and cover massive expanses of the sea with varying thickness on the surface. As time proceeds, wind and wave action tends to break the oil into narrow oil bands or windrows which form parallel to the wind direction.

2.1.2 Evaporation

This is one of the most important processes that occur following oil spillage. In this process the lighter components of the oil evaporate into the atmosphere at a greater rate changing the properties and composition of the oil that remains on the sea. Evaporation can increase as oil spreads due to the increased surface area of the slick thereby further increasing the rate of evaporation of lighter crude oils which also tend to spread more easily due to their low viscosity. For a light volatile crude evaporative loss is very pronounced with up to 40% being lost due to this process.

Information available on the Exxon Valdez, Braer and Sea Empress spills (see Figure 2.1) show the following variations in evaporation levels for each release:

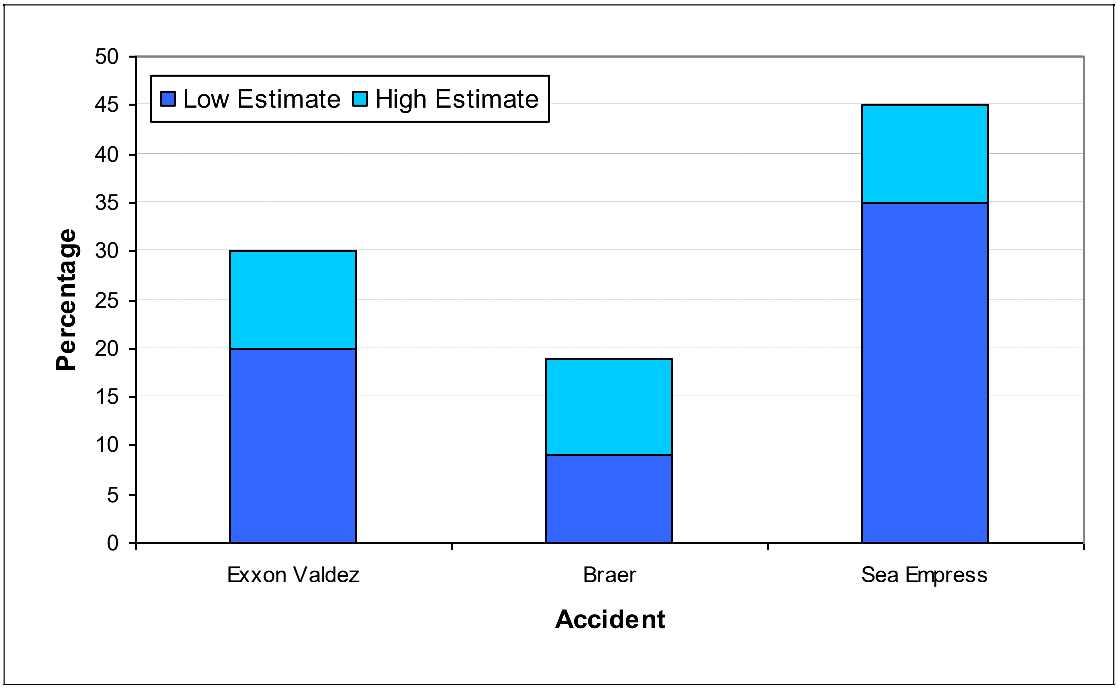


Figure 2.1 Percentage Evaporation of Spilled Oil

2.1.3 Dispersion

Waves and turbulence at the sea surface can cause all or part of a slick to break up into fragments and droplets of varying sizes. These become mixed into the upper levels of the water column. Some of the smaller droplets will remain suspended in the sea water while the larger ones will tend to rise back to the surface, where they may either coalesce with other droplets to reform a slick or spread out to form a very thin film. The oil that remains suspended in the water has a greater surface area than before dispersion occurred. This encourages other natural processes such as dissolution, biodegradation and sedimentation to occur. The speed at which an oil disperses is largely dependent upon the nature of the oil and the sea state, and occurs most quickly if the oil is light and of low viscosity and if the sea is very rough. These factors led to the dispersion of the oil spilled from the Braer (Shetland Islands, United Kingdom, 1993). The addition of chemical dispersants can accelerate this process of natural dispersion. Figure 2.2 presents the estimated percentages of oil dispersed in different incidents.

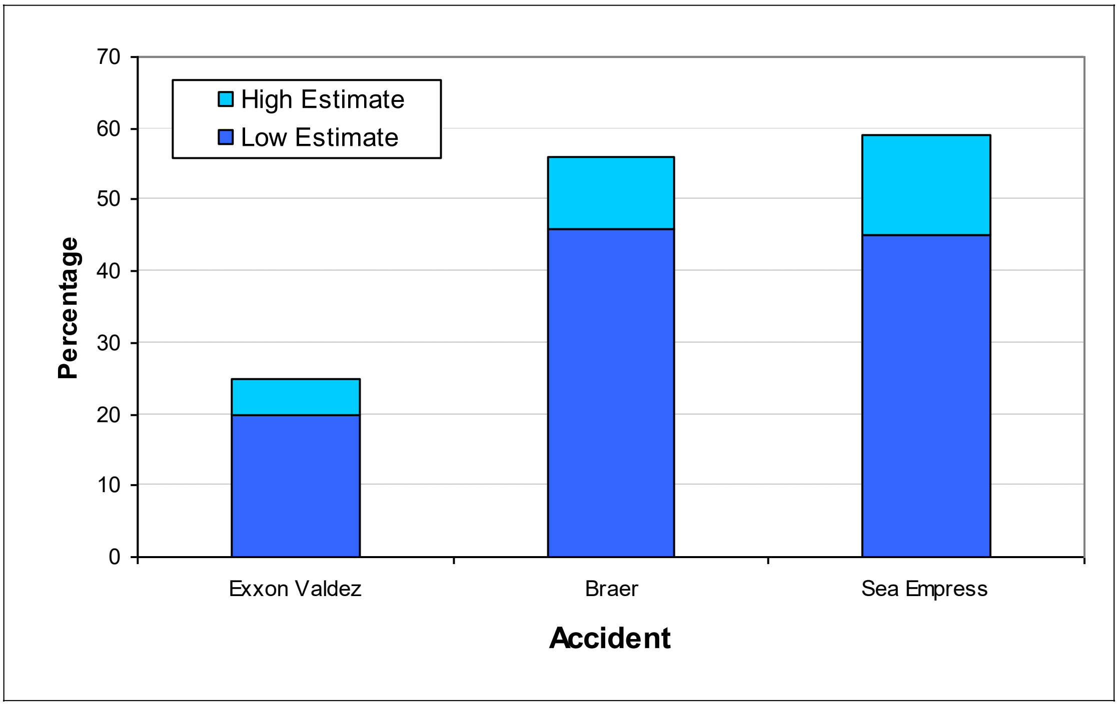


Figure 2.2 Estimates of Percentage of Oil Dispersed

2.1.4 Emulsification

An emulsion is formed when two liquids combine, with one ending up suspended in the other. Emulsification of crude oils refers to the process whereby sea water droplets become suspended in the oil. This occurs by physical mixing promoted by turbulence at the sea surface. The emulsion thus formed is usually very viscous and more persistent than the original oil and is often referred to as "chocolate mousse" because of its appearance. The formation of these emulsions causes the volume of pollutant to increase by a factor of 3-4. This slows and delays other processes, which would allow the oil to dissipate. Oils with an asphaltene content greater than 0.5% tend to form stable emulsions which may persist for many months after the initial spill has occurred. Those oils containing a lower percentage of asphaltenes are less likely to form emulsions and are more likely to disperse. Emulsions may separate into oil and water again if heated by sunlight under calm conditions or when stranded on shorelines.

2.1.5 Dissolution

Water soluble compounds in an oil may dissolve into the surrounding water. This depends on the composition and state of the oil, and occurs most quickly when the oil is finely dispersed in the water column. Components that are most soluble in sea water are the light aromatic hydrocarbon compounds such as benzene and toluene. However, these compounds are also those first to be lost through evaporation, a process which is 10 -100 times faster than dissolution. Oil contains only small amounts of these compounds making dissolution one of the less important processes.

2.1.6 Oxidation

Oils react chemically with oxygen either breaking down into soluble products or forming persistent compounds called tars. This process is promoted by sunlight and the extent to which it occurs depends on the type of oil and the form in which it is exposed to sunlight. However, this process is very slow and even in strong sunlight, thin films of oil break down at no more than 0.1% per day. The formation of tars is caused by the oxidation of thick layers of high viscosity oils or emulsions. This process forms an outer protective coating of heavy compounds that results in the increased persistence of the oil as a whole. Tarballs, which are often found on shorelines and have a solid outer crust surrounding a softer, less weathered interior, are a typical example of this process.

2.1.7 Sedimentation/Sinking

Some heavy refined products have densities greater than one and so will sink in fresh or brackish water. However sea water has a density of approximately 1.025 and very few crudes are dense enough or weather sufficiently, so that their residues will sink in the marine environment. Sinking usually occurs due to the adhesion of particles of sediment or organic matter to the oil. Shallow waters are often laden with suspended solids providing favourable conditions for sedimentation. Oil stranded on sandy shorelines often becomes mixed with sand and other sediments. If this mixture is subsequently washed off the beach back into the sea it may then sink. In addition, if the oil catches fire after it has been spilled, the residues that sometimes form can be sufficiently dense to sink.

2.1.8 Biodegradation

Sea water contains a range of micro-organisms or microbes that can partially or completely degrade oil to water soluble compounds and eventually to carbon dioxide and water. Many types of microbe exist and each tends to degrade a particular group of compounds in crude oil. However, some compounds in oil are very resistant to attack and may not degrade. The main factors affecting the efficiency of biodegradation, are the levels of nutrients (nitrogen and phosphorus) in the water, the temperature and the level of oxygen present. As biodegradation requires oxygen, this process can only take place at the oil-water interface since no oxygen is available within the oil itself. The creation of oil droplets, either by natural or chemical dispersion, increases the surface area of the oil and increases the area available for biodegradation to take place.

2.1.9 Summary

As can be seen from the preceding text, there are a number of different factors, which influence the fate of an oil spill, which is largely dependent on the type of oil as well as the weather and sea conditions at the time of the release. The following figure summarises the different processes undergone by oil when spilt into the sea.

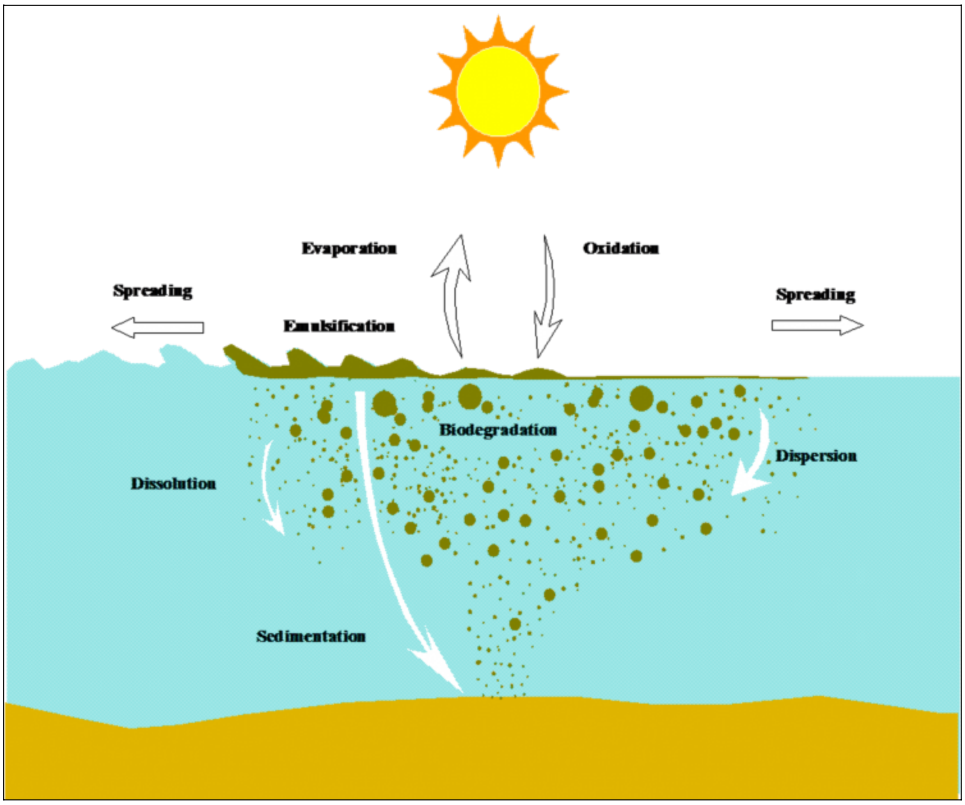


Figure 2.3 Summary of Fate of Oil in the Sea

2.2 Fate of Oil Reaching Shore

The MEHRA's initiative is aimed towards protection of the environment. One of the main impacts of an oil spill is realised if it reaches the coastline. There are two main mechanisms that this can be achieved, which are through transference on water and in air as an aerosol. When oil reaches the shore two of the main factors, which will determine the persistence of the spill, are coastal morphology and the degree of water turbulence (i.e. wave action).

The following table presents examples of typical oil residence times for different types of coastal morphology and in areas with different wind and wave exposure:

Table 2.1 Estimated Oil Residence Based on Different Coastal Morphology & Wave Exposure

Wave Exposure	Substrate	Texture	Mobility	Oil Residence
High	Rock	n/a	n/a	Days to weeks
	Rock & sediment	Gravel	Mobile	Weeks to months
			Immobile	Months
		Gravel & sand	Mobile	Weeks
			Immobile	Weeks to months
		Sand	Mobile	Weeks to months
	Man-made	Impermeable	n/a	Days to weeks
		Permeable	n/a	Weeks
Low	Rock	n/a	n/a	Weeks to months
	Rock & sediment	Gravel	Immobile	Months to years
		Gravel & sand	Immobile	Months to years
		Sand	Mobile	Months to years
	Man-made	Impermeable	n/a	Weeks
		Permeable	n/a	Months to years

Table 2.1 shows that an area which has rock and a low wave exposure will have a much longer residence time than an area which consists of rock with high wave exposure. Wave action in more exposed areas will result in a faster "natural" cleaning operation, with the oil, being broken up into small droplets. On the other hand, oil which has penetrated mud in sheltered areas is likely to persist for longer.

The following sections looks at the coastal morphology of the UK as well as wind and wave exposure for different areas around the UK. A methodology is presented which could form a starting point for a more detailed evaluation if the MEHRAS assessment was extended further to include persistence together with the likelihood of a spill and coastal sensitivity.

3 COASTLINE TYPES

The coastline of the United Kingdom has been classified by the habitats in a specific area. The coastal classification can then be used to give an estimate of the length of time that an oil spill will take to be cleared with sandy beaches being the worst and rocky stretches the most easily cleared. The habitats included in this report are:

- Cliffs and cliff top vegetation,
- Saltmarsh,
- Shingle and fringing beaches,
- Coastal lagoons,
- Wet grass and
- Sand dunes

Each of the habitats, including a description and their distribution throughout the UK are covered in the following paragraphs.

3.1 Cliffs and Cliff Top Vegetation

Sea Cliffs are generally steep slopes greater than 15 degrees, but can show great diversity of form. The two distinct types of cliff are hard, or consolidated cliffs developed from resistant bedrock and soft, or unconsolidated cliffs developed in easily eroded materials. As as well geology and geological structure, cliff forms are determined by the environmental history of the area. The soil and vegetation of cliffs and cliff tops are closely related to slope angle, soil type and salt spray deposition. With the major natural and semi-natural cliff and cliff top habitats being bare ground, lichen-covered rock, perched saltmarsh, maritime grassland and maritime heath. Cliffs are amongst the least modified of terrestrial habitats, although in certain areas of the United Kingdom the cliff top zone has been affected by a variety of human impacts, sometimes leading to major habitat loss. The most extensive influences on hard cliff vegetation are grazing and burning.

In the United Kingdom, nine nationally rare and four nationally scarce species or sub-species of higher plant are found mainly or exclusively on cliffs. Most are restricted to cliff habitats in the South and West of the country. Cliff sites as well as stretches of cliff coastline are identified in Figure 3.1. From this diagram it is apparent that cliff habitats are spread fairly evenly throughout the UK, with over 4,059 km being classified as cliffed coastline. The West Highlands boasts the greatest length of coastline with 14% of the UK distribution being in the region.

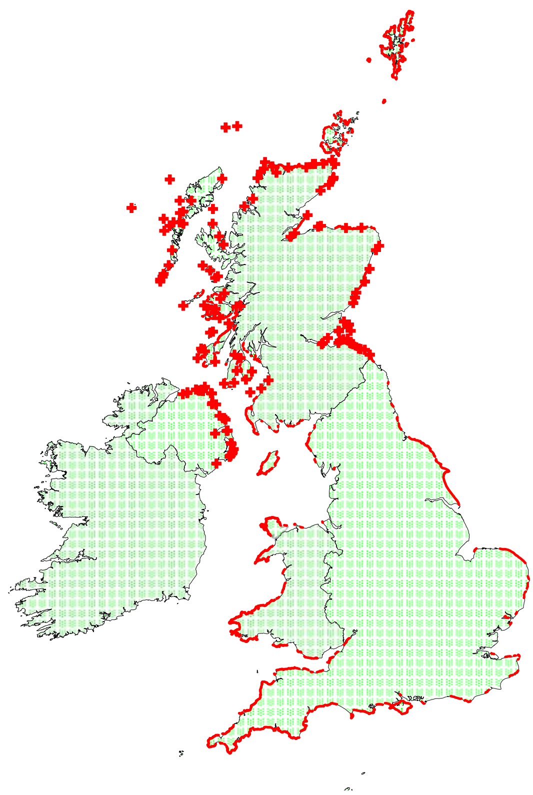


Figure 3.1 Locations with Greater than 90% Cliffed Coast

Source: JNCC Coastal Directories Series (1999),

3.2 Shingle & Fringing Beaches

Shingle is defined as sediment whose grains are larger than sand but smaller than boulders, that is, between 2 and 200mm in diameter. Where the coast features shingle, it is often mixed with large amounts of sand, or else sand dunes have developed on it. Frequently the shingle is admixed with considerable amounts of silt or clay and is adjacent to saltmarsh or lagoonal features. Shingle and fringing beaches cover 5,129.1 hectares accounting for some 6.5% of the British coastline. Such sites include both simple fringing beaches and also more complex structures, such as raised beaches, where the shingle is vegetated yet not buried by more than 20 cm of sand.

Many of the shingle beaches in the UK are protected areas such as Sites of Special Scientific Interest and National Nature Reserves. Some have no designation and may be subjected to high levels of disturbance from leisure and recreational use or have been damaged by exploitation as a source of gravel and grit. Sites have also been damaged as a result of coastal development. Figure 3.2 shows the distribution of shingle and fringing beaches, more than 400km of British coastline falls into this classification.

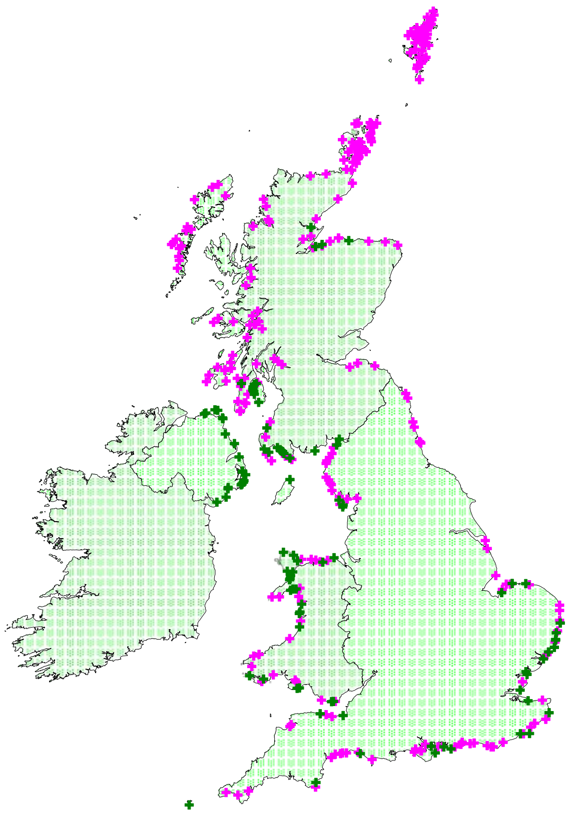


Figure 3.2 Locations of Coastal Shingle (✚) and Fringing (✚) Beaches

Source: JNCC Coastal Directories Series (1999),

3.3 Saltmarsh

Saltmarshes are areas of marshy ground that are intermittently inundated with salt water. The different classifications, include low-mid marsh, mid-upper marsh, driftline, upper swamp, transition and wet depression. Saltmarsh sites tend to be in more sheltered locations and may be found in harbours or embayments, brackish lagoons and estuaries. Some sites may be formed by man-made barriers such as roads enclosing an area, with tidal water entering through a narrow channel. The most important saltmarshes for nature conservation show a wide range of plant communities. Three British species of eelgrass (zostera) are nationally scarce and are present in intertidal and subtidal saltmarsh areas, all three species are present in the saltmarshes of Cornwall and Devon.

Some sites are designated SSSI's, but in some cases the saltmarsh is only a small part of the site and may not be the main reason for the designation, however such sites provide additional and interesting examples of transitions from saltmarsh to other habitats, i.e. saltmarsh-woodland, saltmarsh-wet grassland and saltmarsh-fen. Saltmarshes may be damaged due to grazing and turf cutting. Land claim of saltmarshes is common throughout Britain with the inner Clyde estuary being claimed for industry.

At present saltmarshes cover 44,370 hectares of the UK coastline. Most sites are found in the West Coast of Scotland, although these tend to be rather small areas, with the East and South East of England holding the largest percentage of the UK's distribution of Saltmarsh area. This region of the UK includes both The Wash and Humber estuary, with The Wash being the largest continuous expanse of saltmarsh anywhere in the UK. Figure 3.3 presents the location of saltmarsh sites around the UK.

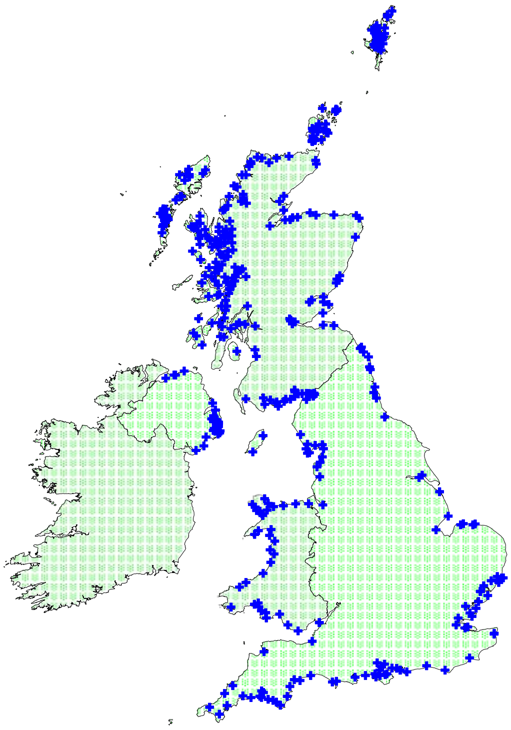


Figure 3.3 Distribution of Saltmarsh Sites in the UK

Source: JNCC Coastal Directories Series (1999)

3.4 Wet Grass

This section covers both coastal grazing marsh subject to maritime influence and lowland wet grassland adjacent to tidal reaches of estuary. Coastal grazing marsh is a distinctive habitat consisting of low lying grassland drained by a series of ditches that may be either brackish or freshwater. Grazing marsh is commonly formed by the enclosure of saltmarsh behind sea walls. Lowland wet grasslands lie near to tidal stretches of rivers and transitional areas of wet grassland between upper saltmarsh and dry land. Many of the sites include typical flora assemblages that hold nationally rare or nationally scarce species, they may be of national importance and are designated Sites of Special Scientific Interest or National Nature Reserves, some are Internationally important, being classified Special Protection Areas and Ramsar sites. Other sites are important for their unique bird populations and are designated RSPB status. For further information on such classifications, refer to Appendix 4.

Much wet grassland has been created by the activities of man over many centuries with some sites being claimed by the Romans. In the past fifty years however, there has been widespread loss of wet grassland through agricultural improvement, conversion to arable land and industrial and urban development. The high conservation value of certain wet grassland sites and the rapidity of which these are being lost have led to considerable protection measures being undertaken such as the introduction of management schemes that involve the retention of grazing, and the conversion of arable land to wet grassland. Figure 3.4 presents the location of wet grassland sites around the UK.

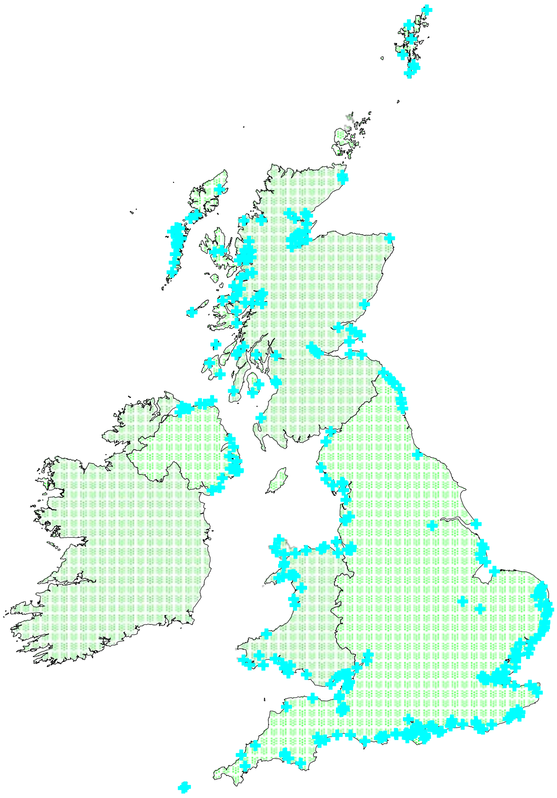


Figure 3.4 Distribution of Wet Grassland along the British Coastline

Source: JNCC Coastal Directories Series (1999)

3.5 Coastal Lagoons

Coastal lagoons are pond like bodies of water either wholly or partially separated from the sea, but with some influx of seawater. Described within this section are 'true' lagoons i.e. those that are separated by a national sedimentary barrier, as well as brackish ponds, coastal ponds and silled inlets and fjards (loch or pool in which the tidal regime is restricted by a very narrow mouth).

Lagoons are commonly shallow and possess a characteristic invertebrate fauna with little regional variation. Several of these species are rare in the UK and are protected under the Wildlife and Countryside Act 1981. There is little or no active management applied to most of the UK's lagoons, however particular sites are part of an enhancement scheme which encourages studies on invertebrate fauna to be carried out.

The totality of lagoonal area within the UK reaches 2,658 hectares. Figure 3.5 includes all classifications of lagoons as mentioned above, although it does not include freshwater lagoons. Natural lagoons are very rare in the UK, with only a few in Scotland. The highest distribution of these natural habitats are in South East England, with the largest single site being the Fleet in Dorset, covering some 480 hectares.

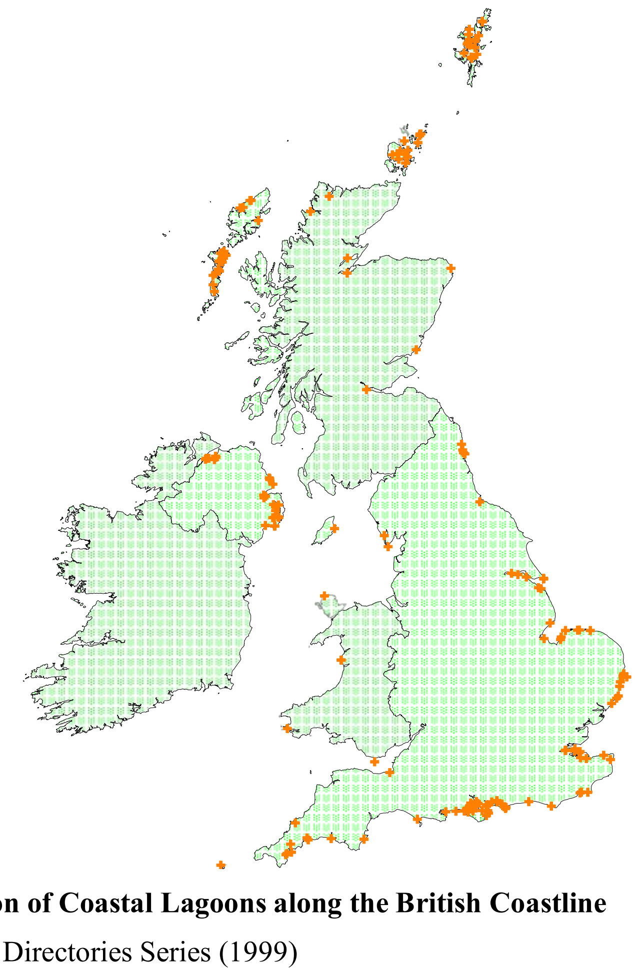


Figure 3.5 Distribution of Coastal Lagoons along the British Coastline

Source: JNCC Coastal Directories Series (1999)

3.6 Sand Dunes

Sand dunes consist of mounds of rock or mineral grains between 0.2 and 2 mm in diameter. The major dune habitats are strand and embryo dune, mobile and semi-fixed dune, acidic fixed dune grassland, neutral and calcareous fixed dune grassland, dune heath, dune slack, dune wetland, dune woodland and scrub, transitions to salt marsh, transitions to marine cliff, vegetated sand and machair.

In general sand dunes are amongst the least heavily modified of the habitats covered in this report. Conservation is a major activity in many locations with many sites being designated under international and national legislation. Recreational development is wide with car parks and golf courses infringing on areas of the dune systems.

50,200 hectares of the British coastline is represented by sand dunes. The West Coast of Scotland holds the largest number of sites in the UK with nearly 18% of the Sand Dune resource being in this region. Figure 3.6 presents the location of sand dunes around the UK coastline.

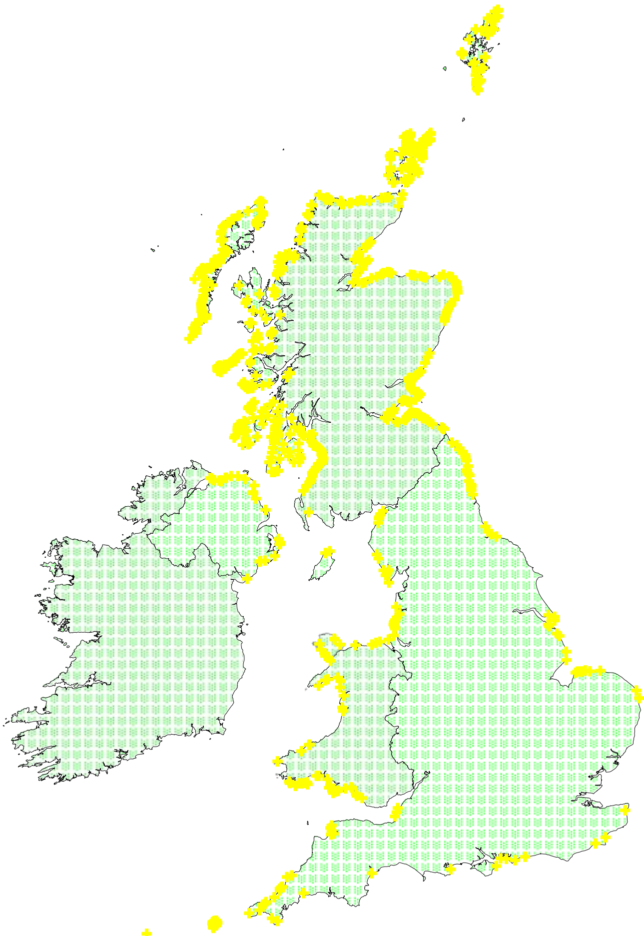


Figure 3.6 Distribution of Sand Dune along the UK Coast

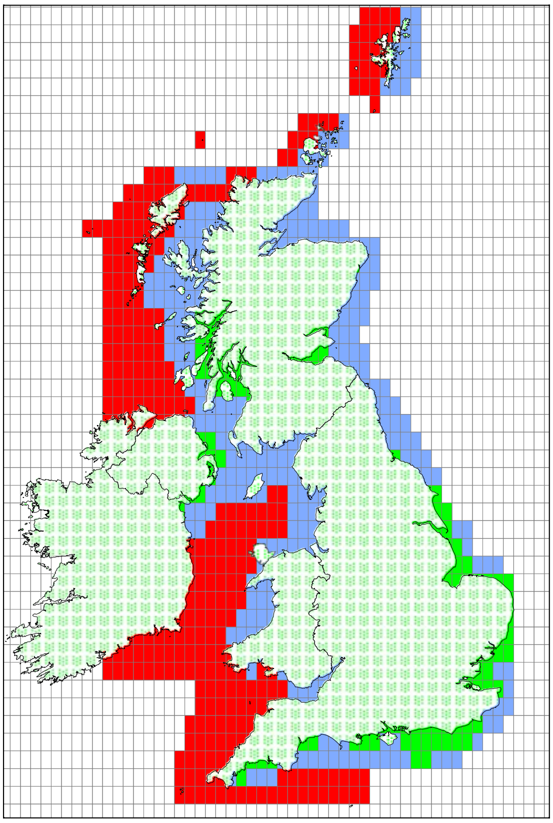
Source: JNCC Coastal Directories Series (1999)

4 EXPOSURE TO WIND AND WAVES

The exposure of the British coastline due to both wind and wave action can be included in order to determine the extent of damage to the coast in the event of an oil spill reaching the shoreline. It is assumed that the persistence of oil, and in particular the time taken for oil clearance from the coastline is related to the exposure of the coastline to such weather characteristics. The weather data presented is from the JNCC Coastal Directories Series.

4.1 Wave Severity

Wave characteristics can be used to classify severity in terms of high, medium or low wave exposure. The most consistent data for wave severity was in the form of significant wave height that was exceeded for 10% of the time. These 10% wave heights were then used to classify the UK coastline in terms of exposure, due to wave severity. The results of such classification are given in Figure 4.1.



low
medium
high

Figure 4.1 Wave Severity based on 10% Wave Height

Source: JNCC Coastal Directories Series (1999)

4.2 Wind Severity

As with exposure due to wave severity wind characteristics can be used to classify severity in terms of high, medium or low wind exposure. The most consistent data for wind severity was in the form of wind contour maps for 75% of the time. These 75% wind speeds were then used to classify the UK coastline in terms of severity. The results of such classification are given in Figure 4.2.

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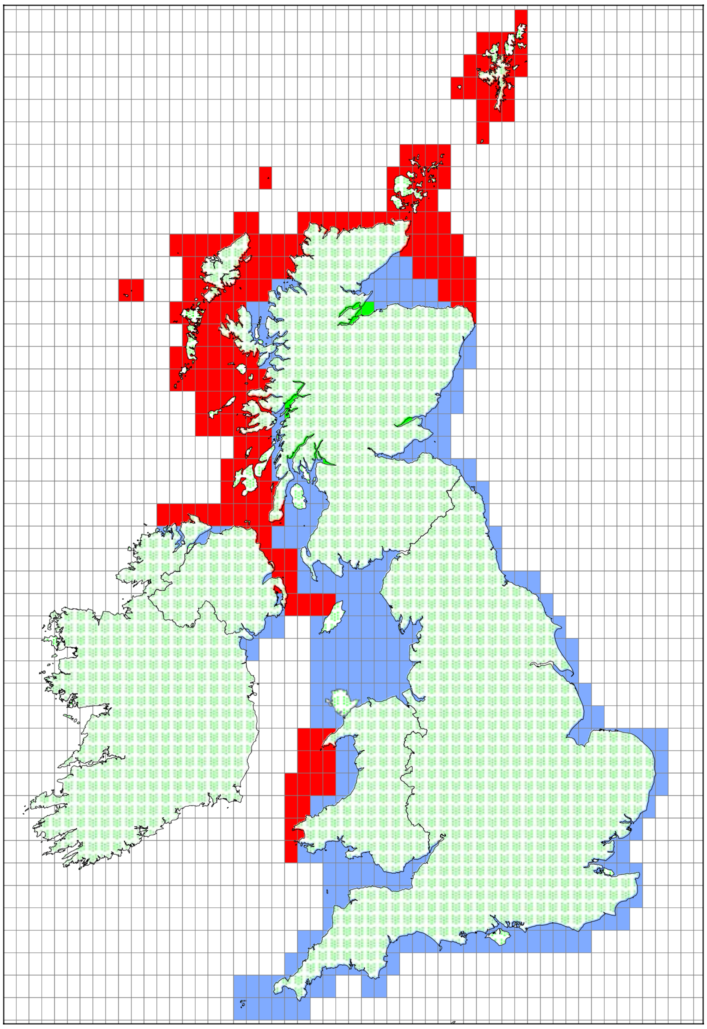

- low
- medium
- high

Figure 4.2 Wind Severity based on 75% Wind Speed

Source: JNCC Coastal Directories Series (1999)

5 METHODOLOGY FOR DETERMINING PERSISTENCE FOR UK COASTLINE

From the previous sections it is concluded that the persistence of oil is dependent on a number of factors including the type of oil, weather conditions, geology of the location and wave exposure. Within this assessment it was considered impractical to carry out a detailed assessment which would require to look at the type of oil, permeability of rock and weather conditions, as insufficient information was available to merit such a detailed analysis. However, a simple methodology is presented based on coastal morphology and wind/wave exposure, which could be used as a starting point for future evaluations.

The methodology presented for assessing the persistence of the oil spill was adopted from previous research in this field, which documented the use of wind/wave exposure and coastline substrate and morphology (Ref. i). This forms the basis of a coarse ranking system that allows for a semi-quantitative evaluation and minimises the application of a purely subjective interpretation.

5.1.1 Coastal Morphology

The coastline of the UK has been classified by the habitats in a specific area. The coastal classification can then be used to give an estimate of the length of time that an oil spill will take to be cleared with sandy beaches being the worst and rocky stretches the most easily cleared. As presented in Section 3, the habitats included in this study are:

- Cliffs and cliff top vegetation,
- Saltmarsh,
- Shingle and fringing beaches,
- Coastal lagoons,
- Wet grass and
- Sand dunes

Each of the above characteristics have been categorised into three groups, each having a factor relating to the degree of rockiness. The groups consist broadly of:

- Sand 0.1
- Gravel 0.4
- Rocky 0.9

The following figure presents the relative ranking of the UK coastline in terms of degree of rockiness.

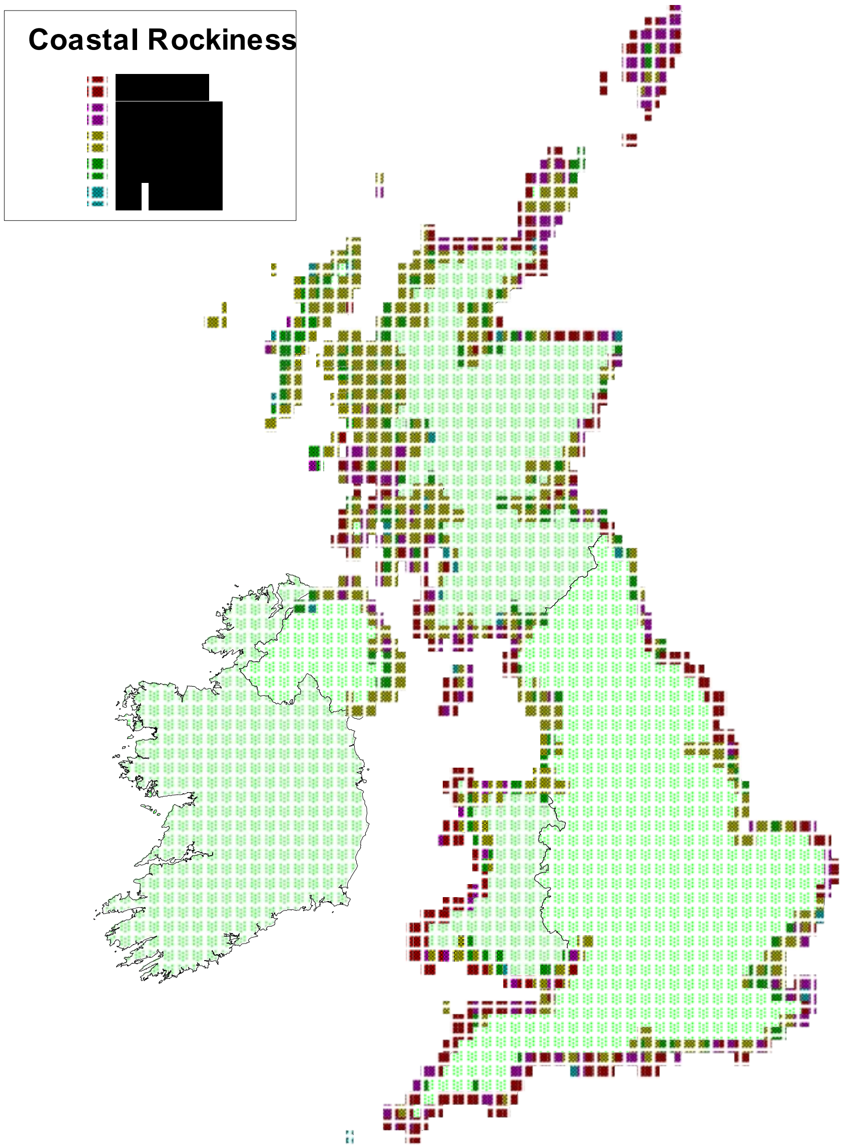

Figure 5.1 Degree of Rockiness of UK Coastline

5.1.2 Wind and Wave Severity

As discussed in Section 4, the exposure of the UK coastline due to both wind and wave action should be included in order to determine the extent of damage to the coast in the event of an oil spill reaching the shore. Taking the wave heights presented and ranked in terms of high, medium or low exposure in Section 4.1, these are scored as follow;

- High 3
- Medium 2

- Low 1

As with wave exposure, wind characteristics presented in Section 4.2 can be used to classify the UK coastline in terms of high, medium or low severity, with the scoring being as follows:

- High 3
- Medium 2
- Low 1

5.1.3 Persistence Factor

As already presented, the persistence of oil is dependent on both the weather characteristics and the nature of the coastline. For example if a stretch of coastline is particularly rocky with high wind and wave exposure then any oil spilled in that area would be more likely to be dispersed quickly i.e. would have a low persistence. Alternatively a sandy stretch of coast with calm weather characteristics i.e. low wind and wave severity would have a high persistence. This persistence can then be calculated by factoring the wind severity, wave severity and rockiness factor. Table 5.1 presents the methodology which can be used to calculate the persistence factor.

Table 5.1 Methodology for Calculating Persistence Factor

Wind Severity	Wave Severity	Coastline Classification	Wind Factor	Wave Factor	Rockiness Factor	Total
Calm	Calm	Sand	1	1	0.1	0.1
Calm	Calm	Shingle	1	1	0.4	0.4
Calm	Calm	Cliff	1	1	0.9	0.9
Calm	Medium	Sand	1	2	0.1	0.2
Calm	Medium	Shingle	1	2	0.4	0.8
Calm	Medium	Cliff	1	2	0.9	1.8
Calm	Rough	Sand	1	3	0.1	0.3
Calm	Rough	Shingle	1	3	0.4	1.2
Calm	Rough	Cliff	1	3	0.9	2.7
Medium	Medium	Sand	2	2	0.1	0.4
Medium	Medium	Shingle	2	2	0.4	1.6
Medium	Medium	Cliff	2	2	0.9	3.6
Medium	Rough	Sand	2	3	0.1	0.6
Medium	Rough	Shingle	2	3	0.4	2.4
Medium	Rough	Cliff	2	3	0.9	5.4
Rough	Rough	Sand	3	3	0.1	0.9
Rough	Rough	Shingle	3	3	0.4	3.6
Rough	Rough	Cliff	3	3	0.9	8.1

Based on the methodology presented, Figure 5.2 presents a graphical representation of the persistence factors for different areas around the UK.

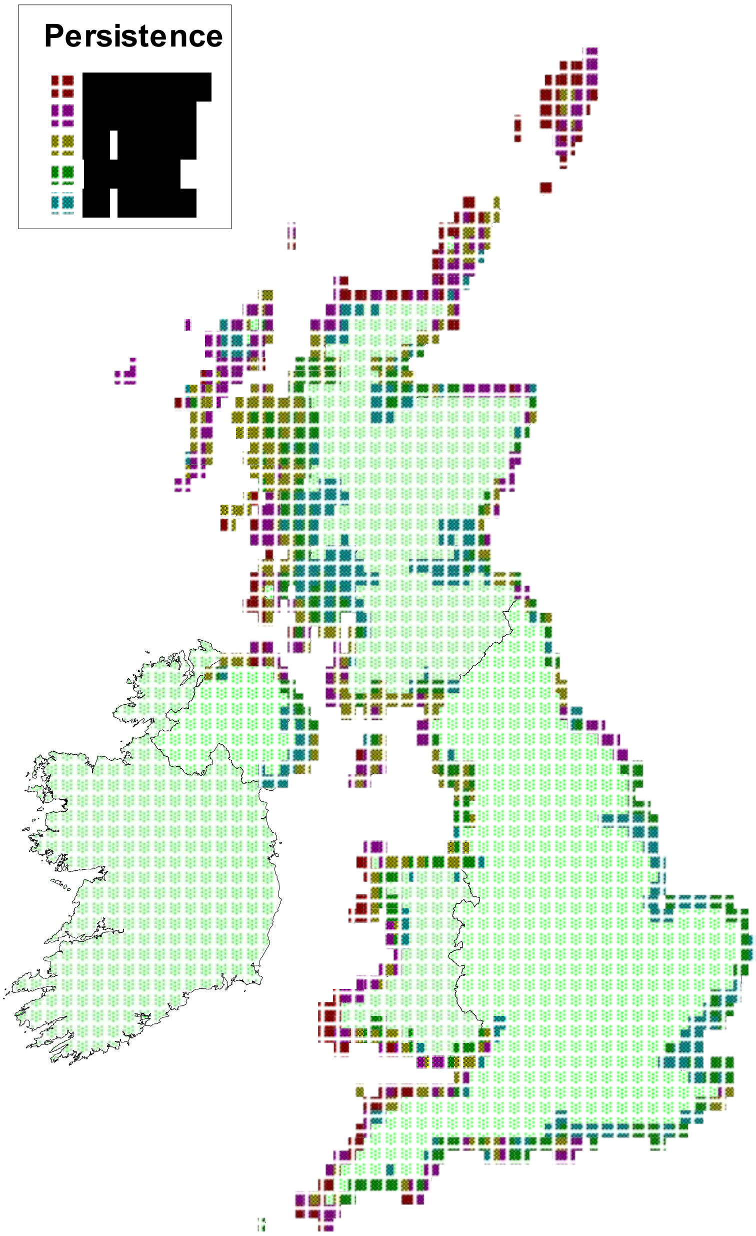

Figure 5.2 Range of Persistence Factors for the UK Coastline

It is considered that in future evaluations, with the availability of more detailed information, then the methodology presented can be revised to allow for the inclusion of persistence within the MEHRA’s assessment.

6 REFERENCES

i Shore-Zone Mapping System for Use in Sensitivity Mapping and Shoreline Countermeasures by Ministry of Environment, Victoria British Columbia.

APPENDIX 6

POLLUTION PREDICTION MODELS

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1 INTRODUCTION

This Appendix provides an overview of the pollution prediction models that were developed during this project.

Five computer models were developed to firstly predict the frequency of shipping incidents and subsequently to predict the frequency distribution of spills.

The five models developed allowed assessment of the following ship incidents:

1. Ship to ship collisions;
2. Fire and explosions on board ships;
3. Founderings;
4. Powered groundings;
5. Drifting groundings.

All of the models used as base data, the COAST ship route database, as detailed in Appendix 1. This route database was converted into a shipping density plot for the sea area under consideration.

Presented in the following section are details of the geographical cell breakdown, which was used to perform the model cell-wise calculations. Following the cell breakdown section, each of the models are outlined.

2 GEOGRAPHICAL BREAKDOWN

In order to determine the frequency distribution for ship impacts and pollutant spills, the UKCS sea area and shoreline was subdivided into cells. The size of the cells was determined based on the area where more detailed site mapping was carried out which in the case of this project was the shoreline. Four different cell sizes have been applied, which increase in size with increasing distance from the coastline. The different cell sizes applied are as follows:

- 7.5nm x 4 nm (shoreline cells)
- 15nm x8nm (sea cells)
- 30nm x16 nm (sea cells)
- 60nmx32 nm (sea areas remote from UK coastline)

Figure 2.1 presents the shoreline and sea area cells used by the pollution models.

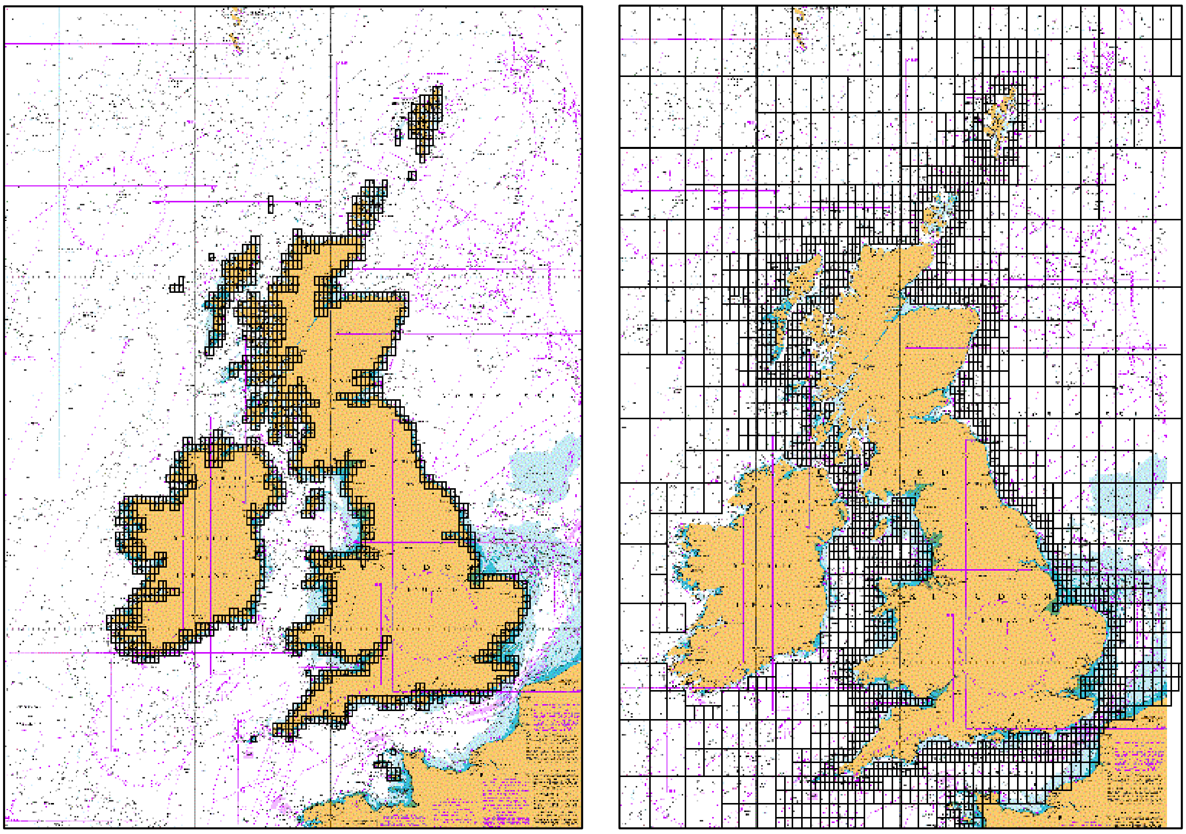


Figure 2.1 Shoreline And Sea Area Cells Used In Pollution Models

3 SHIP TO SHIP MODEL

The ship to ship model allows assessment of the frequency of collisions and any subsequent pollutant spills between ships travelling in open waters (i.e. the model excludes restricted waters for example, within harbours, river estuaries, etc.).

The ship to ship model takes into account factors that have been identified, either within this project's research or during previous referenced research, as having a significant influence on ship collision incidents. The factors so identified were:

- Encounter angle;
- Visibility;
- VTS areas;
- Size of vessels;
- Type of vessels.

The ship to ship model systematically stepped through the sea area cells to determine the probable ship to ship encounter frequency, the collision frequency and the pollutant spill frequency for each cell. The model results were subdivided by vessel type, size of ship and size of spill.

The ship to ship model assessed the frequency of ship collision in two stages. It first examined the probability of a collision between vessels on the same route and secondly examined the probability of collisions between vessels on different routes.

Vessels that travel along the same route (e.g. Aberdeen to the Humber) will travel at varying speeds. Therefore, there is a probability that a slow ship will be caught up by a faster ship. In the COAST database, ships on a route were subdivided into three speed categories, as illustrated in Figure 3.1.

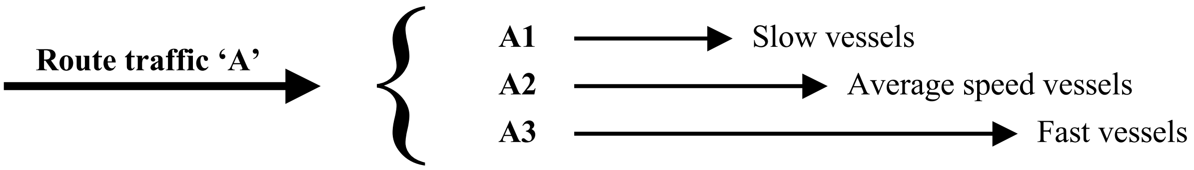
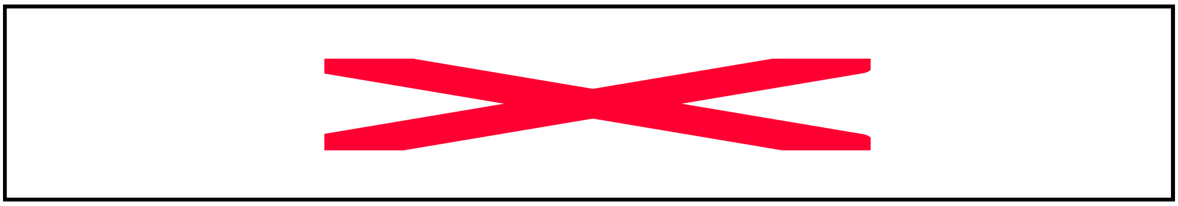


Figure 3.1 Intra-Lane Speed Vectors

This leads to three possible intra-lane interactions, namely A3 → A1, A3 → A2 and A2 → A1.

The three speed categories were used in the ship to ship model to determine the encounter frequency by use of the following formula:



Where:	Fenc	= Frequency of encounters of vessels heading in the same direction along a route
	N	= Number of vessels on route per day
	Le	= Encounter length
		= +/- 0.5 nautical miles (i.e. an encounter occurs if two ships pass within 1 nm of each other)
	A	= Area of cell in nm^2
	Pft	= Proportion of fast vessels on route
	Pav	= Proportion of average speed vessels on route
	Psl	= Proportion of slow vessels on route
	v3	= Speed of fast vessels in knots
	v2	= Speed of average speed vessels in knots
	v1	= Speed of slow vessels in knots

The inter-lane encounters are encounters which occur between vessels on different routes (or as assumed in the model, vessels on the same route travelling in opposite directions). Inter-lane encounters are illustrated in Figure 3.2.

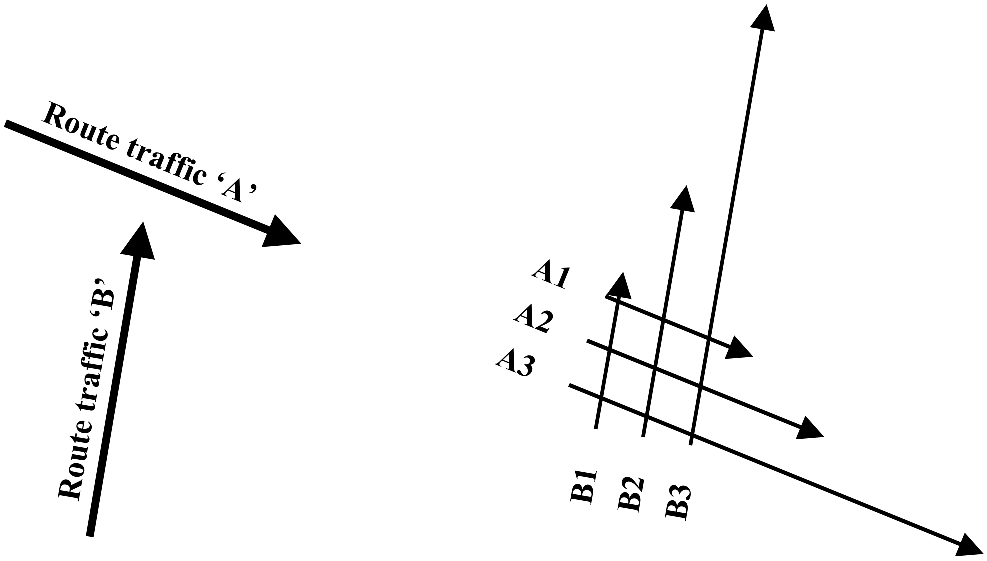
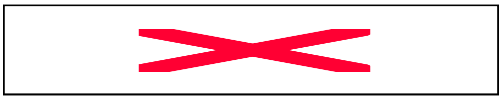


Figure 3.2 Inter-Lane Speed Vectors

This leads to nine possible inter-lane interactions.

The encounter frequency for vessels on routes which pass each other at a cross over angle was determined using the formula:



Where: Na = Number of vessels on route A per day
Nb = Number of vessels on route B per day
DeltaV = Sum of the relative velocities between each of the routes speed vectors

The ship to ship collision frequency, obtained from the encounter frequency, took into account the types and the size distributions of the vessels on each route. It also took into account the proven (Ref. 1) benefits of sea areas covered by VTS systems, the affects of bad visibility (see Appendix 2), and the difference that encounter angle has been seen to have on ship to ship collisions (Ref. 2).

The ship to ship collision model subdivided the collision frequencies predicted by vessel type, vessel size and by what part of the ship would suffer damage (i.e. bow, stern or side - based on encounter angle).

4 FIRES AND EXPLOSIONS

The main causes of fires and explosion are:

- Repair;
- Discharging and loading;
- Boiler explosions;
- Electrical faults;

- Tank cleaning;
- Engine trouble.

Since it would be virtually impossible to individually take these factors into account in a predictive model, the fire and explosion model developed for this project was based on examination of the overall fire and explosion casualty data for the UKCS (see Appendix 2). Examination of this data allowed the overall number of fire and explosion events to be broken down by ship type and size.

The fire and explosion model assessed the frequency of a fire and explosion event occurring in each of the sea area cells considered with the result being subdivided by ship type and size.

5 FOUNDERINGS

The foundering model predicted the frequency distribution of foundering incidents in a similar way to the fire and explosion model with the exception that it took into account the noted (see Appendix 2) affect that severe weather had on the casualty rate.

6 GROUNDING RISK MODELS

6.1 General Approach

The risks associated with ships going aground along the UK coastline were assessed using the following two computer models:

1. Powered grounding model;
2. Drifting grounding model.

Both models made use of cell-wise calculations to predict the frequency of interactions between a shoreline cell and a sea area cell. The cell geometry used in both models has been described in Section 2.

6.2 Powered Grounding Model

Powered groundings tend to occur where shipping approach the restricted waters around the coast.

The powered grounding model assessed the likelihood of powered grounding within each of the shoreline cells from the traffic in the surrounding sea cells. The model took into account a large number of factors which have been found by observation, past research and review of powered grounding accidents to influence the likelihood of such incidents occurring.

The frequency of powered groundings within each shoreline cell was based on the following formula:

$$Freq_{(shorecell)} = \sum_{i=1}^{p}\sum_{j=1}^{q}\sum_{k=1}^{r}\sum_{l=1}^{s} N \times P_{err} \times P_{fail} \times P_{dir} \times F_{sea} \times F_{vts} \times F_{size} \times F_{type}$$

Where:

p	= number of shoreline cells
q	= number of sea cells within (conservative) search radius
r	= number of routes in sea cell
s	= number of size categories on each route
N	= number of ships on route per year
P_{err}	= probability of navigational error
P_{fail}	= probability of failing to avert grounding
P_{dir}	= geometrical probability
F_{sea}	= sea state influence factor
F_{vts}	= VTS system influence factor
F_{size}	= vessel size influence factor
F_{type}	= vessel type influence factor

The probabilities and factors contained within the grounding formula were chosen based on experience, geometrical aspects and assessment of past powered grounding incidents.

Each of the main parameters in the formula are discussed further below.

6.2.1 Number Of Ships On Route (N)

The number of ships on each route within a sea cell was obtained from route data contained in the COAST database.

6.2.2 Navigational Errors (P_{err})

P_{err} was the probability that the crew of a ship will make a navigational error which results in the ship altering course to, or failing to alter course away from, the shoreline.

The P_{err} probability was used during the assessment of powered grounding risk to calibrate the model against historical accident statistics.

6.2.3 Failure To Avert Grounding (P_{fail})

The probability to avert a collision was based on the assessed time available to identify a navigational error has occurred and to take effective action to avert a collision.

In determining the P_{fail} probability, the following were taken into account:

1. The distance between the shoreline cell under consideration and the centre co-ordinate of the sea cell being considered;
2. The average speed of vessels on the route being considered;
3. A representative mass of vessels within each size category being considered.

From the above, the time to impact, the stopping time required for a representative ship of certain displacement and speed (Ref. 3), and hence the time available to avert a collision were estimated. A probability ranging from 0.0 (i.e. 100% averting action taken) for conditions when the time available was more than 30 minutes, to 1.0 (i.e. no time available to avert grounding).

The 30 minute limit was defined based on experience and knowledge of navigational practice.

The model conservatively assumes that once a vessel is within its stopping distance and on a grounding course, a grounding will occur. No benefit has been taken from the possibility of the vessel steering clear of the shoreline rather than attempting to stop the vessel.

6.2.4 Geometrical Limits (P_{dir})

During normal navigation, a vessel which is underway should not deviate far off its chosen course without some sort of human and/or systems failure. Under the International Regulations For Preventing Collisions At Sea (Ref. 4) every vessel must at all times maintain a proper look-out (Rule 5) and must at all times proceed at a safe speed (Rule 6). When approaching land, vessel masters are required to be extra vigilant due to not only the increased risk of running aground but also the increased risk of ship to ship collision as a result of reduced sea room and higher densities of shipping.

There is no established model for evaluation of the probability of powered grounding, but in the COST 301 study (Ref. 1) the powered grounding frequency as estimated using a weighting factor based on the reciprocal of the distance of the traffic to shore. In another study (Ref. 5) which examined groundings in channels suggested that the probability of grounding for traffic passing through a channel of width C was $4T/\pi C$, where T was the stopping distance of the ship. The aspect ratio of a channel's length to its width has also been suggested as an influencing factor in the determination of a grounding frequency.

Based on the above, the geometrical factors which are considered to have influence on whether a vessel on transit in the vicinity to shore will run aground, include:

- Course of traffic;
- Aspect angle of shoreline with respect to vessel course;
- Deviation of shoreline from traffic course.

Figure 6.1 presents an illustration that shows the geometrical factors which have been considered in the powered grounding model.

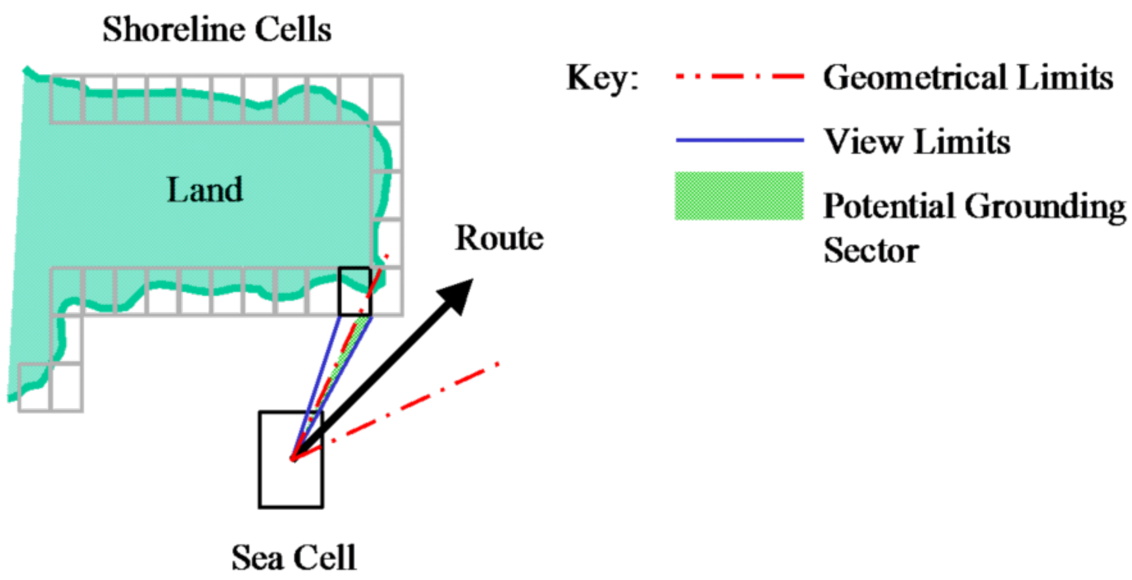


Figure 6.1 Geometrical Aspects For Powered Grounding Model

For each sea cell, the view limits of each shore cell is determined. Where a shore cell is either completely or partially sheltered from a sea cell by another shore cell, this is taken into account in the computer model.

Each route in the sea cell is then examined to establish if, based on the course of the route, there is considered a potential for a vessel on this route to deviate sufficiently to go aground in the shore cell being looked at. In the powered grounding model, a geometrical limit angle, relative to the route course, is used to identify shore cells that are at risk of a powered grounding from a particular route.

A geometrical limit angle of ± 20° with respect to route course was selected for use in the powered grounding model. Vessel deviations in excess of this geometrical limit angle were not considered reasonable.

By comparison between the view limits and the geometrical limits, the potential grounding sector was determined for each route. A geometrical probability (P_{dir}) was determined for vessels on a route which was based on the included angle of the grounding sector and the relative angle between the grounding sector and the route course. If, for example, a route was heading directly towards a shoreline cell, the geometrical probability would be high, whereas if a route was, say, passing along a shoreline cell, the geometrical probability would be very low.

6.2.5 Bad Weather Factor

Analysis of accident statistics indicated that powered grounding was more likely in bad weather (see Appendix 2). This weather influence was taken into account in the powered grounding model based on the assumption that bad weather equated to severe sea state conditions. The probabilities of differing seastates occurring in different regions around the UK are presented in Appendix 7.

6.2.6 VTS System Factor

As noted in Section 3, VTS coverage has been shown to decrease the probability of a navigation error occurring on a ship. This benefit was taken into account in the powered grounding model. The following figure presents the areas in UK waters where VTS has been taken into consideration.

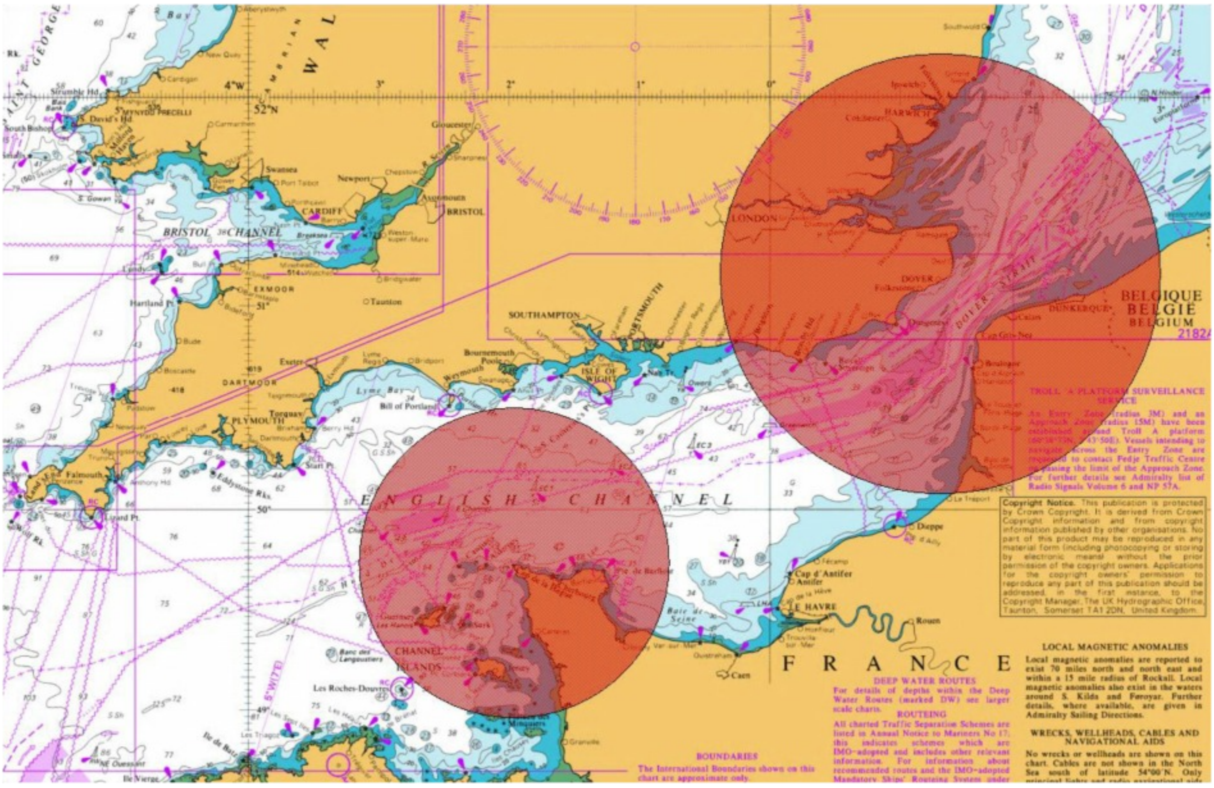


Figure 6.2 VTS Coverage in UK Waters Taken Into Account in Risk Assessment

6.2.7 Vessel Size Factor

By examination of the powered grounding casualty data (Appendix 2), the variation in accident rate by vessel size was determined. This was taken into account in the model.

6.2.8 Vessel Type Factor

By examination of the powered grounding casualty data (Appendix 2), the variation in accident rate by vessel type was determined. This was taken into account in the model.

6.3 Drifting Grounding Model

The drifting grounding model assessed the likelihood of a ship which breaks down and drifts in each of the sea area cells reaching the shore of the UK and running aground. The model takes into account the historical probabilities for wind strength, direction, sea conditions, self repair, and the vessel type and size influences as detailed in Appendix 2.

The model does not, however, take into account the availability of tugs since this was outside the scope of the project. The exclusion of tugs results in a pessimistic risk picture.

The drifting grounding model systematically steps through each of the sea area cells for each number of vessel of each of the types considered. A probability of mechanical failure was chosen to be representative of historical data.

The model then "drifted" the vessels from the sea cell in twelve directions (i.e. drift lines at 30° intervals) to determine if the vessels would, if they continued in the drift direction, come into contact with any part of the UK coastline. The model assumed that vessels would drift in a direction governed by the wind and at a speed governed by the sea conditions[1]. In terms of the drift velocity of the vessels, data was taken from a study commissioned by the oil companies International Marine Forum (Ref. 6). This study provides different drift velocities in different sea-states:

Calm	1 knot
Moderate	1.5 knots
Severe	3 knots

The probability of wind being from each of the twelve directions considered was obtained from wind data for the UKCS area as was sea condition data. The wind rose data applied is presented in Appendix 7.

If the model identified that a drift direction, from a sea cell would come into contact with the shore of the UK, the shoreline cell in which the contact point would be, was identified. A frequency of grounding was then determined for the identified shoreline cell and this was added to the shoreline cell's total frequency. By examining each sea cell in turn and adding the frequency of grounding to each shore cell that a broken down vessel could drift onto, the overall shoreline grounding frequency, subdivided by shoreline cell, was determined.

An illustration of how the drifting grounding model assessed the grounding frequency along the shoreline of the UK is presented in Figure 6.3.

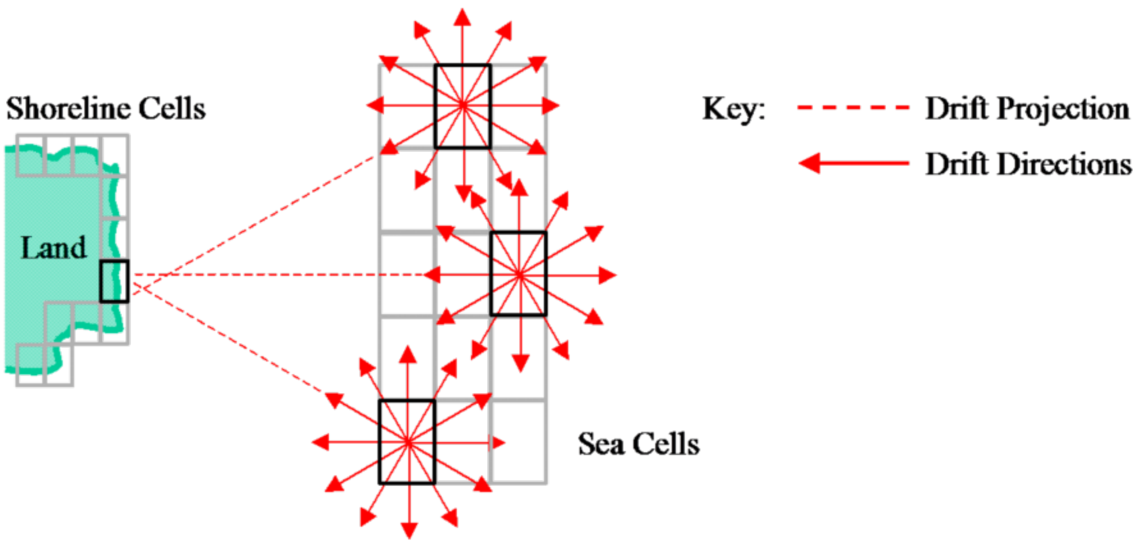


Figure 6.3 Illustration of Drifting Grounding Model Methodology

1 This is recognised as a simplification and it is recommended that the models are updated to incorporate the affects of tidal currents.

From Figure 6.3 it can be seen how three sea cells contribute to the drifting grounding frequency of a shoreline cell. The model was developed to take into account the difference in size between the shoreline cells and the sea cells so that if necessary, the frequency of grounding is "spread" over a number of consecutive shoreline cells.

The self repair time, as used in the calculation of grounding frequency, was determined based on the time available to affect repairs which in turn is dependent on:

1. The separation distance between the sea cell under consideration and the shoreline cell that has been identified as being on one of the drift directions;
2. The speed of drift which was based on the sea state probabilities.

The model assumes that self repair would not be possible if the time to ground was less than 2 hours, and that there would be a 0.9 probability of self repair if there was more than 24 hours available for repair.

7 ACCIDENT FREQUENCY MODEL CALIBRATION (VALIDATION)

All five models were calibrated to achieve model frequencies, which matched the historical accident information presented in Appendix 2. This calibration was undertaken by adjusting a single probability in each model. This ensured that the other influencing factors, as determined from research and analysis (as noted in the model descriptions above) were not altered.

8 SPILL MODEL

8.1 Introduction

Given that a serious vessel casualty, such as a grounding, has occurred, it is necessary to calculate the probability of a spill and the likely size of the release. The models used to estimate these two parameters are discussed in the following subsections.

8.2 Spill Probability Model

This section focuses on the likelihood of a spill arising from a marine casualty. All vessels are capable of spilling oil in the form of bunker fuel. In addition to bunkers, tankers (coastal and shuttle) carry oil as cargo.

Therefore, the spill probability has been divided into two categories:

- Probability of a Bunker Spill
- Probability of a Cargo Spill

8.2.1 Bunker Spill Probability

The probability of a fuel oil spill for each type of accidental event considered is as follows:

Table 8.1 Bunker Spill Probability

Casualty Type	Bunker Spill Probability (Spill per Casualty)
Ship to ship collisions	0.128
Fires and explosions	0.017
Founderings	1.000
Groundings (Powered and Drifting)	0.120

These probabilities are based on fuel oil spills from bunkers resulting from serious casualties occurring to ships of all types above 1,000 DWT between 1990 and 1995 Worldwide (Ref. 7). For foundering the probability has been made equal to 1, as all sunken ships will release some fuel oil, although it may only be a small amount. After foundering, it can be seen that collisions and groundings are the most likely accidents to cause a bunker spill.

8.2.2 Cargo Spill Probability

For tankers travelling in ballast, i.e., with no cargo onboard, the bunker spill probabilities presented in Section 8.2.1 have been used, as only spills of fuel oil can potentially result from an accident.

However, when tankers are laden, spills of cargo and/or fuel may occur. The spill probabilities per casualty have been derived from historical data for oil tankers Worldwide between 1980 and 1995 and are presented in Table 8.2. Again, it is assumed that all founderings will give rise to a spill.

Table 8.2 Spills from Oil Tankers (1980-1995)

Ship Size (DWT)	Cargo Spill Probability (Spills per Casualty)			
	Ship Collision	Fire/Explosion	Foundering	Grounding
0 - 2,000	0.52	0.04	1.00	0.19
2,000 - 5,000	0.56	0.06	1.00	0.19
5,000 - 20,000	0.24	0.11	1.00	0.35
20,000 - 50,000	0.24	0.11	1.00	0.35
> 50,000	0.31	0.13	1.00	0.39
Average	0.39	0.10	1.00	0.30

Therefore, the pattern is similar to bunker spills, with founderings, collisions and groundings most likely to result in a spillage.

With regard to the probability of a tanker being laden, an average value of 0.85 has been used based on a survey of UK ports in April 1999. However, within some areas, such as The Minches (see Figure 8.1) and The Needles Channel, laden tankers are advised to use an alternative route. This geographical variation has been taken into account within the spill probability model.

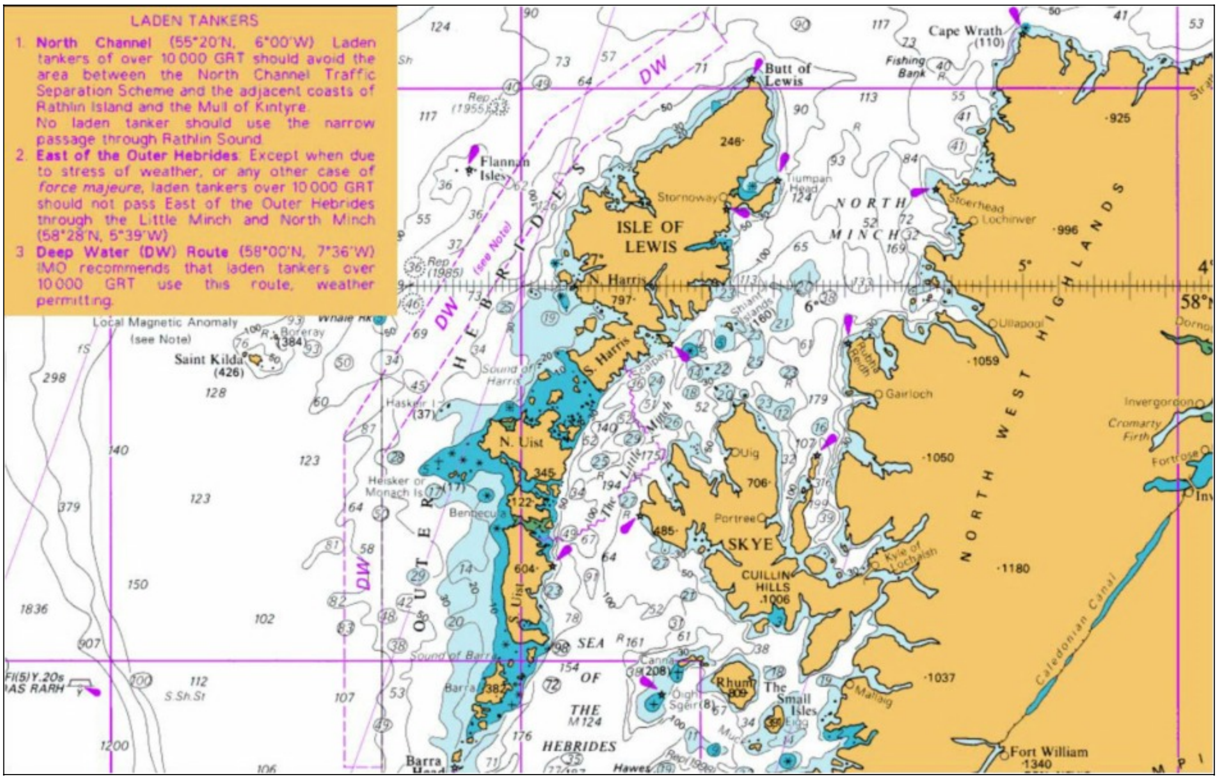


Figure 8.1 Routeing Advice to Laden Tankers East of the Outer Hebrides

8.3 Spill Size Model

For accidents that lead to a spill, the spills have been distributed into the following five size categories:

Table 8.3 Definition of Spill Size Categories

Spill Size Category	Range (Tonnes)
1	0 - 1,000
2	1,000-10,000
3	10,000-50,000
4	50,000 - 100,000
5	> 100,000

Most ships can only spill oil in the form of fuel oil from bunkers, however, oil and shuttle tankers can additionally spill cargoes of oil. Spills from laden tankers (carrying cargo and fuel) are likely to be of greater magnitude, therefore, the spill size model is divided into the following two categories:

- Bunker Spill Size Model
- Cargo Spill Size Model

8.3.1 Bunker Spill Size Model

This model applies to all ships except for laden oil and shuttle tankers, when the cargo spill size model is used.

The size of spill will be dependent on the amount of fuel that a ship can carry. A correlation between bunker capacity and ship size is presented in Table 8.4.

Table 8.4 Bunker Capacity for Different Ship Sizes

Ship Size Category	Ship DWT	Average Bunker Capacity (Tonnes)
1	0 - 2,000	200
2	2,000 - 5,000	350
3	5,000 - 20,000	750
4	20,000 - 50,000	1,200
5	> 50,000	4,500

It can be seen that only ships in size categories 4 and 5 are capable of fuel oil spills over 1,000 tonnes. From historical spill data for all ships in UK waters from 1980 to 1995, there were 84 fuel oil spills, with only one larger than 1,000 tonnes. Historical bunker spills were generally limited to a size below 50% of the total bunker capacity (Ref. 7).

Therefore, it has been assumed that only ships above 50,000 DWT are capable of spilling more than 1,000 tonnes of fuel oil, with a 20% chance of a spill of this magnitude. Bunker spills from all other ship sizes, and 80% of those for ships above 50,000 DWT, are assumed to be below 1,000 tonnes.

This is summarised in Table 8.5.

Table 8.5 Bunker Spill Size Distribution (All Casualty Types)

Ship Size Category	Spill Size Probability				
	1	2	3	4	5
1	1	0	0	0	0
2	1	0	0	0	0
3	1	0	0	0	0
4	1	0	0	0	0
5	0.8	0.2	0	0	0

Therefore, the vast majority of spills are in the 0-1,000 tonnes category, and it is noted that the majority of these are likely to be at the lower end of this range (Ref. 8).

8.3.2 Cargo Spill Size Model

This model considers spills that result from accidents involving laden tankers. These spills may be of cargo, fuel or both. The main factors that influence spill size are considered to be:

- Ship Size
- Accident Cause

Data from Lloyd's, ACOPS and MAIB was examined but none of these sources contained the above information for all incidents as well as the spill size. Therefore, this information was obtained from ITOPF (International Tanker Owners Pollution Federation) for accidental oil spills from tankers occurring in UK waters for the period 1974 to 1995. Forty spills were recorded during this period.

Due to the low number of historical spills in the UK, it was considered necessary to supplement the ITOPF data with data from the Worldwide Tanker Spill Database (Ref. 9). Details of this database are as follows:

- Covers the period 1974 to June 1990.
- The source of the spill must be a tanker on which a petroleum product was a cargo. The spill may be cargo or fuel.
- Spills must be accidental.
- Spills must be at least 1,000 barrels in size (approximately 136 tonnes).

The ITOPF data was combined with the Worldwide Tanker Spill Database to create a database containing all spills from tankers of 1,000 barrels or greater. From ITOPF data it was estimated that the ratio of spills above and below 1,000 barrels for each accident type is as follows:

Table 8.6 Ratio of Spills from Laden Tankers

Casualty Type	Probability	
	< 1,000 BBL (136 tonnes)	≥ 1,000 BBL (136 tonnes)
Ship to Ship Collisions	0.42	0.58
Fires and Explosions	0.83	0.17
Founderings	N/A*	N/A*
Groundings	0.50	0.50

* Separate figures are not available for founderings.

Therefore, collisions and groundings historically result in a higher percentage of large spills.

For all incidents where the tanker size, spill size and accident cause were known, the breakdown per cause was as follows:

Table 8.7 Historical Oil Spills from Tankers above 1,000 Barrels (ITOPF and Worldwide Tanker Spill Database)

Casualty Type	Number of Spills
Ship to Ship Collisions	98
Fires and Explosions	94
Founderings	11
Groundings	149

The incidents were assigned a ship size category (1 to 5 based on DWT of ship involved) and a spill size category (1 to 5 based on spill tonnage converted from barrels). This was used to distribute spills for each accident type and each ship size into five spill sizes. However, for founderings, due to the low number of incidents it was assumed that all the cargo and fuel will be lost when the ship sinks (oil release approximately 100% of DWT).

Using the probabilities in Table 8.6 to take account of the fact that only spills above 136 tonnes (1,000 barrels) were included in the combined database, the final spill size distribution for laden tankers is presented in Table 8.8.

Table 8.8 Cargo Spill Size Distribution per Casualty Type

Casualty Type	Ship Size Category	Probability of Spill Size				
		1	2	3	4	5
Ship to Ship Collisions	1	0.88	0.12	0	0	0
	2	0.82	0.18	0	0	0
	3	0.71	0.18	0.11	0	0
	4	0.86	0.11	0.03	0	0
	5	0.65	0.22	0.07	0.05	0.01
Fires and Explosions	1	0.92	0.09	0	0	0
	2	0.86	0.14	0	0	0
	3	0.87	0.06	0.07	0	0
	4	0.87	0.06	0.07	0	0
	5	0.86	0.09	0.03	0.01	0.02
Founderings	1	0.47	0.53	0	0	0
	2	0	1	0	0	0
	3	0	0.65	0.35	0	0
	4	0	0	1	0	0
	5	0	0	0	0.66	0.34
Groundings	1	0.92	0.08	0	0	0
	2	0.82	0.18	0	0	0
	3	0.79	0.14	0.07	0	0
	4	0.76	0.19	0.05	0	0
	5	0.68	0.24	0.05	0.02	0.02

8.4 Average Spill Size

In order to rank the cells within UK waters in terms of oil pollution, an average spill size is required for each spill size category. The total oil spilled in each cell can be calculated using the formula:

$$T_{oil} = \sum_{i=1}^{i=5} F_i \cdot Av_i$$

where T_{oil} = Total oil spilled (tonnes).
F_i = Annual frequency of an oil spill within category i.
Av_i = Average amount of oil released in a category i spill.

Using the Worldwide Tanker Spill Database and ITOPF data, all the oil spills from tankers within each size category were identified. The following five plots shows the spills within each category distributed by tonnage.

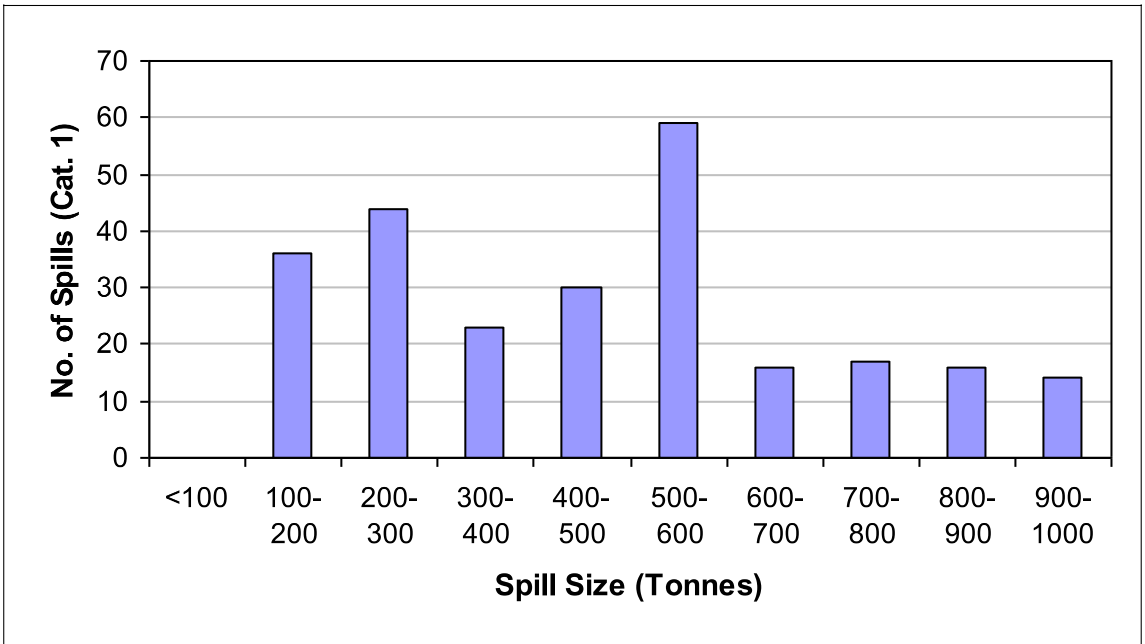


Figure 8.2 Spill Distribution within Size Category 1 (136-1,0000 Tonnes)

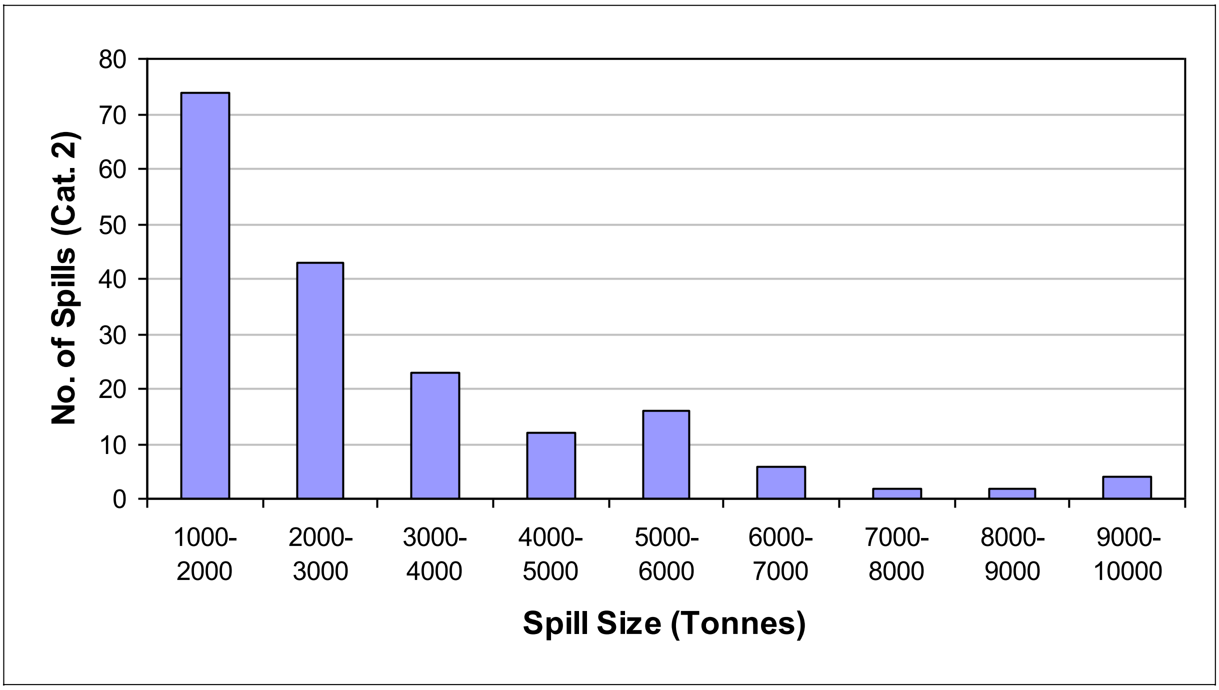


Figure 8.3 Spill Distribution within Size Category 2 (1,000-10,000 Tonnes)

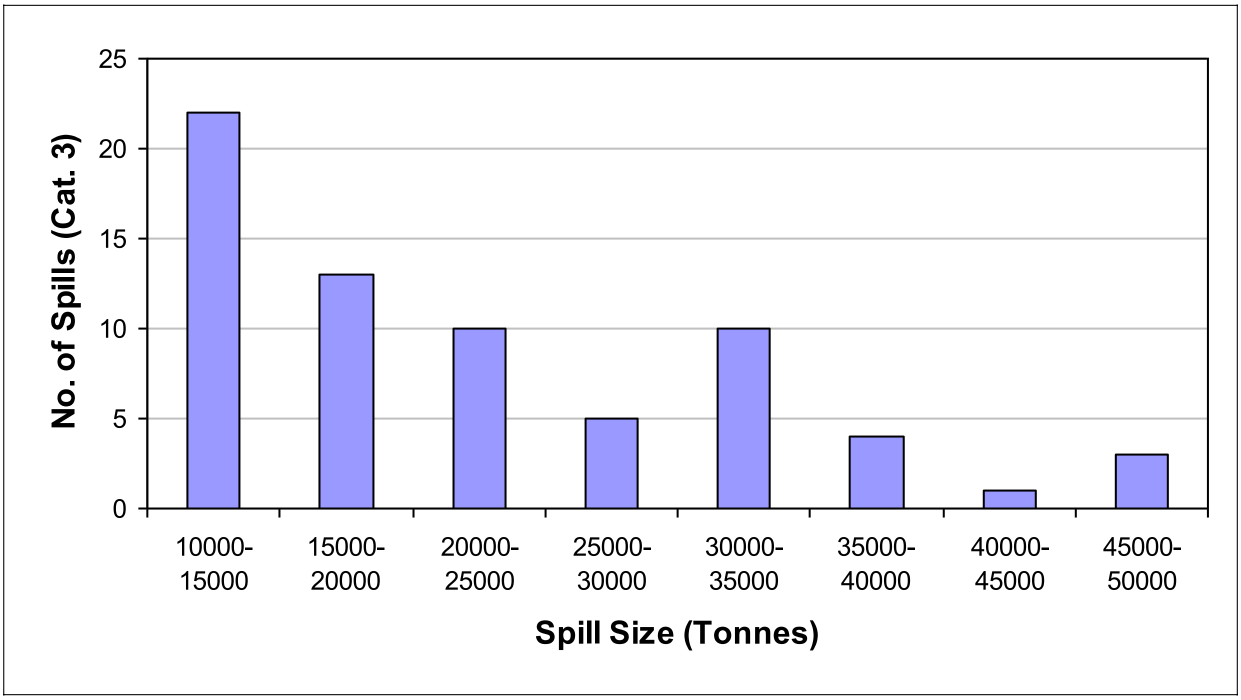


Figure 8.4 Spill Distribution within Size Category 3 (10,0000-50,000 Tonnes)

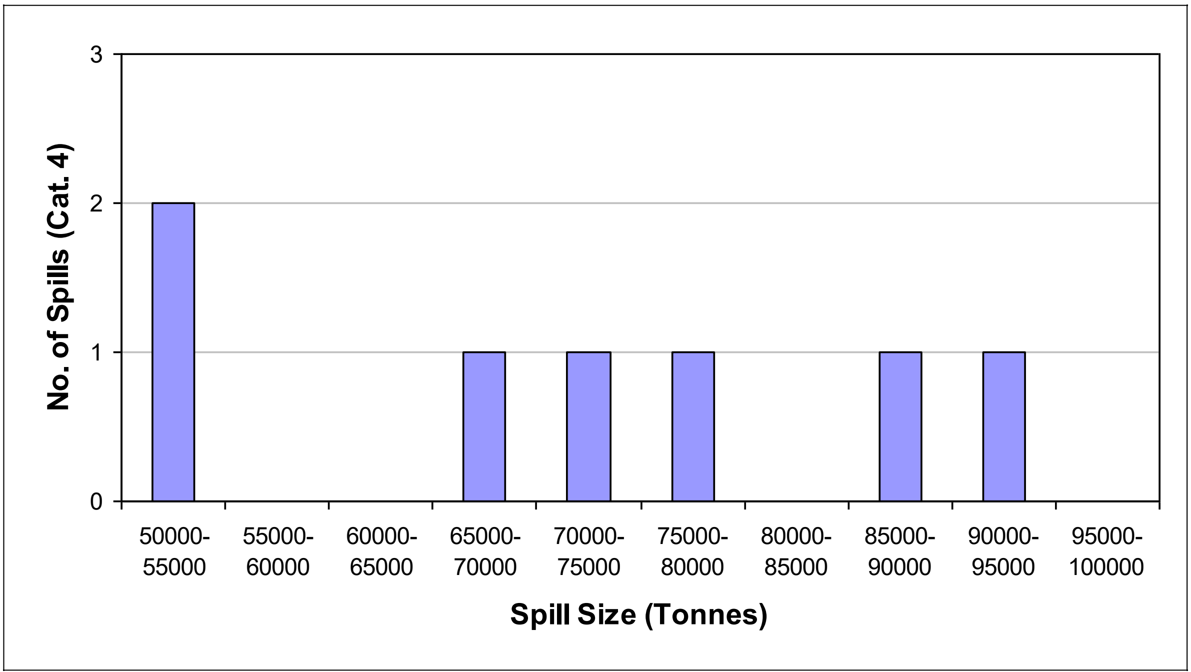


Figure 8.5 Spill Distribution within Size Category 4 (50,000-100,000 Tonnes)

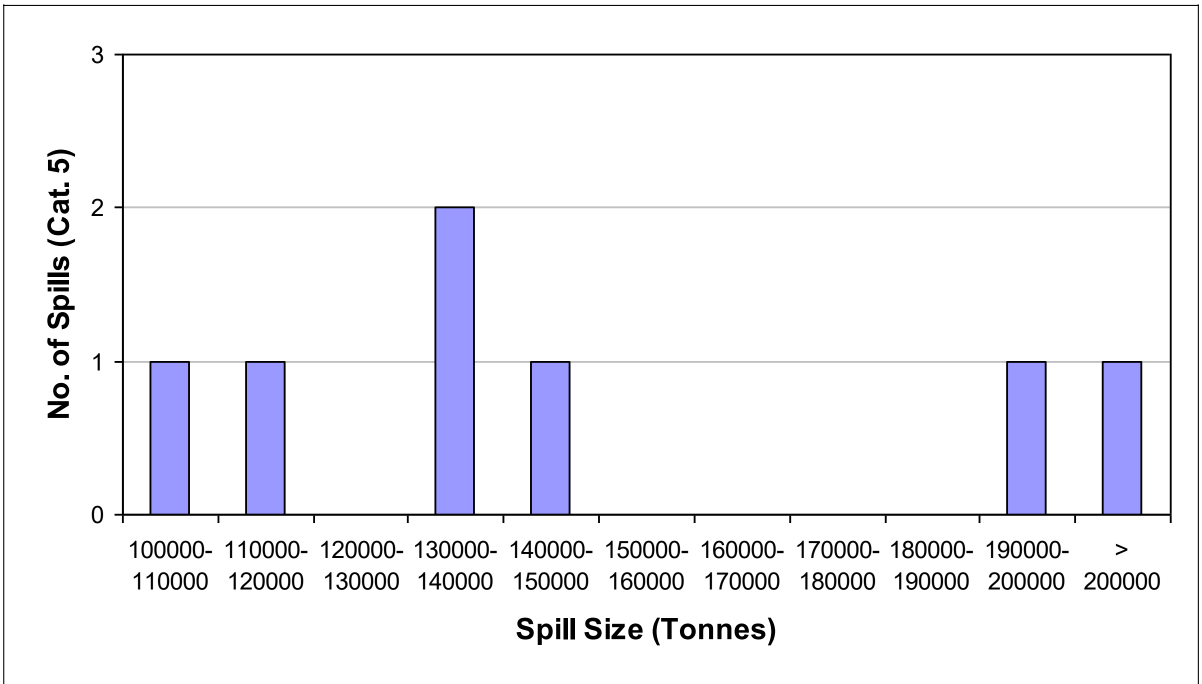


Figure 8.6 Spill Distribution within Size Category 5 (> 100,000 Tonnes)

This historical spill data was used to estimate the average size of spill within categories 2 to 5. However, as can be seen from Figure 8.2, only spills over 136 tonnes (1,000 barrels) are included in the database. Therefore, the average spill size in category 1 was estimated using data from ITOPF on the frequency of smaller spills (< 7 tonnes and 7-700 tonnes).

The estimates are presented in Table 8.9.

Table 8.9 Average Spill Amount for each Spill Size Category

Spill Size Category	Range (Tonnes)	Average Spill (Tonnes)
1	0 - 1,000	170
2	1,000 - 10,000	3,000
3	10,000 - 50,000	25,000
4	50,000 - 100,000	75,000
5	> 100,000	150,000

8.5 Calibration of Results using ACOPS

In addition to calibrating the results against shipping accident data and oil spill data from ITOPF/Worldwide Tanker Spill Database, a final calibration exercise was conducted using ACOPS data of oil spills in UK Waters from 1989 to 1998 (Ref. Appendix 3). This data does not contain comprehensive information on accident cause or ship size, but can be used to calibrate the average frequency and size of spills.

8.5.1 Spill Frequency

The annual frequency of spills of each size category within UK waters predicted by the model and reported by ACOPS was compared, as shown in Table 8.10.

Table 8.10 Frequency of Oil Spills in UK Waters (Model versus ACOPS)

Size Category	No. of Spills Per Year	
(Tonnes)	Model	ACOPS (1)
< 1,000	9.82	10.40
1,000 – 10,000	0.46	0.10
10,000 – 50,000	0.07	0
50,000 – 100,000	0.06	0.20
> 100,000	0.03	0

(1) Spills between 1989 and 1998 (inclusive) excluding spills at port and from fishing vessels.

It can be seen that there is good agreement in the frequency of smaller spills (<1,000 tonnes). For larger spills (>1,000 tonnes), there were only 3 reported incidents over the 10 years, however, the model predictions are considered to be of the correct order of magnitude.

8.5.2 Average Spill Size

The average spill size predicted by the model was compared with the historical data from ACOPS, as presented in Table 8.11.

Table 8.11 Average Size of Oil Spills in UK Waters (Model versus ACOPS)

Size Category (Tonnes)	Average Spill Size (Tonnes)	
	Model	ACOPS
< 1,000	170	21
1,000 – 10,000	3,000	1,073
10,000 – 50,000	30,000	0
50,000 – 100,000	75,000	79,124
> 100,000	150,000	0

It can be seen that for spills in size category 1, ACOPS indicates an average spillage of 21 tonnes (based on 104 incidents), compared to 170 tonnes predicted by the model. This overestimation by the model is considered to result from the lack of precise data on oil spills of less than 136 tonnes. It is therefore considered appropriate to modify the average spill size for category 1 spills in the model to 25 tonnes, to more closely match ACOPS.

Overall, the average amount of oil spilled in UK waters per annum reported by ACOPS data and predicted by the model is presented in Table 8.12.

Table 8.12 Comparison of Annual Oil Spill Amount in UK Waters

Source	Average Annual Oil Spilled (Tonnes)
Model (Uncalibrated) [1]	14,200
Model (Calibrated) [2]	12,500
ACOPS	16,200

(1) Assuming average spill size in Category 1 of 170 tonnes.
(2) Assuming average spill size in Category 1 of 25 tonnes.

Therefore, the calibrated model underestimates the average quantity of oil spilled from marine accidents per annum within UK waters by 20% compared to the ACOPS data for 1989-1998. However, this is mainly due to two large spills during this period from Braer (84,000 tonnes in 1993) and Sea Empress (72,000 tonnes in 1996). These two large spills dominate the ACOPS figure, hence, it is considered that the model predictions are a reasonable estimate.

8.5.3 Geographical Spill Distribution

Finally, the geographical distribution of spills predicted by the model was visually compared with a plot of the ACOPS data on historical spill locations. The two figures are presented below:

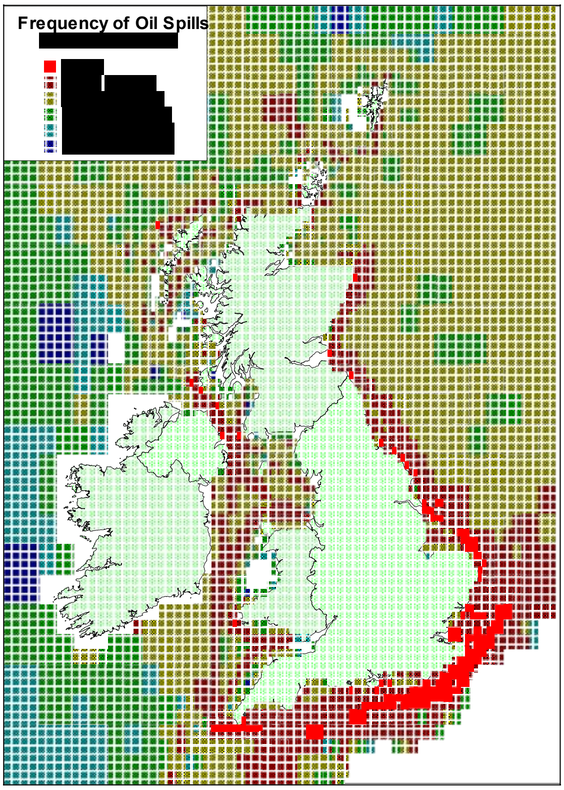


Figure 8.7 Plot of Cells Ranked by Predicted Total Oil Spill Amount Per Annum

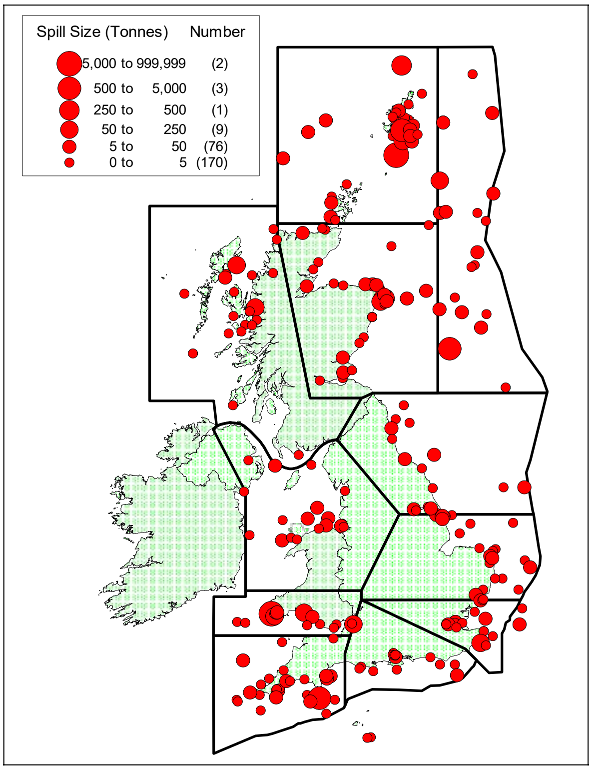


Figure 8.8 Plot of the Reported Oil Spills within UK Waters (ACOPS, 1989 – 1998)

It can be seen that historically the highest density of spills have occurred in the English Channel, The Wash and Humber Estuary, Liverpool Bay and Shetland Islands. The model predictions compare well with the ACOPS plot, although spills in the waters to the South of the Shetland Islands are underestimated.

Overall, it is considered that the model provides a reasonable representation of the historical geographical distribution of oil spills.

9 REFERENCES

1 "COST 301 Shore-Based Marine Navigation Aid Systems", Fabre et al., Report No.: EUR 11304 EN, 1988.

2 "The Estimation of Collision Risk For Marine Traffic In UK Waters", Lewison, Journal of Navigation, Vol. 33, No. 3, 1980.

3 "A Guide To The Collision Avoidance Rules", Cockcroft and Lameijer, ISBN 0 540 07272 9, 1976.

4 "The International Regulations For Preventing Collisions At Sea 1972 – with amendments from November 1989", The Trustees of the Rivers Wye and Lugg Navigation.

5 "The Probability of Vessel Collisions – a note on encounters between ships, ground and offshore structure", Macduff, Ocean Industry, 1974.

6 Disabled Tankers – Report of Studies on Ship Drift & Towage; Oil Companies International Marine Forum, 1983, Reprinted 1993.

7 UK Coastguard Agency - Risk Analysis of Spills of Bunker Fuel Oils, Refined Products and Vegetable Oils in UK Waters, Lloyd's Register.

8 ITOPF (The International Tanker Owners Pollution Federation Limited), Database of Oil Spills from Tankers, Combined Carriers and Barges, 1974-1998.

9 United States Mineral Management Service, Worldwide Tanker Spill Database, 1974 to June 15, 1990.

APPENDIX 7

ENVIRONMENTAL (WEATHER) DATA

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1 ENVIRONMENTAL DATA

This appendix presents a summary of the different environmental data, which has been applied in the assessment of the risks associated with shipping in UK waters.

1.1 Probability of Different Seastates in UK Waters

This weather influence was taken into account in the determination of shipping incident frequencies based on the assumption that bad weather equated to severe sea state conditions. The following figure presents the variations in sea states utilised in the assessment.

Table 1.1 Probability of Different Seastates in UK Waters (Ref. 1)

Seastate Code	Calm Beaufort 0-3	Moderate Beaufort 4-7	Severe Beaufort 8-12
1	0.12	0.78	0.1
2	0.22	0.78	0
3	0.12	0.88	0
4	0.17	0.83	0
5	0.25	0.75	0
6	0.5	0.5	0
7	0.16	0.81	0.03
8	0.17	0.73	0.1
9	0.1	0.8	0.1
10	0.09	0.73	0.18
11	0.1	0.65	0.25
12	0.12	0.7	0.18
13	0.25	0.65	0.1
14	0.62	0.38	0
15	0.75	0.25	0
16	0.37	0.63	0

The data presented in the above table is presented geographically in the following figure:

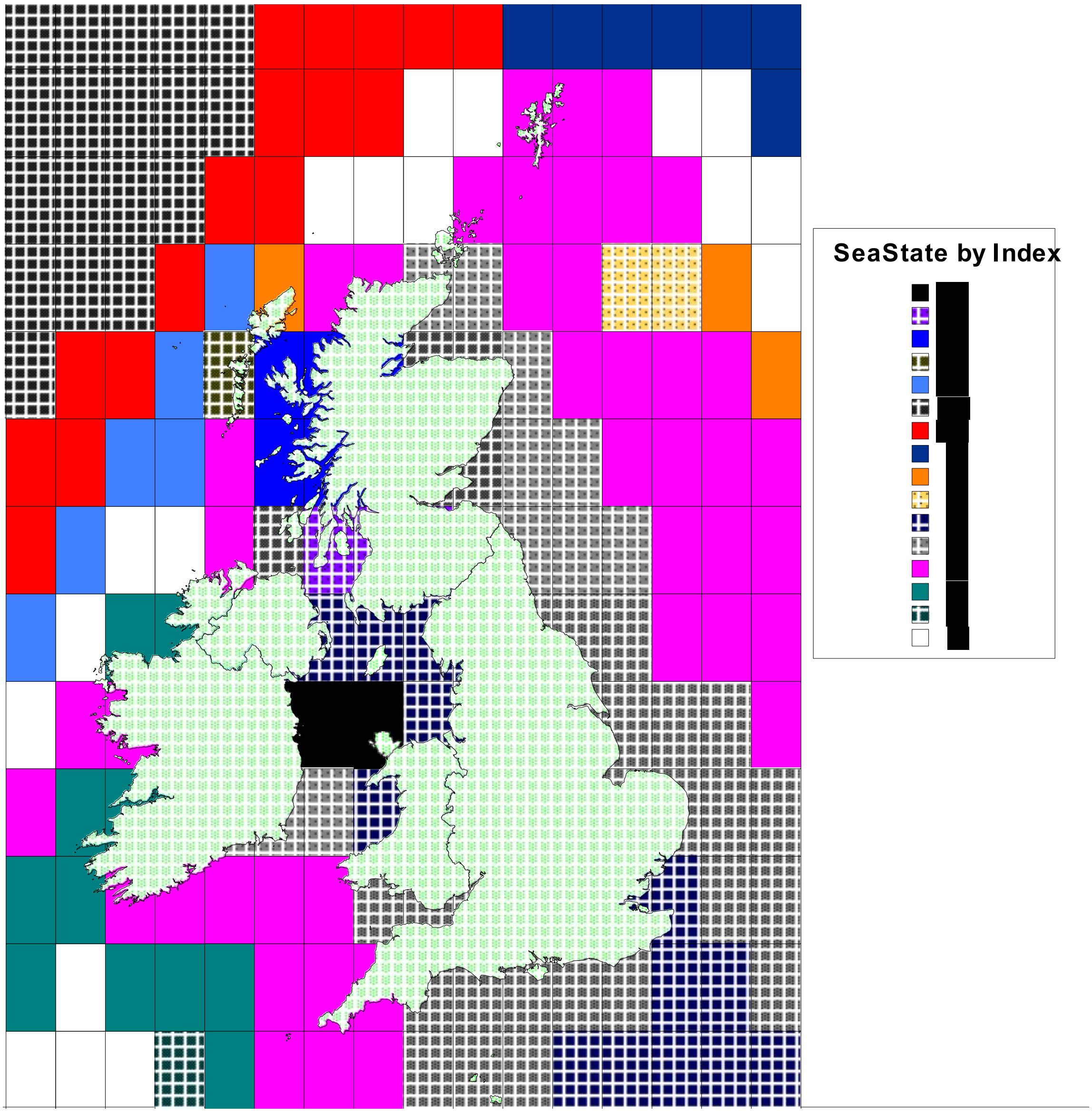

Figure 1.1 Index of Annual Average Seastate Conditions in UK Waters

1.2 Wind Rose Data

In the drifting grounding model as well as in the estimates made of the probabilities of spills at sea reaching the coastline, consideration requires to be given to the probability of a vessel drifting in different directions. The following table presents the percentage of time that the wind blows from different directions in different areas around the UK (Ref. 2)

Table 1.2 Probability of Wind Blowing From

Windrose	N0°	N30°	N60°	E90°	E120°	E150°	S180°	S210°	S240°	W270°	W300°	W330°
1 (Not Used)	0	0	0	0	0	0	0	0	0	0	0	0
2 (Culdrose)	0.07	0.07	0.09	0.08	0.03	0.04	0.06	0.12	0.15	0.13	0.08	0.08
3 (Plymouth)	0.05	0.04	0.08	0.13	0.05	0.04	0.05	0.14	0.13	0.11	0.09	0.09
4 (Hurn)	0.08	0.09	0.06	0.03	0.03	0.07	0.09	0.13	0.16	0.08	0.1	0.08
5 (Manston)	0.05	0.02	0.04	0.05	0.08	0.08	0.12	0.19	0.2	0.06	0.06	0.05
6 (Newcastle)	0.05	0.05	0.04	0.04	0.06	0.05	0.12	0.12				

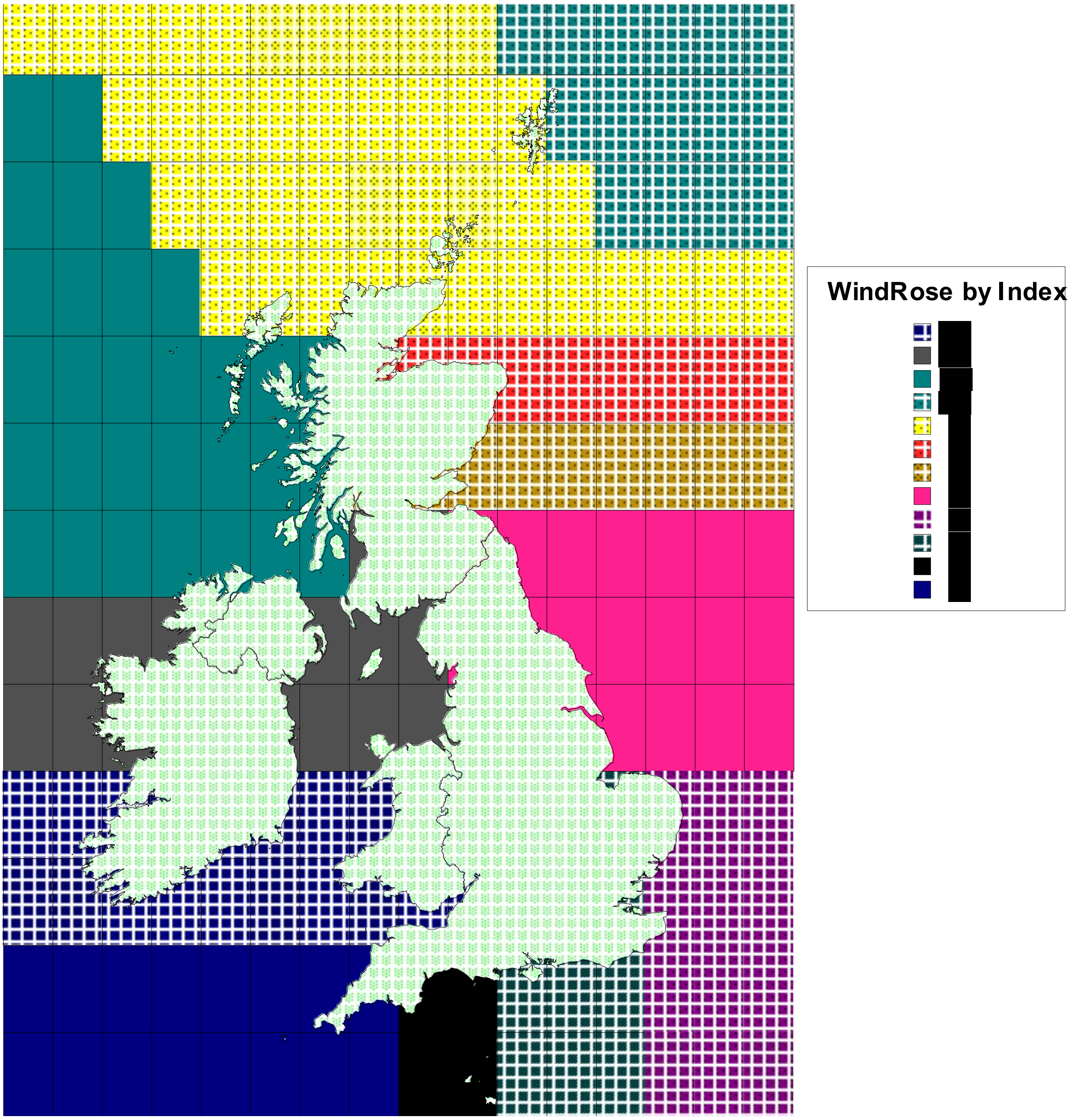

Figure 1.2 Wind Rose Index for UK Waters

1.3 Bad Visibility

One of the factors which has been identified as having an effect on the likelihood of a shipping incident taking place is bad visibility (see Appendix 2). This factor has been considered in the risk modelling. The following figure presents the different probabilities of having dense fog in different areas around the UK (Ref. 3).

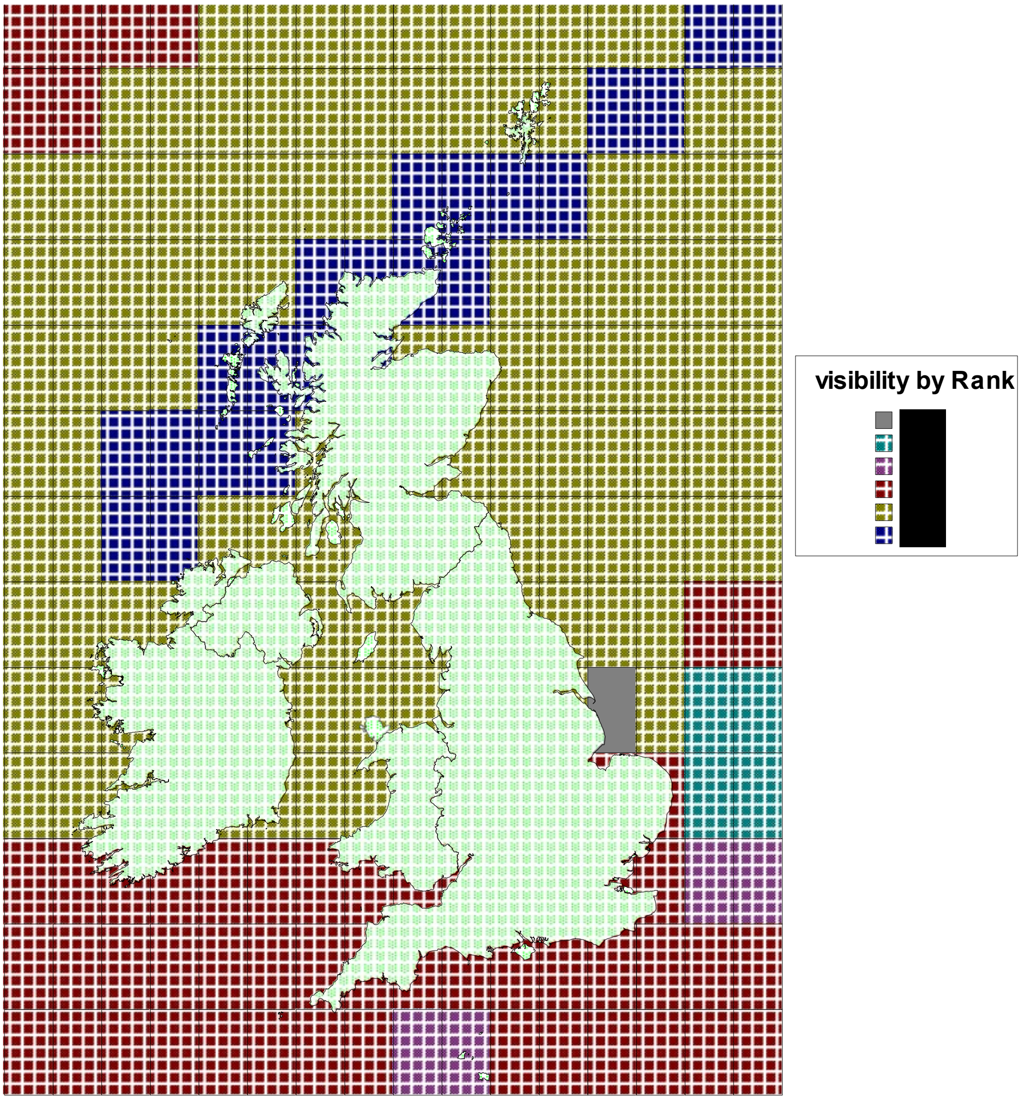

Figure 1.3 Probability of Dense Fog in UK Waters

2 REFERENCES

1 Lloyds(1994): Lloyd's Nautical Year Book 1995", Lloyd's of London Press, 1994.

2 DoE(1992): "The UK Environment", Ed Brown, A, HMSO, 1992.

3 Technica (1991); CRASH PC Program User's Manual

APPENDIX 8

SHIPPING INCIDENT FREQUENCY RESULTS

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1 SHIPPING INCIDENT FREQUENCY RESULTS

This appendix presents a summary of the different shipping incident frequency results, which have been generated during the course of this project. Presented in this appendix are the geographical distribution of different types of incidents determined from predictive modelling. Also presented are graphical comparisons between the model predictions and historical data.

1.1 Geographical Distribution of Different Types of Marine Accidents

The following figures present the geographical distributions of different types of marine accidents. Plots are presented for all types of vessels as well as for tankers only.

1.1.1 Ship to Ship Collisions

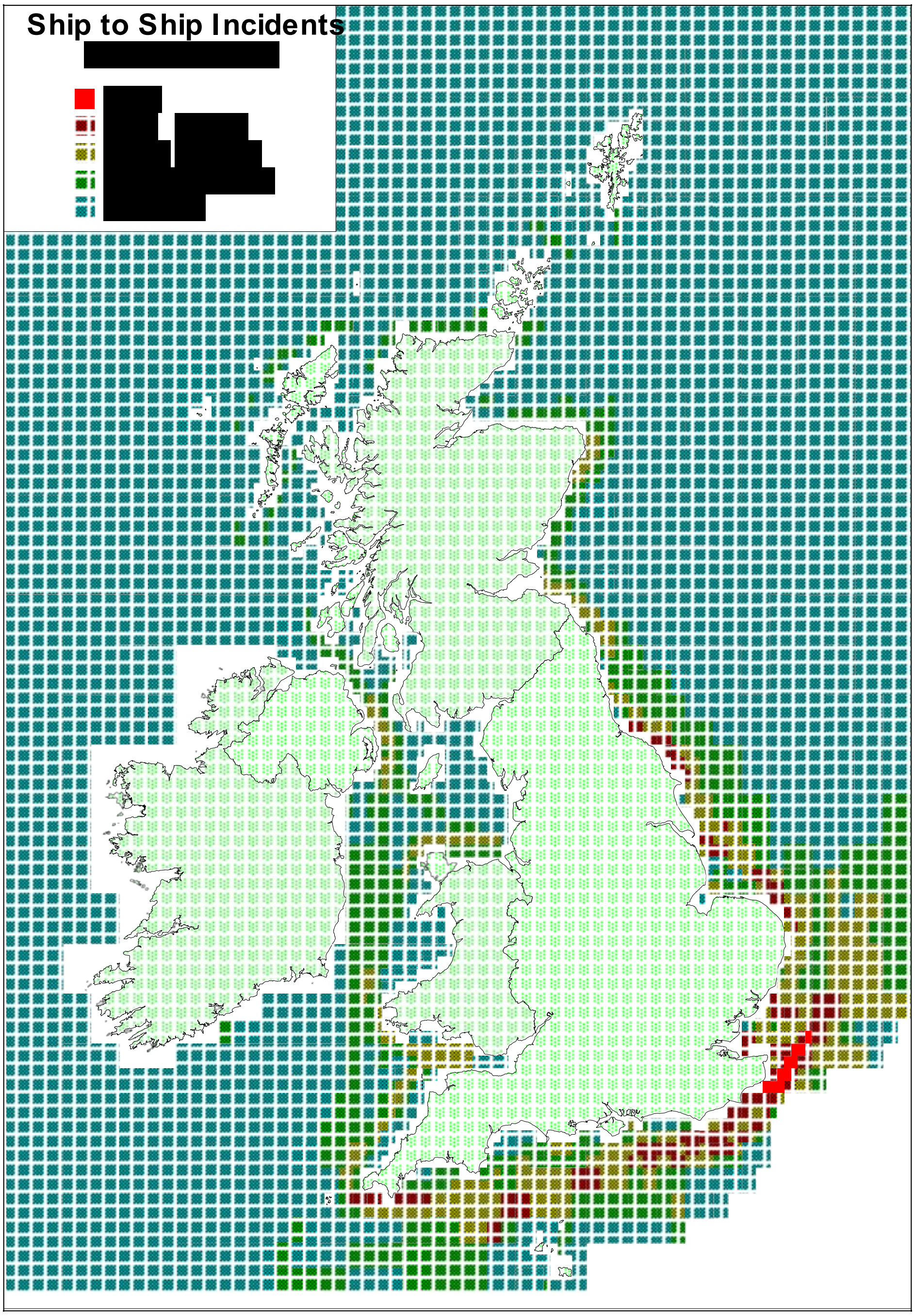

Figure 1.1 Geographical Distribution of Ship to Ship Collision Risks for All Vessel Types

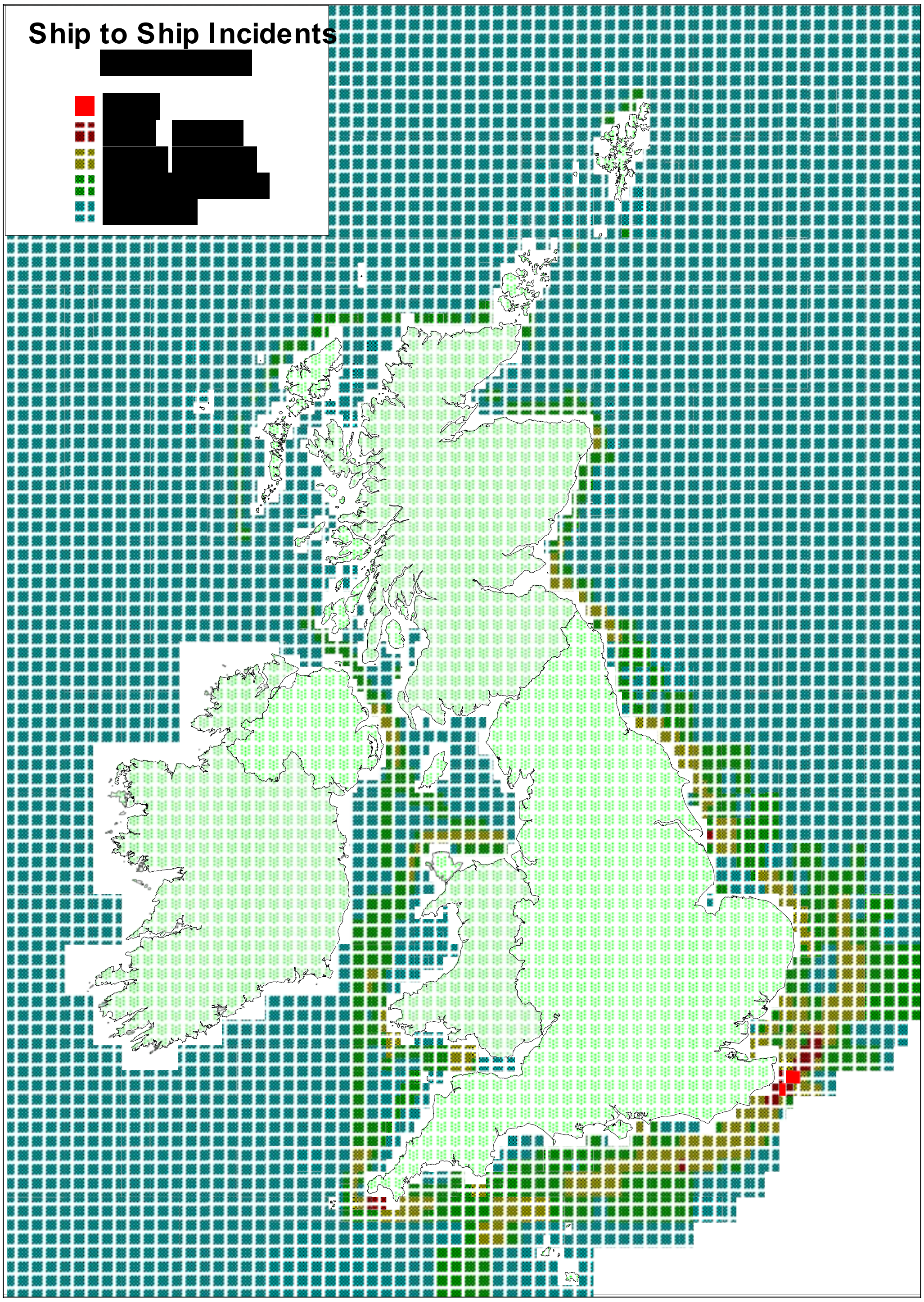

Figure 1.2 Geographical Distribution of Ship to Ship Collision Risks for All Tankers

1.1.2 Powered Grounding Incidents

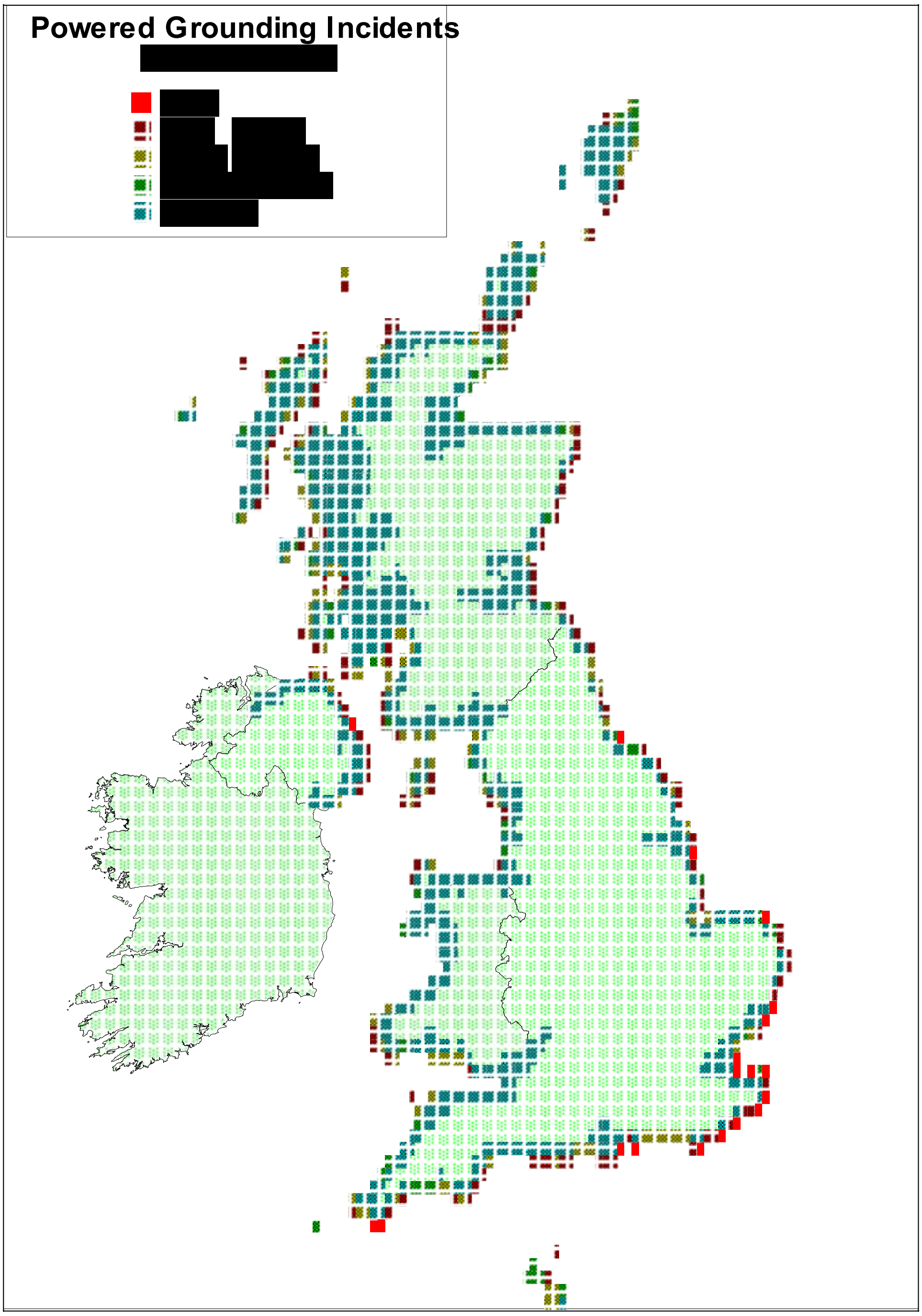

Figure 1.3 Geographical Distribution of Powered Grounding Risks for All Vessel Types

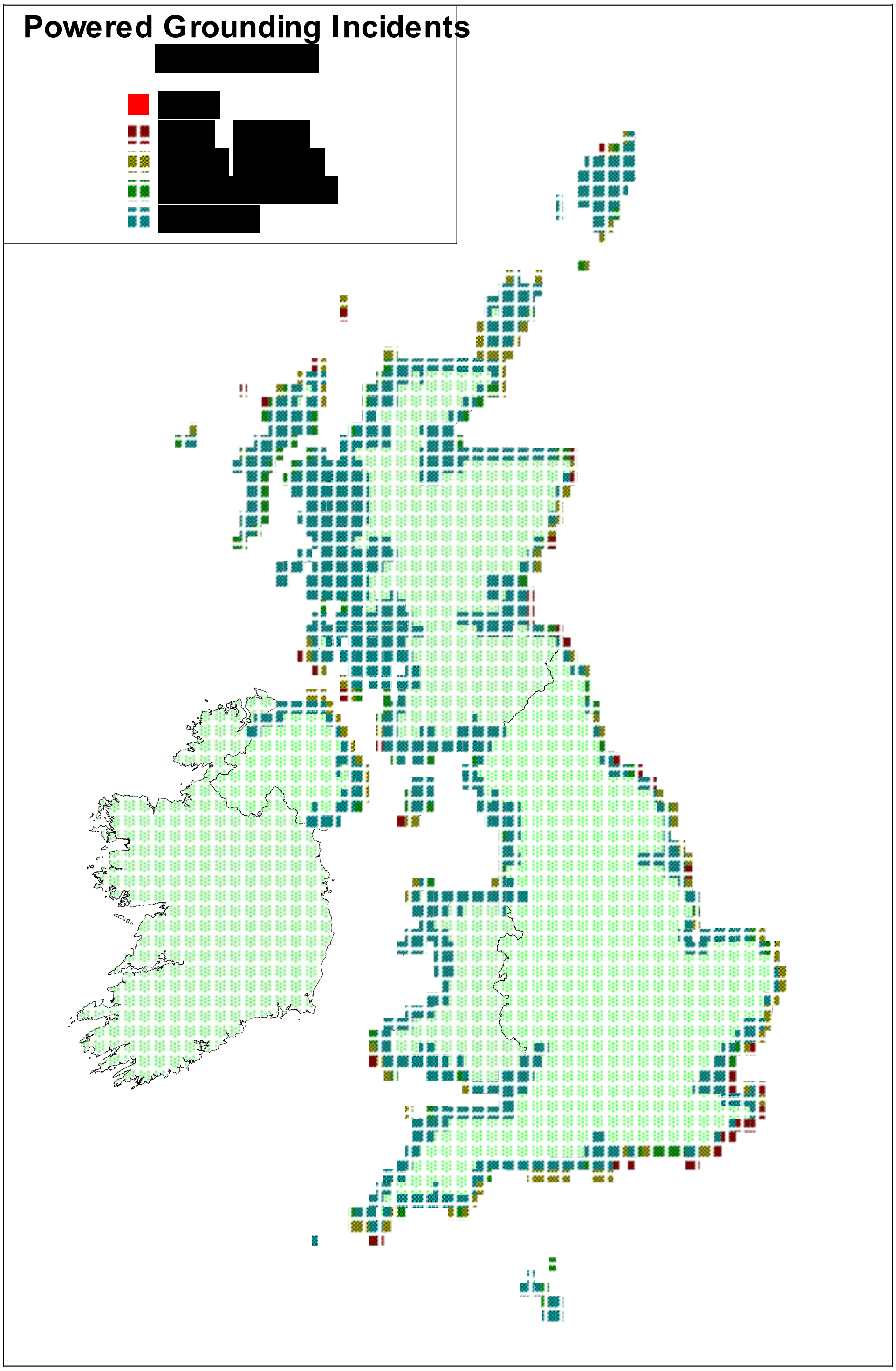

Figure 1.4 Geographical Distribution of Powered Grounding Risks for All Tankers

1.1.3 Drifting Grounding Incidents

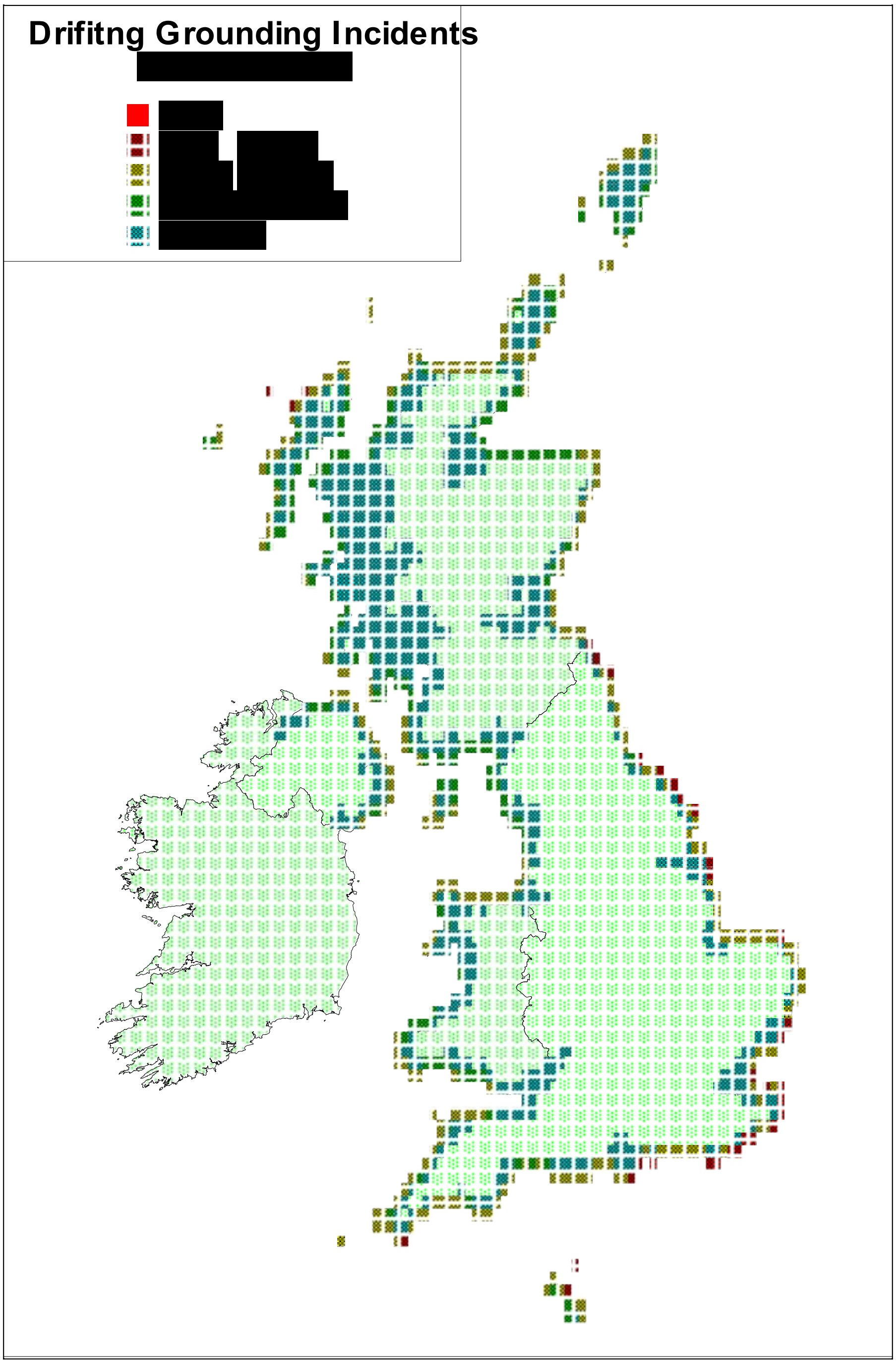

Figure 1.5 Geographical Distribution of Drifting Grounding Risks for All Vessel Types

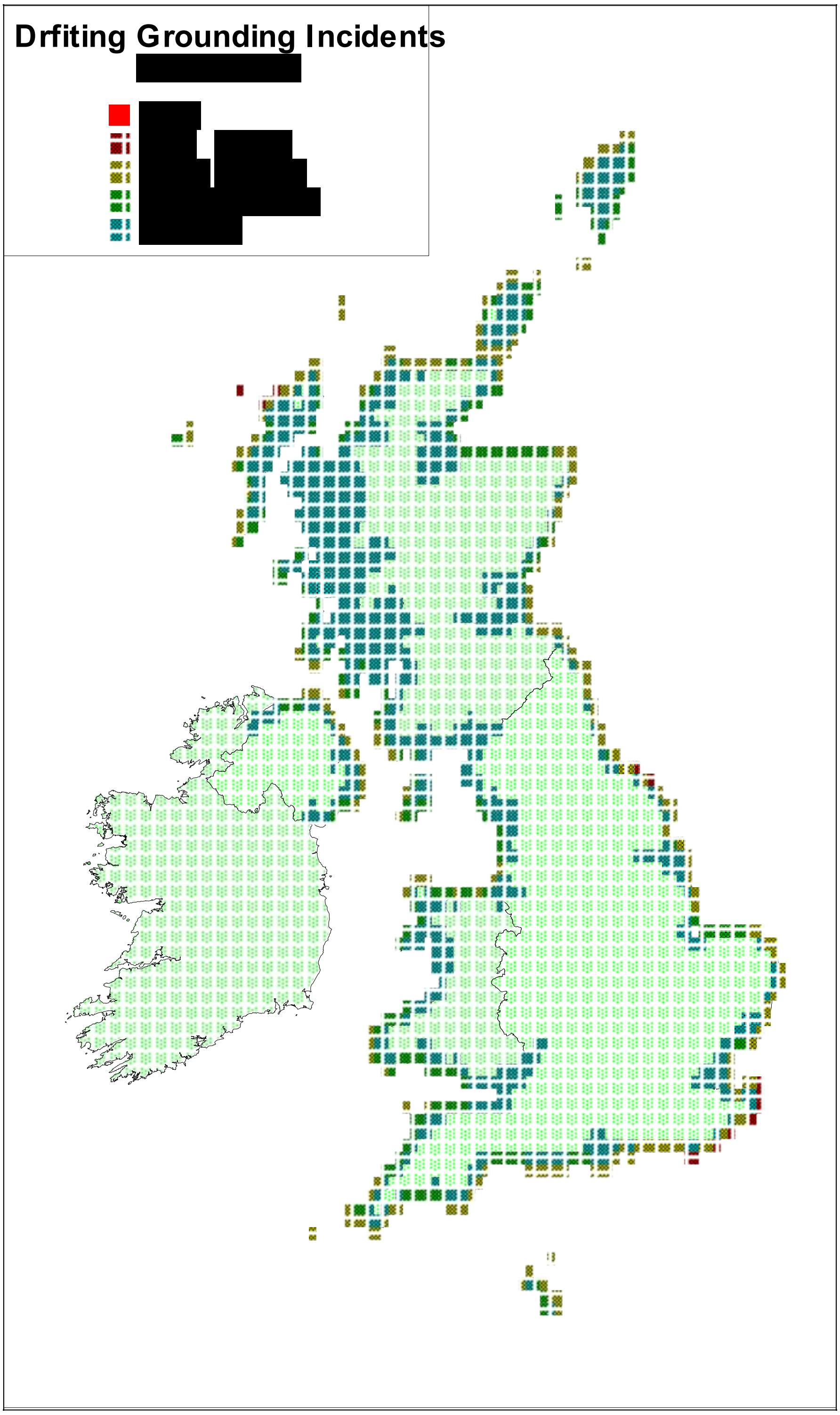

Figure 1.6 Geographical Distribution of Drifting Grounding Risks for All Tankers

1.1.4 Fire & Explosion Incidents

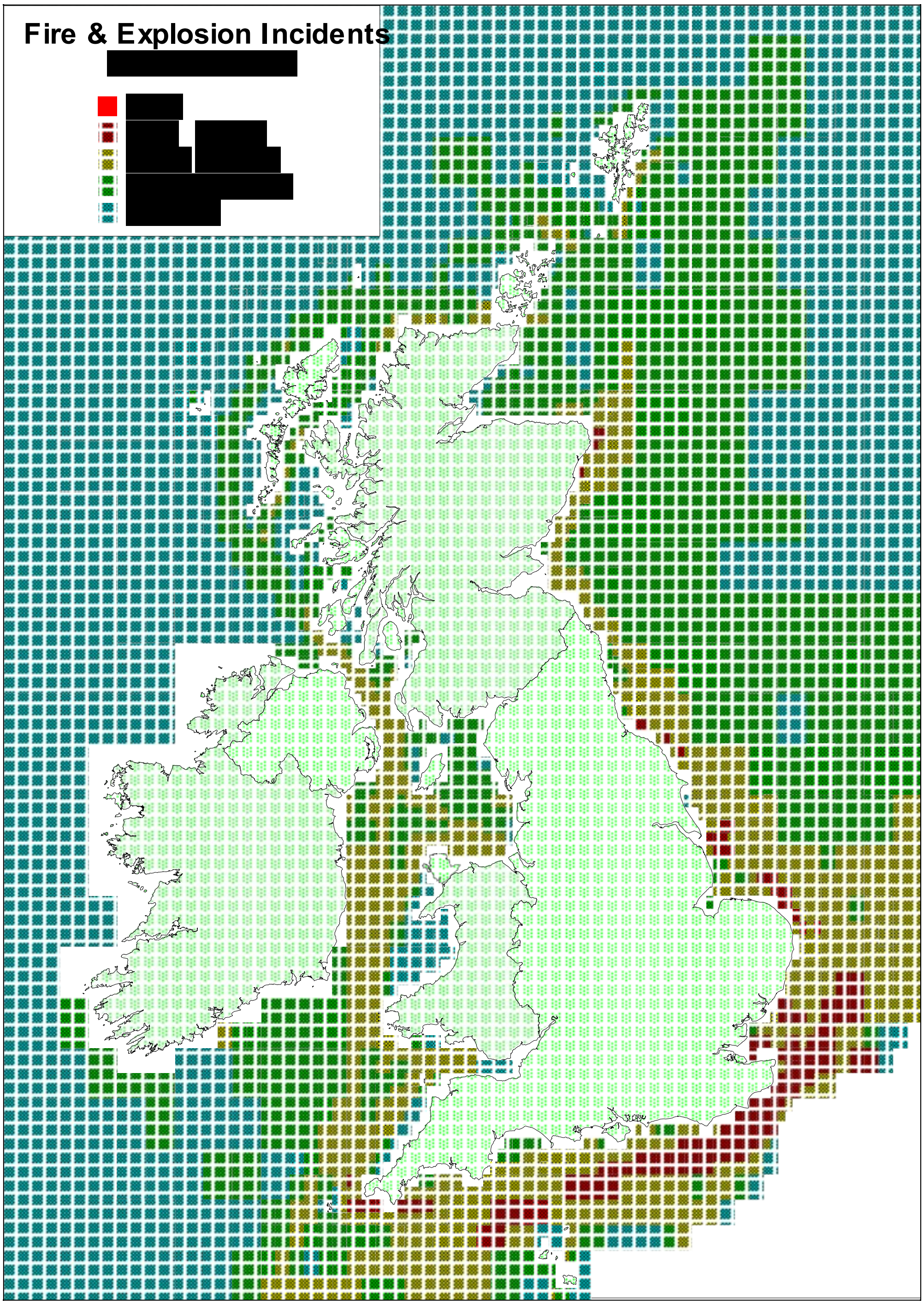

Figure 1.7 Geographical Distribution of Fire & Explosion Risks for Vessel Types

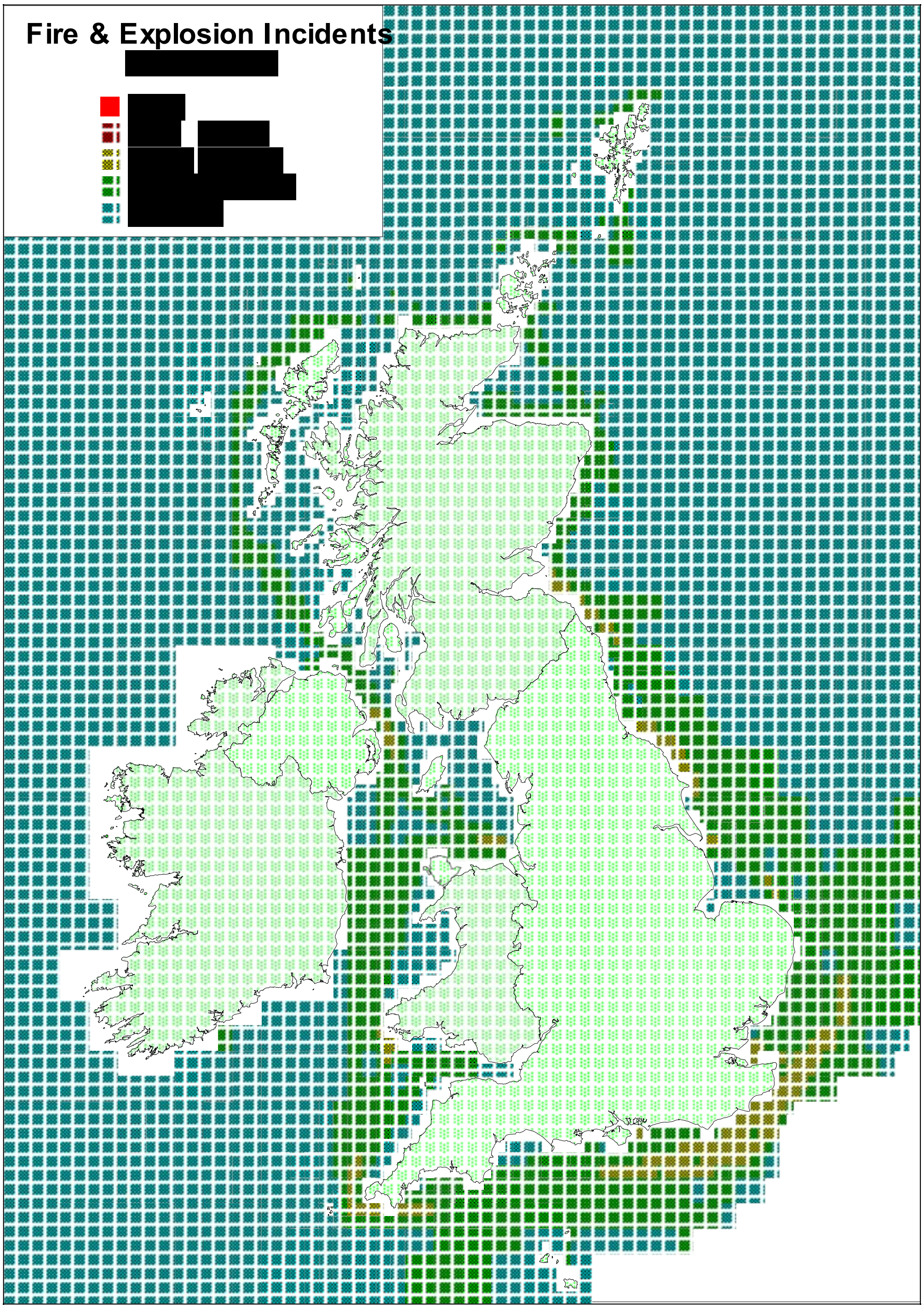

Figure 1.8 Geographical Distribution of Fire & Explosion Risks for All Tankers

1.1.5 Foundering Incidents

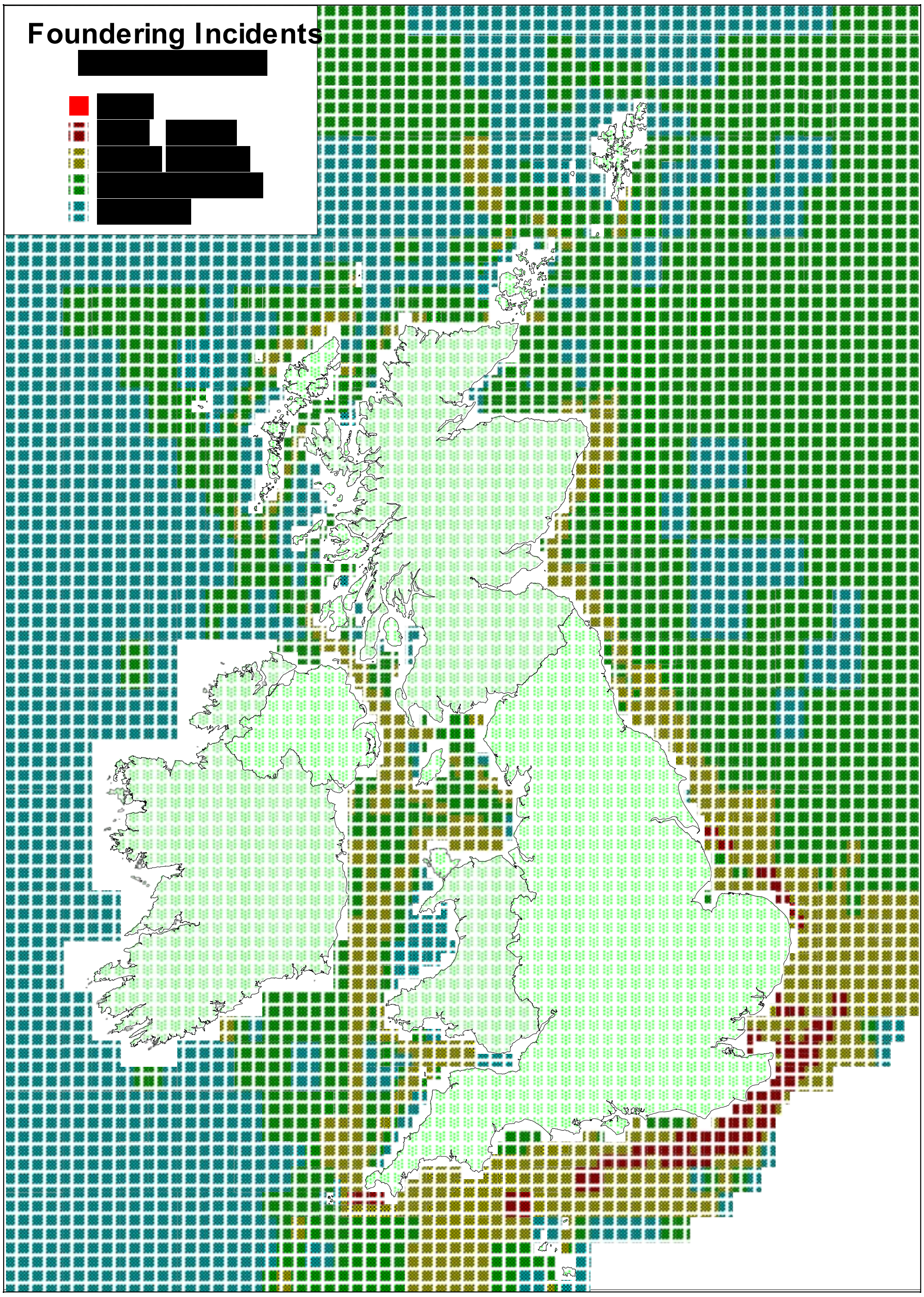

Figure 1.9 Geographical Distribution of Foundering Risks for Vessel Types

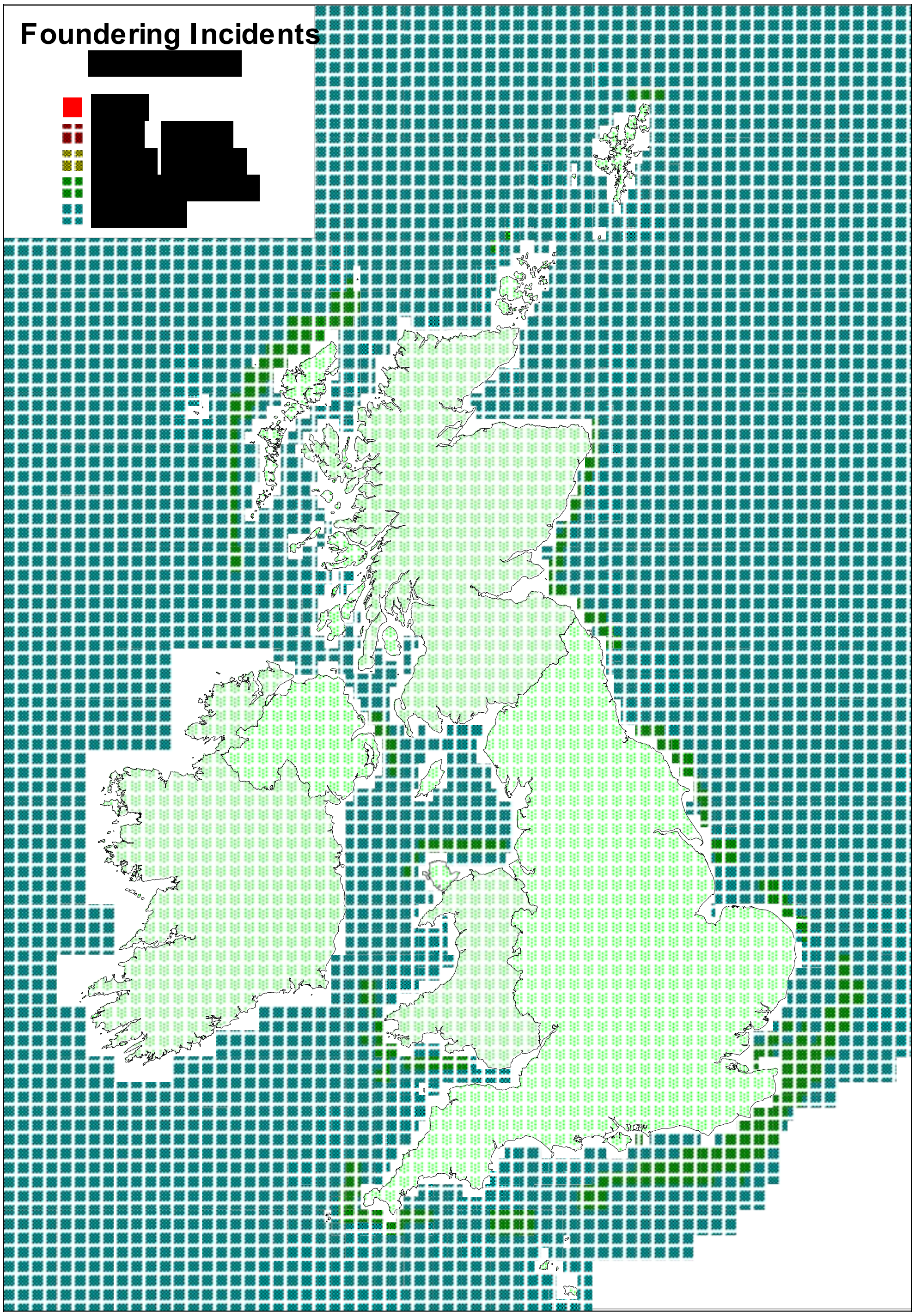

Figure 1.10 Geographical Distribution of Foundering Risks for All Tankers

1.2 Model Predictions vs Historical Data

This section presents a comparison of the model predictions versus historical data for different vessel types and sizes.

1.2.1 Drifting Grounding:

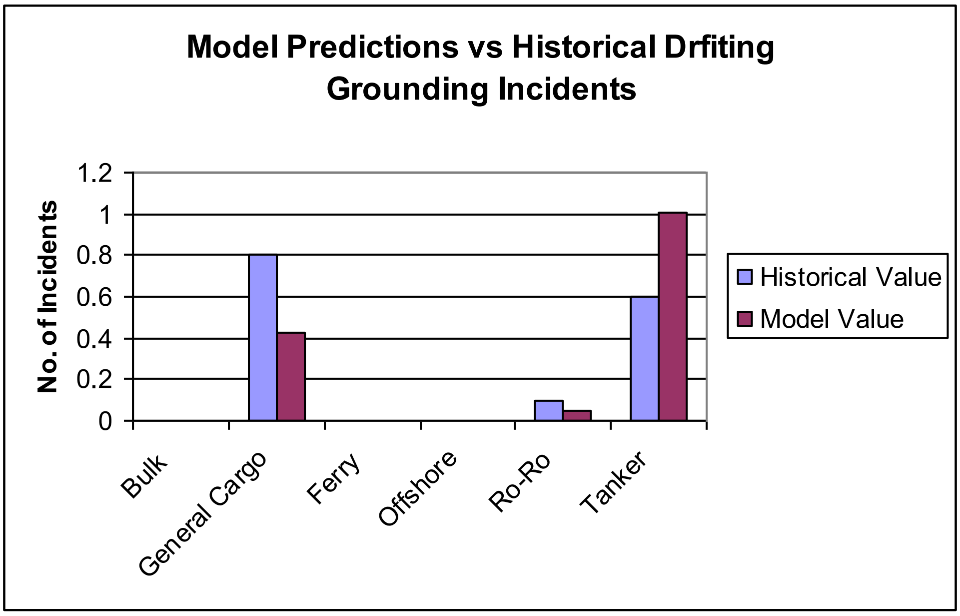

Figure 1.11 Model Predictions vs Historical Data for Drifting Grounding (Vessel Type)

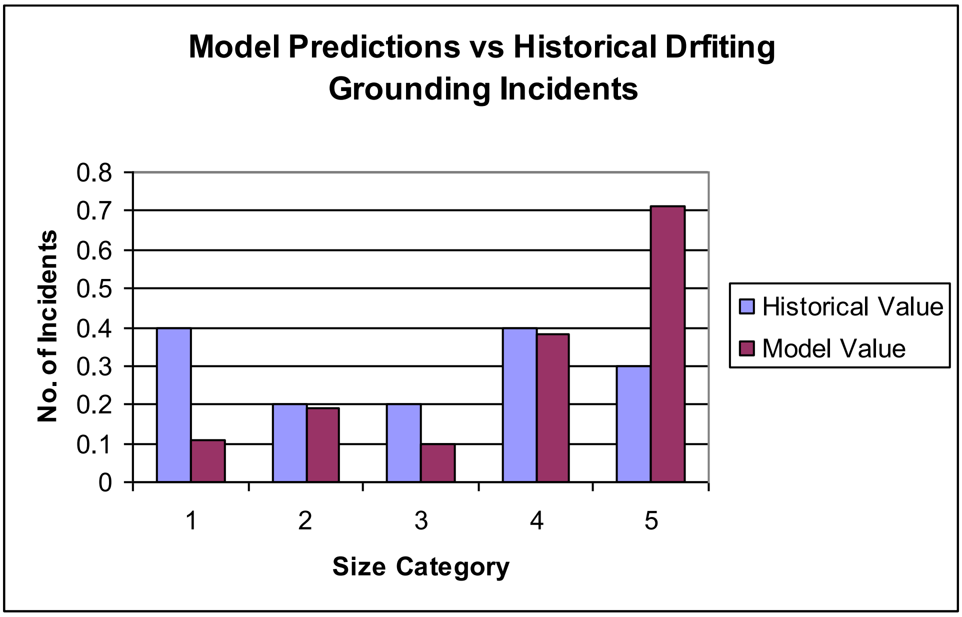

Figure 1.12 Model Predictions vs Historical Data for Drifting Grounding (Vessel Size)

1.2.2 Fire & Explosion

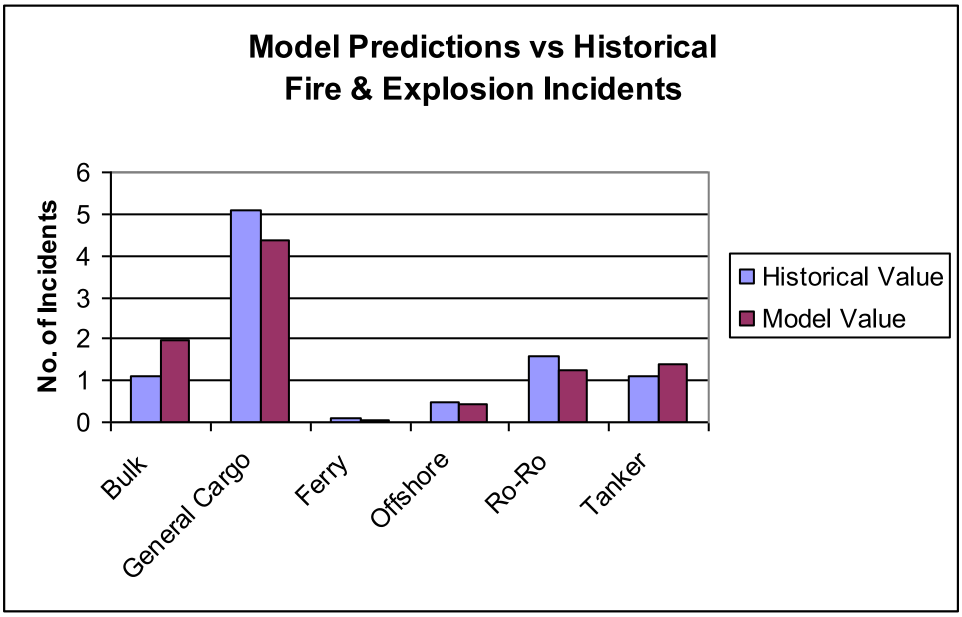

Figure 1.13 Model Predictions vs Historical Data for Fire & Explosion (Vessel Type)

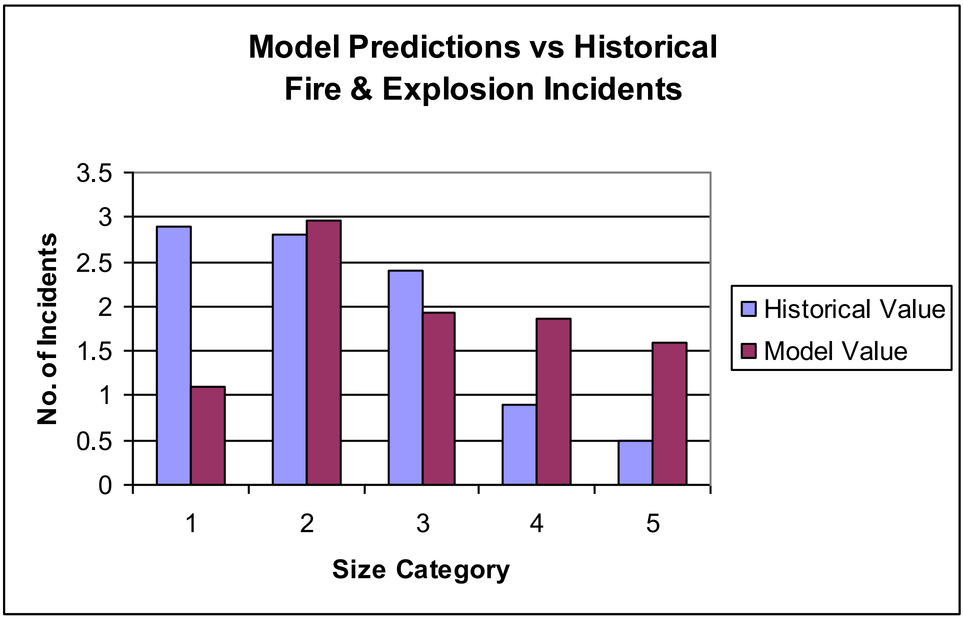

Figure 1.14 Model Predictions vs Historical Data for Fire & Explosion (Vessel Size)

1.2.3 Foundering

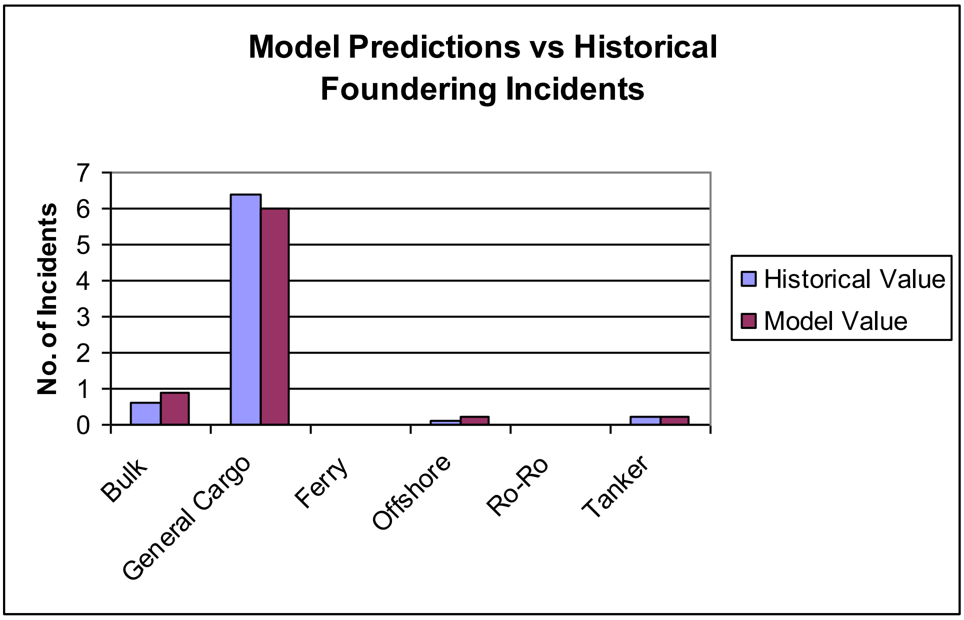

Figure 1.15 Model Predictions vs Historical Data for Foundering Incidents (Vessel Type)

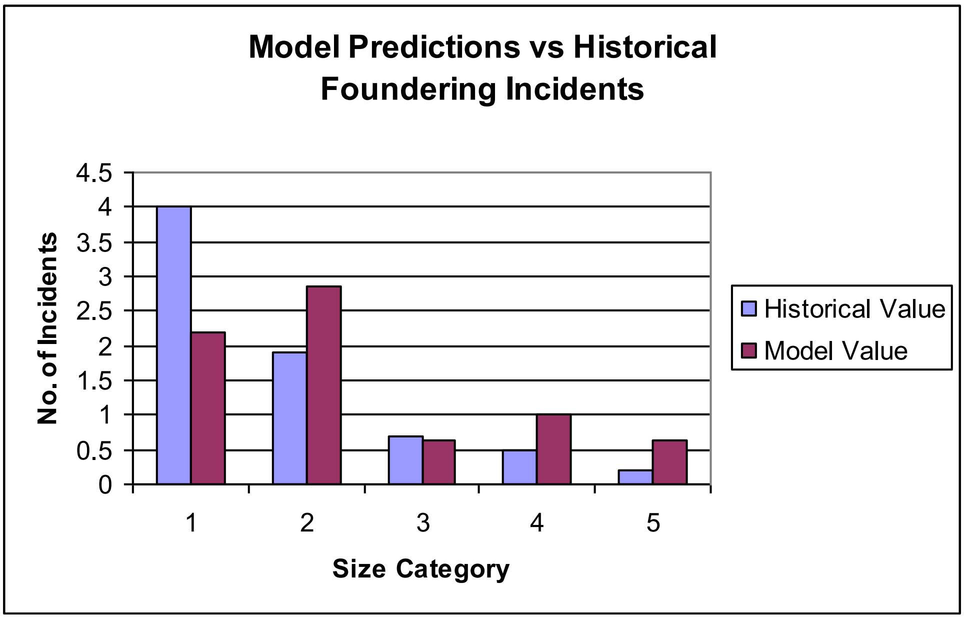

Figure 1.16 Model Predictions vs Historical Data for Foundering Incidents (Vessel Size)

1.2.4 Powered Grounding

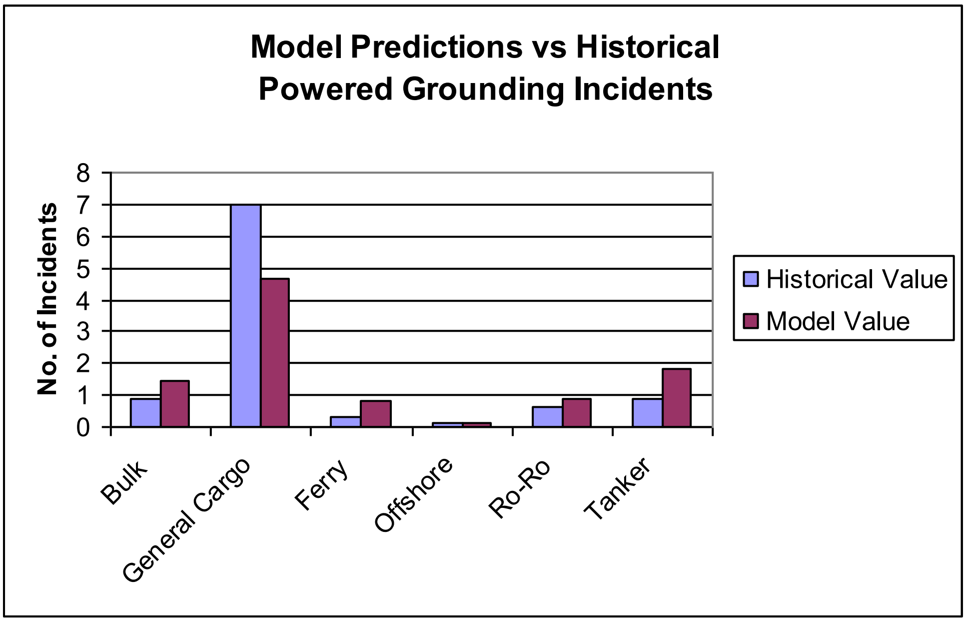

Figure 1.17 Model Predictions vs Historical Data for Powered Grounding Incidents (Vessel Type)

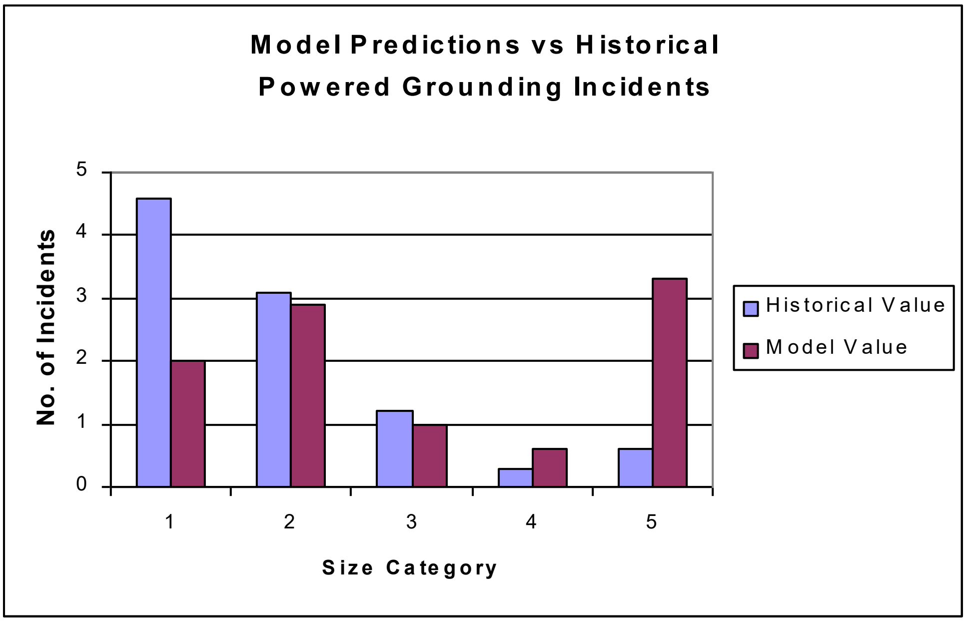

Figure 1.18 Model Predictions vs Historical Data for Powered Grounding Incidents (Vessel Size)

1.2.5 Ship to Ship Collision:

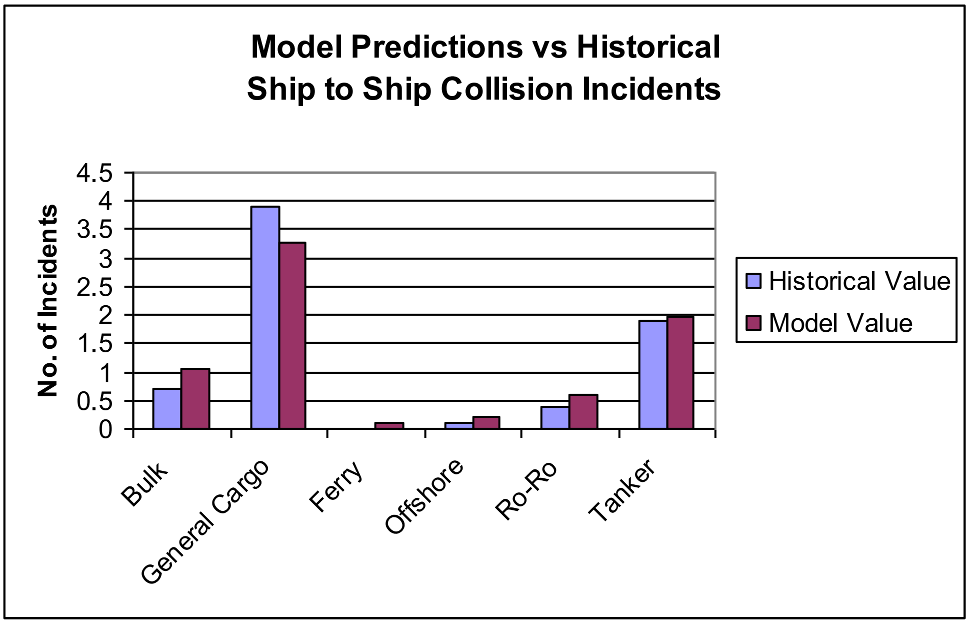

Figure 1.19 Model Predictions vs Historical Data for Ship to Ship Collision Incidents (Vessel Type)

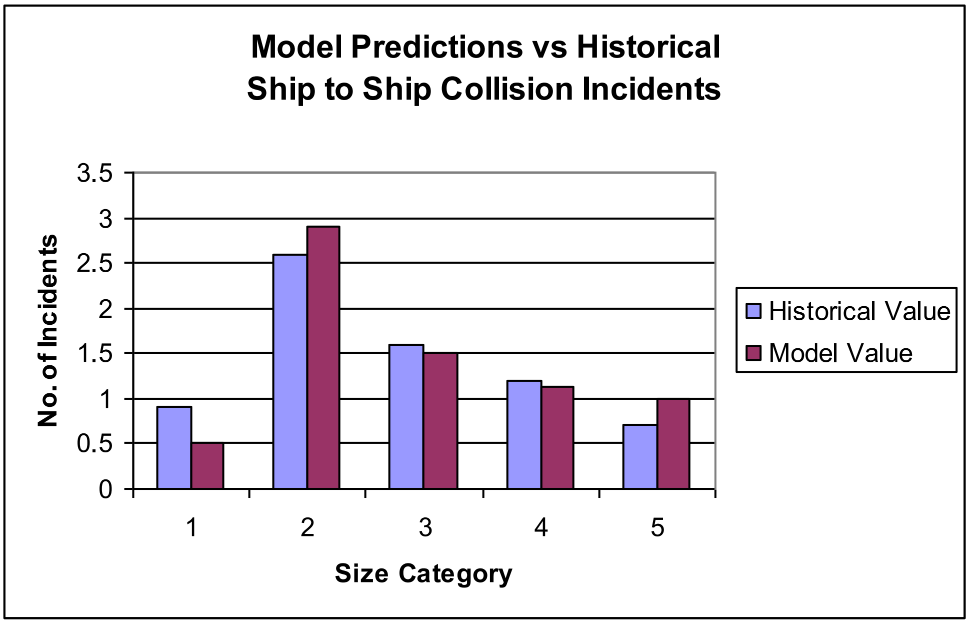

Figure 1.20 Model Predictions vs Historical Data for Ship to Ship Collision Incidents (Vessel Size)