Risk Impact from Shipping Traffic

Dr. A. Pillay (Manager Asia), T. Eriksen (Senior Safety Engineer), F. Vollen (Director)
Safetec Nordic AS,
Sluppenvegen 12E, 7037 Trondheim, Norway.

ABSTRACT

Shipping traffic is a major risk contributor to environmental high-risk areas offshore and around a coastline.

The Computer Assisted Shipping Traffic (COAST) database has been used around the world to determine the risk posed by shipping traffic to offshore and sub sea structures and the environment. This includes hazards like ship groundings, ship/ship collisions, ship foundering/structural failure, collisions between vessels and surface structures (e.g. offshore installations, fish farms and wind farms), and impacts to sub sea pipelines. The COAST database was developed by utilizing several sources of information together with several different types of data collection exercises. The collated information is then represented using a Geographical Information System (GIS) showing the routes and associated volumes for each route distributed by vessel type and size.

This paper presents the data collection methods, and highlights the available resources that can be utilized to populate such a shipping traffic database. The analysis and presentation of the raw data is also discussed. The different methods employed to validate the information that the COAST database carries are also presented.

The COAST database currently covers the United Kingdom Continental Shelf, Irish Waters, Norwegian Coast, parts of the Baltic Sea, Mediterranean Sea, the Netherlands, Faeroe Isles, Gulf of Mexico and the Singapore Straits. Coverage of the Barents Sea and parts of the Campos Basin in Brazil and the Gulf of Paria in Venezuela are presently being developed.

INTRODUCTION

Several serious oil spills have brought the world's attention to the damage that can result from oil spills.

A considerable contribution to this risk is related to shipping, and the increasing seaborne trade (see Figure 2) and a growing public interest in safety matters and environmental issues, focus on oil spills, oil spill consequences and oil spill prevention will become even bigger in the future.

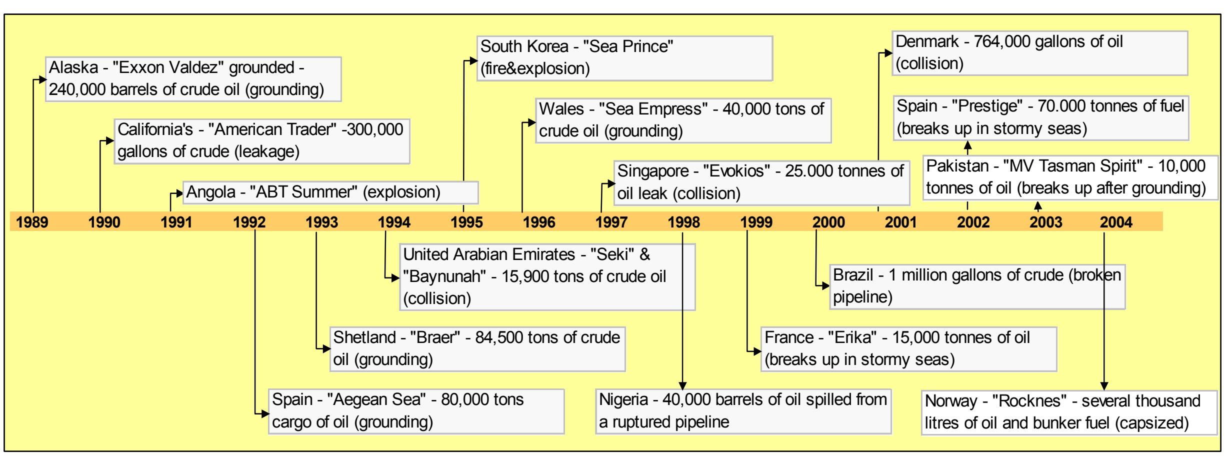

Figure 1 Some major oil spills, 1989-2004 (Ref. i)

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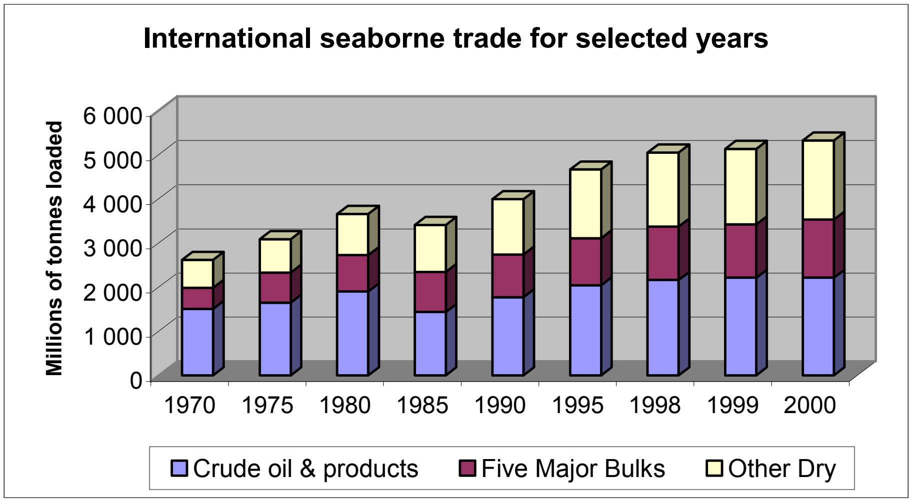


Figure 2 World wide Seaborne Trade for Selected Years (Ref. ii)

The purpose of all safety work is to prevent and control hazardous events in order to protect personnel, the environment and economical values. And in order to be able to protect personnel, the environment and economical values we have to know the risk exposure.

It is obvious that activities posing the greatest risks should get the most attention. But this demands objective assessments of risk – including assessment of the probability of an event occurring and of the magnitude of the consequences should the worst occur.

The objective of policy and management should be to achieve the greatest long-term benefit to society by making wise and consistent choices in the trade-offs between cost of proposed measures and estimated risk reducing effect.

Risk impact from shipping traffic has been increasingly used to assist different governmental bodies and organisation (e.g. harbours and offshore operators). Examples on projects include:

- Assessing the benefits of navigational aids
- Pollution risk assessment
- Establishing emergency response strategies
- Collision risk assessment
- Identifying coastal sites particularly sensitive to shipping
- Prioritising coastal surveys

This paper presents the data collection methods, and highlights the available resources that can be utilized to populate such a shipping traffic database. The analysis and presentation of the raw data is also discussed. The different methods employed to validate the information that the COAST database carries are also presented.

METHODOLOGY

In order to ensure a systematic, transparent and focused assessment of the environmental risks posed by shipping traffic, it is proposed to use a methodology based on Formal Safety Assessment (FSA), which has the following main stages:

- Description of intention
- Data Collection
- Hazard identification
- Frequency 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.

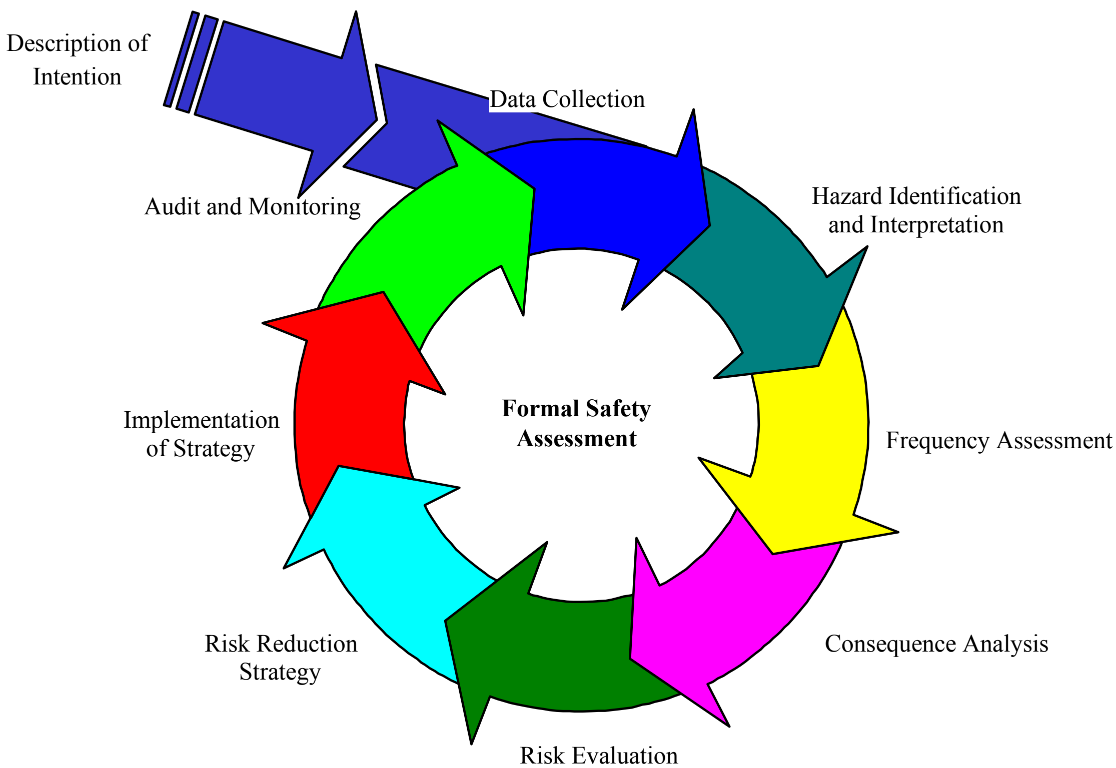


Figure 3 Formal Safety Assessment Approach Overview

The two main factors suggested for consideration when identifying the risk impact from shipping are:

- The risk of pollution from shipping related incidents; and
- The environmental sensitivity of offshore and coastal waters considered.

This paper will only be related to the assessment of frequency of shipping related incidents and will as such, when considering the above illustration, only be focusing on the first three stages: data collection, hazard identification and frequency assessment.

IDENTIFY SHIP ROUTING PATTERN

An important part of assessing the environmental risk related to shipping is to identify the routeing and volume of the shipping traffic in general, and in areas of special environmental importance in particular. The amount of shipping traffic, size, type, age, cargo, etc. is very dependant of location and could in some cases be very difficult to estimate. The waters around the UK coastline include e.g. 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.

There are considerable geographical differences in the range of threats and impact of marine pollutants, ecological balance and habitat change in different regions of the world. This concludes that the risk will not be proportional with the amount of shipping in the area.

An area of particular concern is the Barents Sea, and both the Norwegian authorities and EU, through the ARCOP project, are currently sponsoring projects assessing the risk of pollution to the sea posed by the shipping traffic in this environmentally and economically important area. One of the main concerns in this is the increasing traffic of large oil tankers from northwest Russia to the Continent and the USA.

An important tool to assess the ship routing pattern in an area have been the COAST database, which holds detailed information on shipping traffic in several sea areas of the world.

Computer assisted shipping traffic database (COAST)
COAST was initially developed for the UK continental Shelf (UKCS) with funding from the Health and Safety Executive, Department for Environment, Transport and the Regions and UK Offshore Operators Association. The database improved upon the reliability of existing traffic databases by utilizing a large number of data sources.

Today the coverage of the database has expanded to include;

- UK waters
- Irish waters
- Norwegian waters
- The Nederlands
- The Faroe Islands
- Baltic Sea
- Gulf of Mexico (pilot)
- Parts of the Mediterranean
- Straits of Hormuz
- Singapore Straits
- Nigeria (areas)
- Brazil (under development)

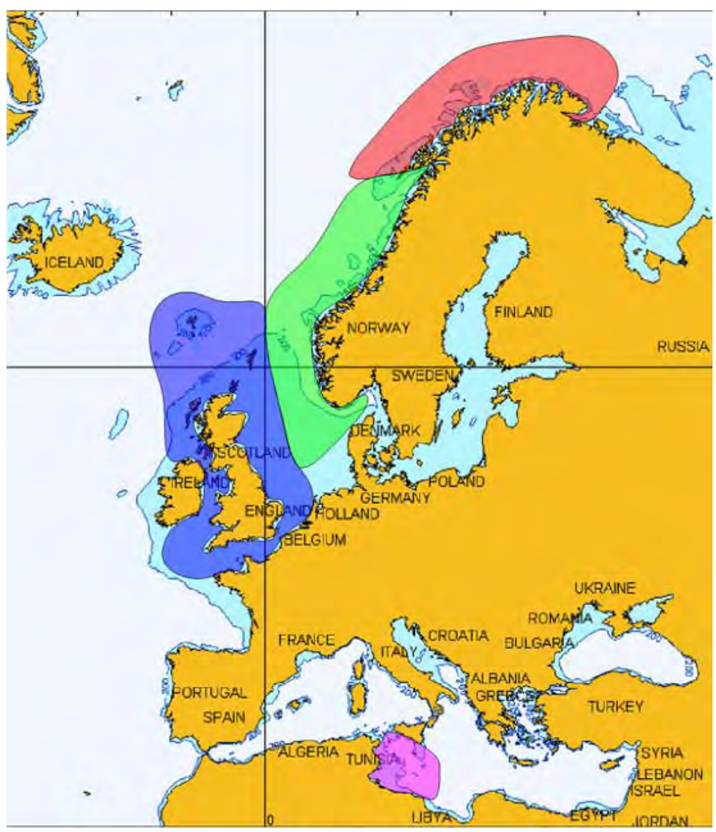


Figure 4 COAST coverage for selected areas (UK, Ireland, Norway and the Mediterranean)

The main data sources used when developing COAST included::

- Port data provided by LMIS (Lloyds Maritime Information Services)
- Offshore traffic surveys
- Shore based radar stations
- 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 utilized by traffic traversing the considered waters, the volumes of traffic and size distribution 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 number of experienced mariners for verification purposes. Following this, the data was input to a Windows based program that facilitates searches around user-defined positions. The program is also linked to a graphical output package that allows the identified routes to be automatically plotted on Admiralty Raster Charting Service (ARCS) hydrographic charts. The whole process is illustrated in Figure 5.

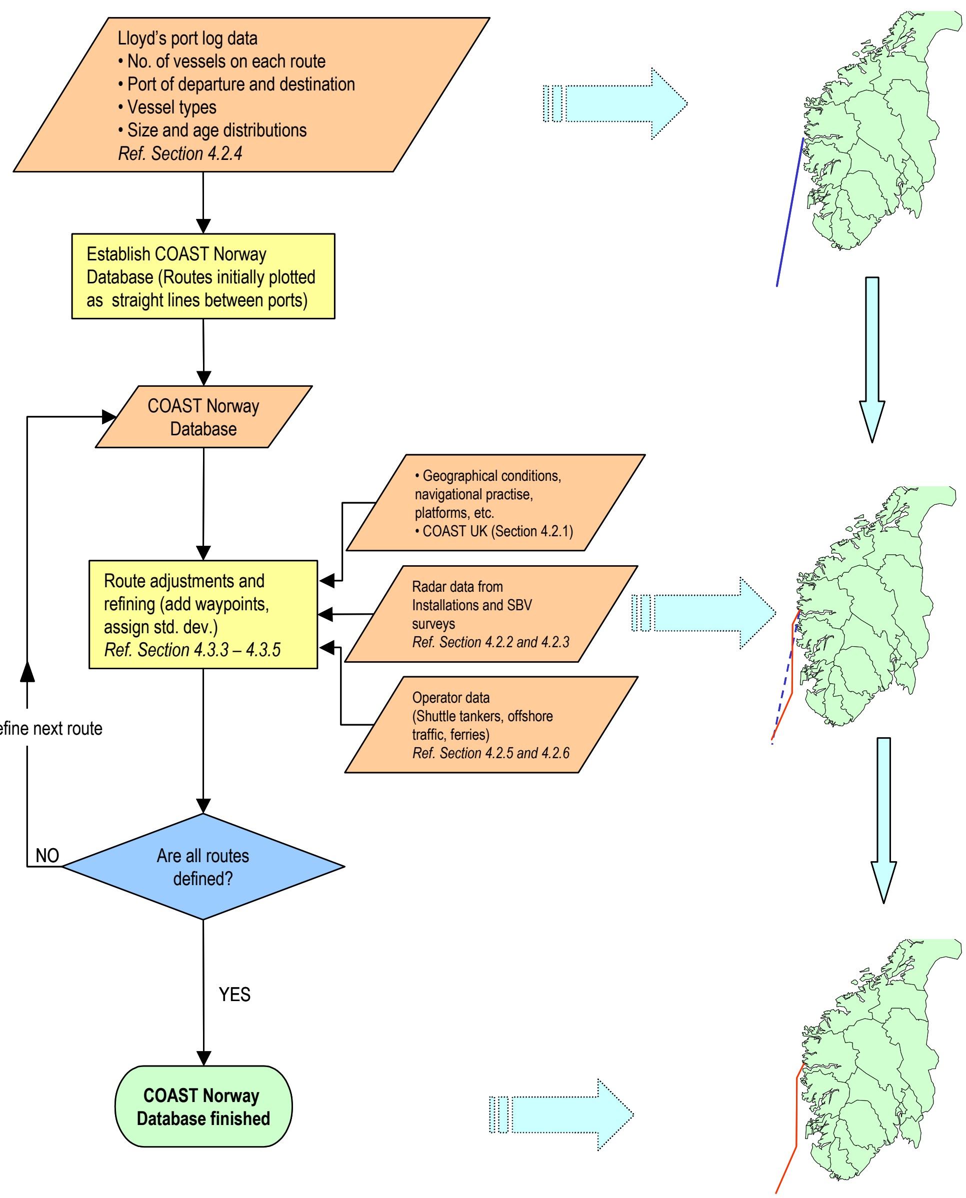


Figure 5 COAST process illustration

The main information contained in the database is as follows:

- Route name and waypoints
- Route standard deviations
- Distance of route to a user defined position
- Bearing from user defined position to route
- Volume of traffic on each route
- Vessel type distribution on each route (merchant, offshore, tanker, ferry)
- Size distribution of vessels on each route
- Age distribution of vessels on each route
- Flag distribution of vessels on each route

The mount of data will vary a lot from one area to another based on the amount of traffic in the area, type of vessels, obstructions, etc.

In connection with a project in the Singapore Straits, traffic data for several months were collected and analysed. A sample of radar tracks for one day data is presented in Figure 6 and an example of data collected by a Standby vessels in the area is shown in Table 1. As the Radar picked up many phantom tracks (waves), non vessel tracks (i.e. buoys, surface structures, etc) and random navigation vessels (small fishing craft, leisure vessel, etc), these had to be filtered out before the route database was developed. Figure 7 shows the tracks picked up from a floating buoy.

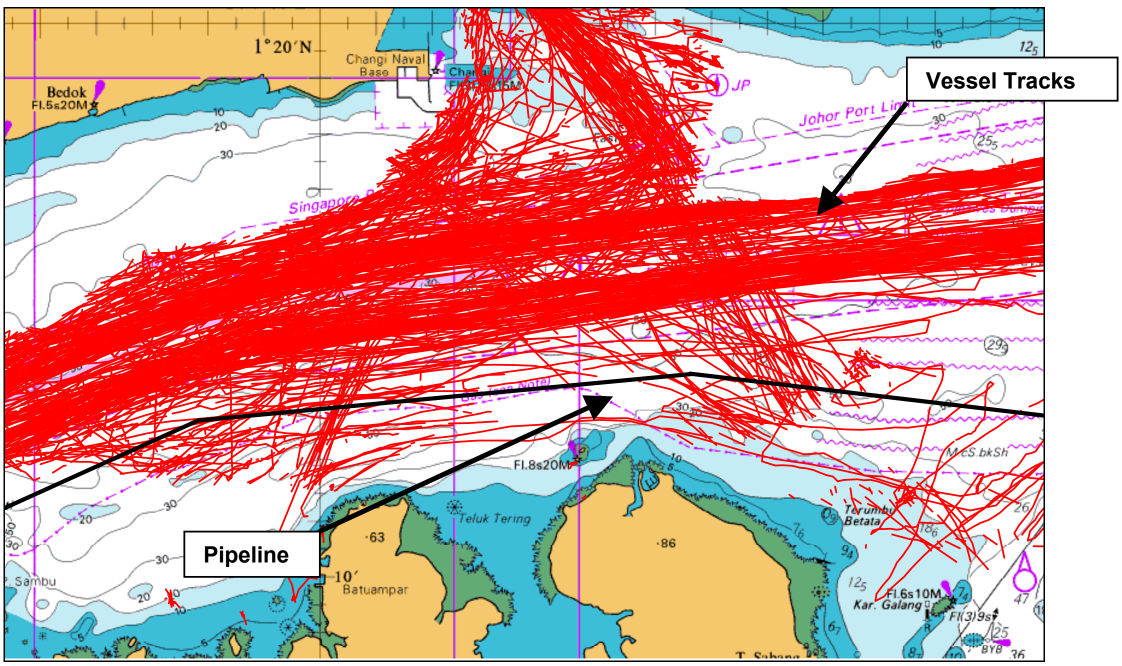


Figure 6 Radar data for one day in the Singapore Straits

Table 1 Sample Data Collected by Standby Vessel

Date	Latitude initial Sighting	Longitude Initial Sighting	Course	Speed	Vessel Name	Target Type	GRT
11-Jul-03	1° 11.8'	103° 56.30'	180	8	Hope 05	Cargo	1,140
13-Jul-03	1° 10.33'	103° 54.76'	80	5	Madura	Tanker	13,439
14-Jul-03	1° 10.47'	103° 54.63'	120	15	Gemini	Tanker	17,400
16-Jul-03	1° 11.11'	103° 55.89'	360	4	Alkor	Fishing	75
16-Jul-03	1° 11.00'	103° 52.00'	170	12	Nusantara	Tanker	13,258
19-Jul-03	1° 10.00'	103° 54.00'	340	18	Cypress	Tanker	52,501
20-Jul-03	1° 11.00'	103° 54.30'	113	8	Asean Joy	Bulk	10,888

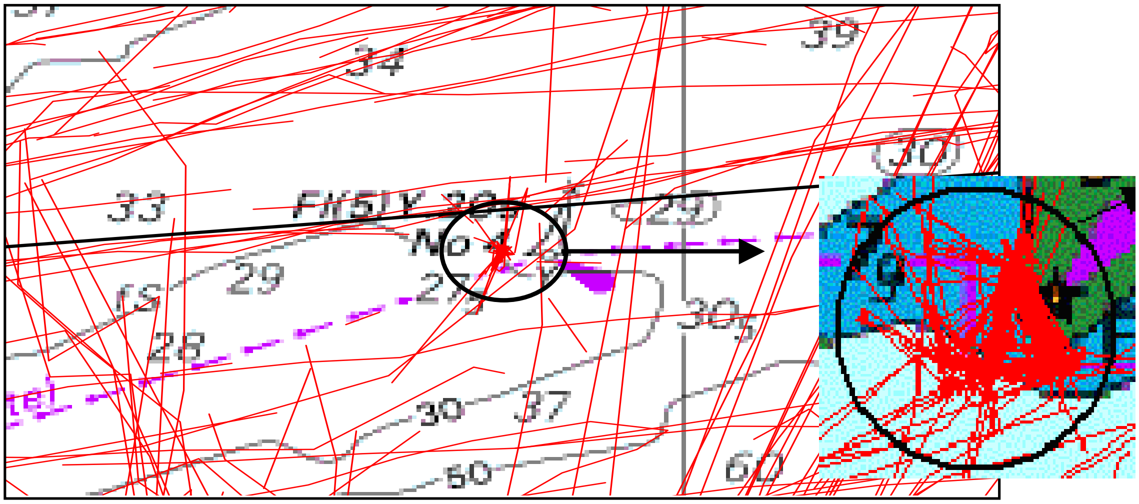


Figure 7 Floating Buoy Tracks

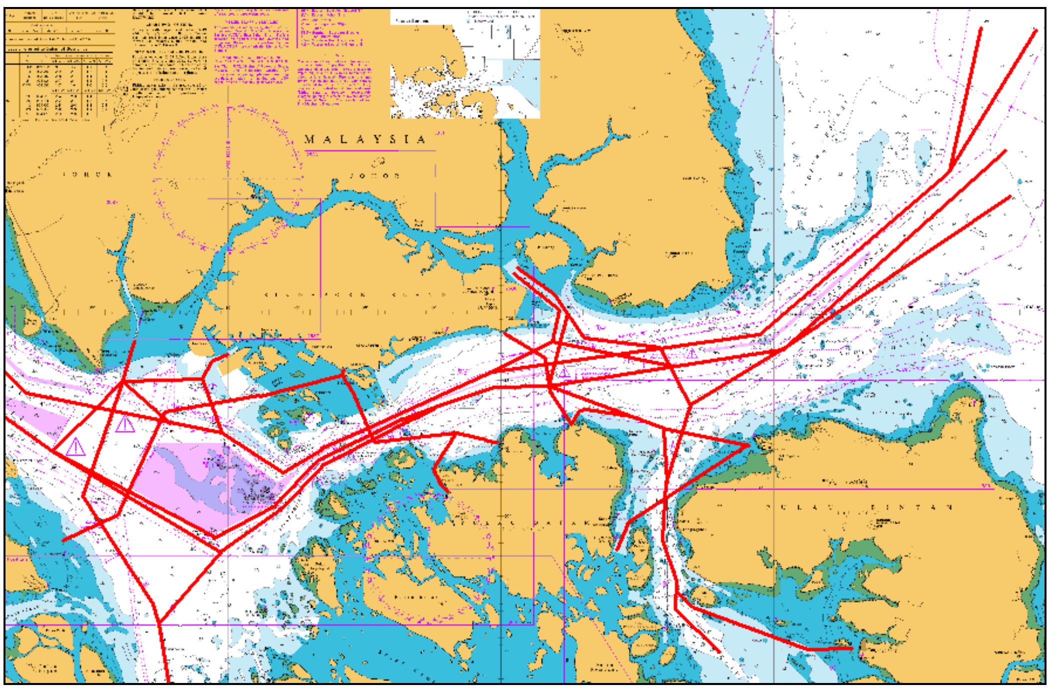


Figure 8 Overview of routes in the Singapore Straits

It was found that many of the routes follow the same pattern of travelling through the Singapore Straits, due to the traffic management system that is in place. As such, these routes were combined, where possible. Figure 8 gives an overview of the routes within the Singapore Straits. For each route shown in Figure 8, there is information on vessel type, size, speed, route standard deviation and route direction.

It is especially important to establish the shipping traffic in environmental sensitive areas. An area of particular concern is the Barents Sea and radar data has been used by Safetec to establish the shipping traffic pattern for the northern cost of Norway, and implemented into the COAST database, similarly to the Singapore Straits. The radar data was used, among other sources, to establish the risk of oil spills along the Norwegian coast of the Barents Sea.

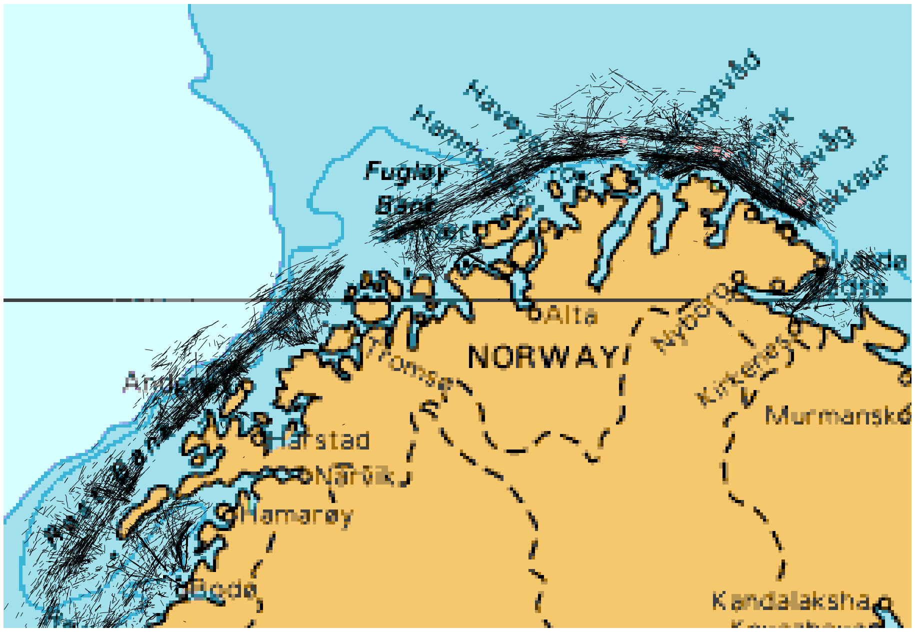


Figure 9 Plot of (RORS) radar tracks from the northern coast of Norway, provided by the Norwegian Coastal Command

Figure 10 Plot of the shipping traffic off the northern coast of Norway held within COAST,

As can be seen in Figure 9, there are several possible “hotspots” where e.g. the shipping traffic to Svalbard crosses the westbound traffic along the Norwegian coast. This westbound traffic includes oil tankers from Russia to the Continent and the USA. This traffic is increasing, and is expected to increase both in numbers and vessel size in the coming years, as the Russian oil export increases. However, it is vital when assessing such ship/ship collisions for large oil tankers to know the size of the colliding vessels, as the size of oil spill resulting from a collision will depend on the collision impact energy. The larger the vessel, the larger the impact energy, and thus the larger the oil spill. COAST holds information on both the vessel types and sizes, and as such is a useful tool when assessing the risk of oil spills due to ship collisions.

New Data sources

During 2004, practically all tankers, passenger vessels and other vessels >300 grt on international voyages are required by SOLAS regulation 19, Chapter V, to be fitted with Automatic Identification System (AIS). This system transmits, inter alia, information about a vessel's position, name, ports of departure and arrival, cargo,. AIS can provide a valuable source of information, which may in fact reduce the risk of accidental pollution from ships. The AIS transmits information to other ships with AIS and to shore-based AIS traffic control centres about a the ship's movements, thus improving the likelihood of detecting vessels on collision course or vessels that may required assistance.

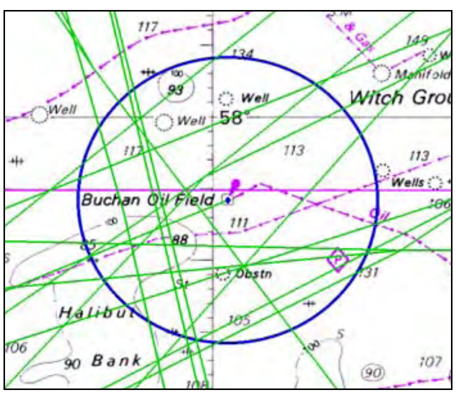
Safetec is currently working to gain access, analyse and incorporate anonymised AIS data for Norwegian waters into the COAST database in the near future. Such an inclusion of AIS data will improve the accuracy and level of detail on the information held within COAST even further, in addition to ensuring that the database holds the most up-to-date information. Similar developments for other sea areas are also being looked into.

DISCUSSION OF TRAFFIC

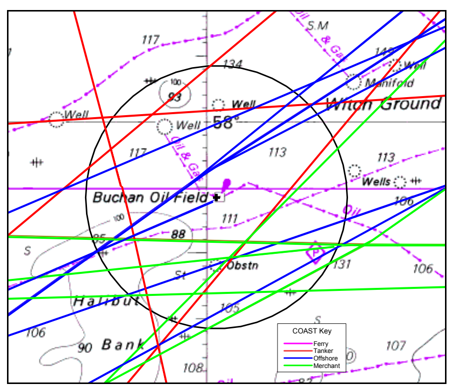
Over the last two decades, Safetec have performed a large number of studies of the shipping traffic in the North Sea (Ref. e.g. iii). These studies show that there have been considerable changes in the shipping traffic pattern over the years due to:

- Close-down of enterprises and/or harbours
- New or expansion and/or harbours
- New or expansion of enterprises and/or traffic routes
- Changes in oil & gas offshore activity
- The size of the vessels are increasing (Several harbours are reporting increased tonnage but reduced number of visits)
- New navigation aids (more accurate routing)
- Reduced manning
- Increased vessel speed

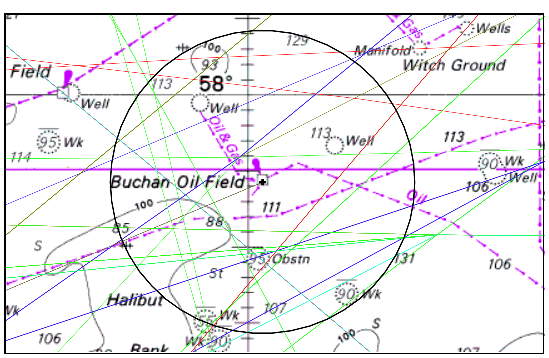
As an example, the shipping routes passing the Buchan Oil Field in Northern North Sea were identified using the COAST database. A 10 nm radius search of the COAST database was carried out around the Buchan Oil Field using the 1995, 1998 and 2001 data as a comparison of the two data sets to see how the routing has changed.



1995 Data



1998 Data



2001 Data

The graph below shows the comparison of the volume of traffic per year with in the routes identified using three sets of data. As it can bee seen there is a significant change in the tanker traffic probably due to a changes in shuttle tanker movements.

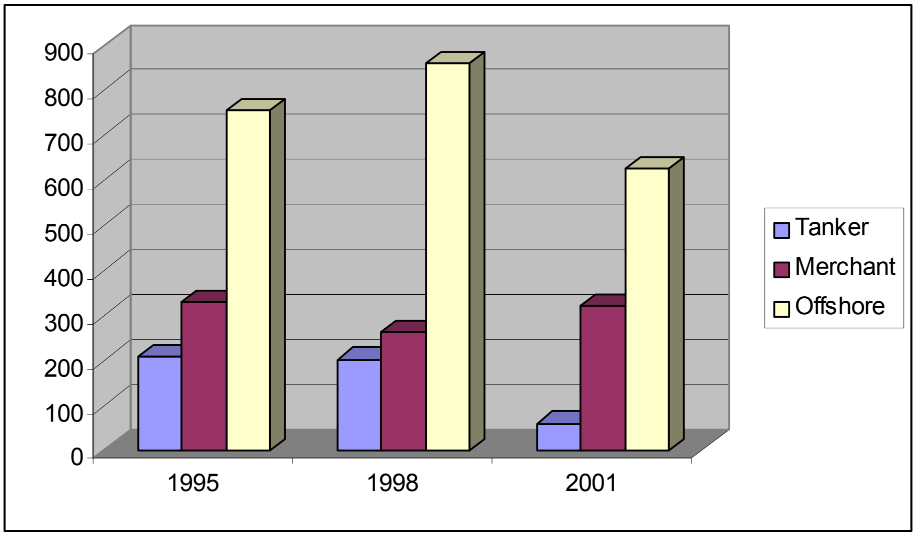


Figure 11 Example on changes in traffic volumes from 1995 to 2001 for a specific area in the North Sea.

HAZARD IDENTIFICATION

Within marine transportation, ships can constitute a 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.

<u>Operational Pollution</u>

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. iv).

MARPOL sets international standards for the discharge of ships' wastes. It also provides for the designation by the IMO of special areas, within which more stringent restrictions apply. Some waters (e.g. 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 areas with strict rules governing discharges of oil and garbage that might affect e.g. the UK coastline.

The Norwegian Government is currently proposing for IMO to establish the Norwegian part of the Barents Sea and the northern part of the Norwegian Sea as a Particular Sensitive Sea Area (PSSA), in accordance with IMO guideline s for the identification of and designation of PSSA (resolution A.927 (22)). Such a designation would allow for more stringent control and restrictions on shipping traffic in the area in question, e.g. through adoption of ships' routeing and reporting systems near or in the area. Whether the area will be designated as a PSSA is uncertain, but the proposal itself underlines the focus and special attention being put on this area, and the need for accurate, up-to-date and easily accessible information on the shipping traffic patterns in such sea areas.

One such source of shipping traffic information is the Safetec developed and owned Computer Assisted Shipping Traffic database (COAST), which is presented within this paper.

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. v), it was observed that the vast majority of accidental releases to the marine environment are of oil from fuel and cargo tanks.

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.

Causes & Sizes of Spills
From the data reviewed it is 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 has been undertaken using data on Worldwide incidents published by the International Tanker Owners Pollution Federation (ITOPF) for the period 1974-2003. Using this information, the following distribution (see Figure 12) was obtained, considering 335 incidents which each caused an oil spill above 700 tonnes.

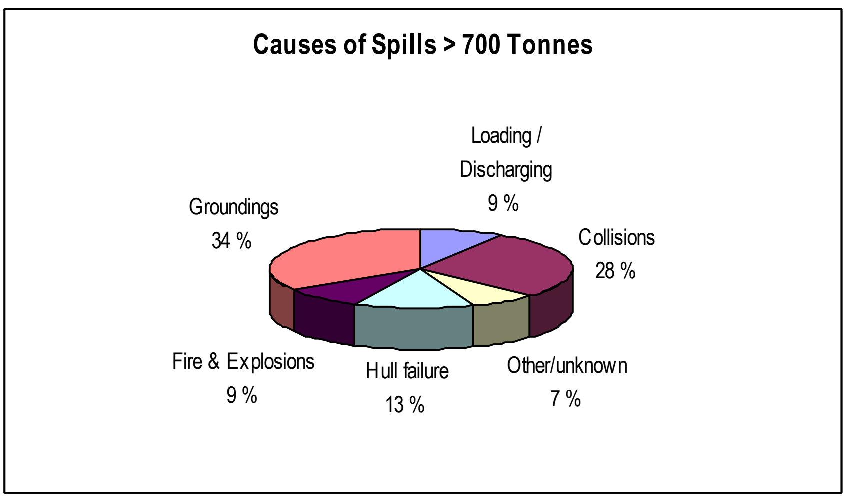


Figure 12 Causes of Spills from tankers for Incidences of oil spills >700 Tonnes by cause, 1974-2003

As shown in Figure 12, only 9% of the major spills from tankers is caused by operational related incidents. However, operational related incidents are dominated by minor spills, whereas accidental events constitute most of the major spills.

Historical data is a very good starting point in the hazard identification process, but a much more complete review have to consider aspects like:

- ship groundings
  - distance from shore, coastal rockiness, water depths, weather conditions, VTS coverage, age of vessels,…
- ship/ship collisions
  - ship traffic density, traffic separation, VTS coverage, fog, …
- ship fire & explosions
  - type of vessels, type of cargo, age of vessels,…
- ship foundering/structural failure
  - weather conditions, age of passing vessels,…

- collisions between vessels and surface structures
  - offshore installations, fish farms and wind farms
- impacts to sub sea pipelines
  - dropped anchor, dragged anchor, grounding, fishing, pipeline protection,..

Summary Discussion - HAZID

From this review it is observed that the vast majority of shipping related pollution to the sea comes from releases of oil from cargo and fuel tanks, which occur as a result of accidental events. Therefore, any detailed risk assessment work undertaken should focus on these scenarios, which are most likely to expose environmental sensitive areas to pollution. Operational pollution tends to result in smaller releases which are already governed by the IMO through MARPOL Annexes I, II and V.

ENVIRONMENT RISK IMPACT FROM SHIPPING

The assessment of the environmental risk will have to include an evaluation of ;

- shipping accident frequency assessment (including amount of pollution)
- assessment of consequences

including an assessment of the effect of risk reduction measures (e.g. VTS, tugs, oil recovery systems and contingency plans).

Shipping Accident Frequency Assessment

Once the ship routeing has been identified, and hazard identification has been performed, the next stages of the assessment are to determine the frequency of the different accidental events identified, and the likely amount of pollution. The frequency models have to include an assessment of the factors which will have an influence on the likelihood of different incidents taking place (see above) and able to determine the geographical distribution of incidents. These tasks involve the application of several predictive models.

Within each of the models developed, it is of paramount importance that the results are validated against the best available historical data to ensure an accurate representation of the pollution risks for the relevant waters considered.

Examples of how historical data could give valuable input is given in Figure 13 which presents the ratio of incidents by vessel age against the industry average for foundering and structural failure. More examples are given in Ref. v.

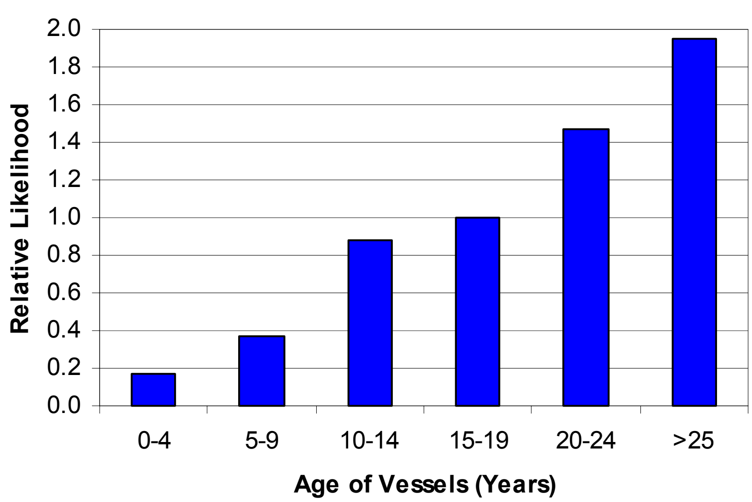


Figure 13 Ratio of Incidents by Vessel Age for Foundering and Structural Failure

From Figure 13 it can be seen that there is a relationship between the age of vessels and the likelihood of foundering and structural failure. This is as expected and is considered to be as a result of deterioration of the hull due to corrosion stresses and fractures.

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

- Spill probability (i.e., likelihood of outflow following an accident)
- Spill size (in 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:

- Cause of Accident
- Vessel Size & Type (single/double hull)

Different databases on releases of oil from tankers have been used to estimate the spill size distribution for each accident type and ship size (see Figure 14).

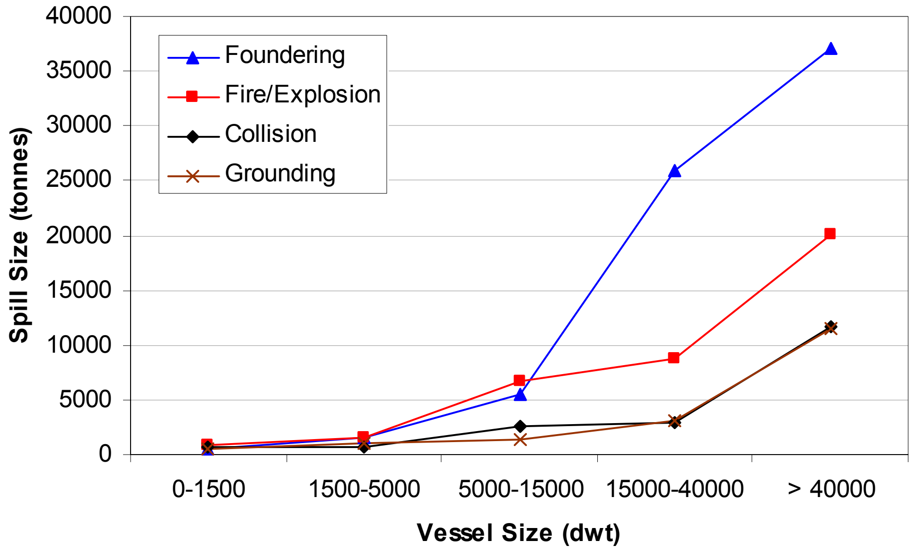


Figure 14 Average Spill Sizes per Ship Size and Accident Type (Ref. v)

Effects of Marine Oil Spills

A certain area will be exposed based on location of the spill, the spill amount, proportion of oil evaporated and naturally dispersed and oil spill drift.

The environmental sensitivity of the considered coastline and surrounding waters is required to be estimated which should include:

- Wildlife
- Landscape
- Geology
- Fishing
- Vulnerability of seabirds to oil pollution
- Economy/Amenity

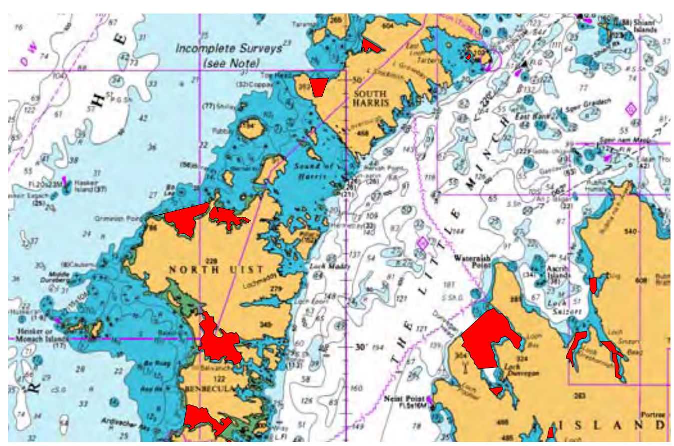


Figure 15 GIS Maping of Shellfish Production Areas

Typical designations considered under wildlife include:

- World heritage sites
- Biosphere reserves
- Special Protection Area
- Ramsar sites
- Sites of Special Scientific Interest
- National Nature Reserves etc. etc.

An example of the mapping of a shellfish production area is presented in Figure 15.

<u>Risk Reduction Measures</u>

The need for and benefit (with regard to risk reduction) of different risk reduction measures should be considered based on the risk picture established.

An example of such a risk picture, including evaluation of frequency of spills as well as the environmental sensitivity, is given in Figure 16.

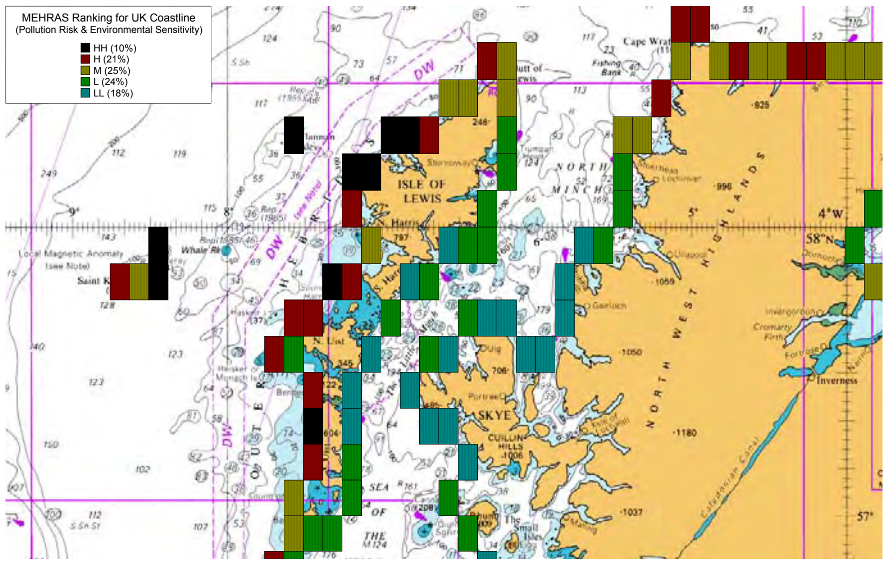


Figure 16 Marine Environmental High Risk Areas (MEHRA's) Ranking for NW Coast of Scotland (Ref. v)

An assessment of risk reduction measures could include an assessment of:

- Assessing the benefits of navigational aids
- Establishing emergency response strategies (e.g. oil recovery)
- Identifying coastal sites particularly sensitive to shipping
- Prioritising coastal surveys
- Assessing the benefits of traffic segregation
- Protection of e.g. pipelines, fish farms, offshore wind farms and offshore oil&gas platforms
- Basis for contingency manuals

CLOSURE

This paper presents a method using live ship vessel tracks and a simple, practical and transparent methodology to analyse the risk posed by shipping traffic. This method and many variations of this method have been used by Safetec to carry similar studies in the North Sea and many other waterways in the world.

The benefits of using the COAST database has been realized in several applications such as for consent to locate purposes for the offshore industry, collision risk management, traffic management, offshore wind farm development etc.

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