Research Project 591 Environmental Risk Criteria

Reference: 50012/D0137/Issue 2
Date: December 2007
Unclassified

Administration Record

Issue	Modification	Approved
01	For Customer Comment	
02	Final Deliverable	

No. Of Pages **Copy No.** **Collated By:**

------------------------- ----------------------- --

Report Authorisation

Author

Sarah Clarke and Michael Starling

Checked

Loren Roberts and David Sell

Certified

Julian Lockett

Executive Summary

This report is the culmination of work completed by BMT Isis and BMT Cordah for the UK Maritime and Coastguard Agency in October and November 2007.

Aim

The aim was to research and develop Environmental Risk Criteria that can be used alongside Safety Criteria when applying the International Maritime Organisation's Formal Safety Assessment process to improve shipping activities, practices and technologies, where risk control options have environmental consequences, as well as safety, property and business consequences.

Environmental Risk Criteria need to be chosen that are appropriate to the conditions under investigation and are unlikely to be agreed internationally in advance of a specific study. Therefore, it was not the aim of this research to develop them; rather the research sought ways for a Formal Safety Assessment study's stakeholders to understand the context surrounding the Environmental Risk Criteria and provide ways for establishing them for a specific assessment.

Background

Environmental Risk Criteria are different to Safety Criteria in many ways including:

a. Environmental risks from shipping are both chronic (in that they happen as part of the day to day emissions and discharges from ships) and acute (in that they are the result of accidents) while safety risks from shipping as assessed by Formal Safety Assessment tend to be acute (as they result from accidents);

b. Environmental risks cover a wider range of issues including multiple species harm, persistence, reversibility, and escalation/concentration through the food chain, location, time of day/year, variety of pollutants, cumulative and in-combination effects, detection times and the balance between benefits and harm.

These issues are explored in the report and in more detail in two supporting annexes on the Scope of Environmental Risk Criteria and the Environmental Aspects of Marine Operations.

Research

There are existing Environmental Risk Criteria used by a variety of organisations including some defined in international standards. These range from simple "Risk Matrix" criteria for operational decision making to detailed "Quantified Risk Assessment" based techniques for analysing the transit of nuclear material. An overview of relevant criteria is given in the report and in more detail in a supporting annex.

Results - Method of Assigning a Risk Index Value

The Environmental Risk Criteria outlined in the report are based on a method for assigning a Risk Index Value to an environmental aspect of shipping operations in a similar way as a Risk Index Value is assigned to a hazardous aspect of operations.

Two methods are proposed for further consideration and consultation. These are:

a. A direct estimate of the Risk Index Value based on an assessment of the Global Environmental Risk resulting from the cumulative effects of all shipping

b. An estimate using the "severity x frequency = risk" process in Formal Safety Assessment based on an assessment of the Per Ship Environmental Risk.

These Risk Index Values have been selected so that an environmental aspect and a safety hazard with the same risk index value are broadly equivalent in terms of cost and therefore can be used for the combined safety and environmental ranking of hazards/aspects.

Results - Measures of Environmental Harm

The Risk Indices used are based on a method for assessing the "Environmental Harm" based on the sum of the "Clean-up Cost" and the "Environmental Cost". The environmental cost is the intangible value set on the damage to the environment and the loss of human amenity from an activity and the report goes on to list some possible "appraisal values" for use when assessing environmental cost.

Contents Page No.

Tables

Figures

Annexes

1 Introduction

1.1 Overview

1.1.1 The Guidelines for Formal Safety Assessment (FSA) for use in the International Maritime Organisation (IMO) Rule-Making Process [Reference 1], (which updates the original issue of the agreed FSA Guidelines [Reference 2]) is a rational and systematic process for assessing the risks relating to maritime safety and the protection of the marine environment. It is used for evaluating the costs and benefits of IMO's options for reducing these risks.

1.1.2 Within these guidelines are broadly accepted risk criteria for human harm, but appropriate criteria are not yet identified for environmental damage.

1.1.3 The European Union (EU) SAFEDOR project included a task to develop Environmental Risk Criteria for use within the projects. This was done because, at the time of writing of the SAFEDOR Report [Reference 3], there had not been any application of FSA for environmental consequences. Therefore, there has not been any detailed discussion on environmental risk criteria.

1.1.4 Since the SAFEDOR Report, the development of Environmental Risk Criteria has been discussed amongst IMO members and submissions to IMO have been made by countries such as Greece [Reference 4], which brings to the Committee's attention some points pertaining to Environmental Risk Evaluation Criteria.

1.1.5 During a correspondence group (intersessional between MSC 77 and MSC 78) that looked into improving the FSA Guidelines "the group noted that it is difficult to estimate environmental impact and damage caused by a sea accident. Even money would not be a relevant figure for such estimation."

1.1.6 At the Marine Environment Protection Committee (MEPC) 56/18 [Reference 5] the Chairman invited members and international organisations to consider the draft Environmental Risk Evaluation Criteria and submit comments to the MEPC 56, for further consideration prior to referring the agreed text to the Maritime Safety Committee (MSC) for appropriate action.

1.1.7 BMT Isis Ltd (BMT Isis) (together with BMT Cordah Ltd) have been commissioned by the UK Maritime and Coastguard Agency (MCA) to conduct and present research to the MCA for the development of Environmental Risk Criteria to be included in IMO FSA methodology [Reference 6].

1.1.8 The MEPC correspondence group recognises that specific empirical environmental risk criteria are unlikely to be agreed internationally and it was not the aim of this research to develop them. The research sought ways for a Formal Safety Assessment study's stakeholders to understand the context surrounding Environmental Risk Criteria and provide ways for establishing the criteria to be used for a specific study.

1.1.9 Formal Safety Assessment is an approach that requires the integrated assessment of the need for, and effect of, regulation changes (based on risk control options). These changes have to be based on an understanding of the effect on safety, environmental, business and property.

1.1.10 The use of environmental risk criteria to broaden the existing approach to formal safety assessment will allow this integrated assessment to me made.

1.1.11 It should be noted that the use of Environmental Risk Criteria is not solely aimed at regulation changes that are directly related to the environment. For example the proposed risk control option on the carriage of ECDIS charts has both safety and environmental effects and could be assessed using FSA.

1.1.12 This document presents BMT's findings. For the purposes of this Report, the term BMT is used to reflect the combined efforts and outputs of both companies.

1.2 BMT Approach to the Task

1.2.1 This research has been conducted in accordance with the methodology at Annex A. This can be summarised as:

a. Research;

b. Drafting Environmental Risk Criteria Guidelines;

c. Holding a workshop to develop the guidelines;

d. Holding a workshop to conduct a trial application of the guidelines;

e. Production of the final Environmental Risk Criteria Guidelines to the MCA.

1.3 Process

1.3.1 The project focussed on extensive research of source material, documented as references throughout the Report. A list of this source literature review can be found at Annex D.

2 Problem Definition

2.1 Overview

2.1.1 For the Environmental Risk Criteria to be broadly equivalent to the FSA Safety Criteria the following issues need to be addressed:

a. The process used to evaluate the environmental risk needs to link to the FSA process;

b. The Environmental Risk Criteria need to recognise the wider scope of environmental risks compared to safety risks;

c. The criteria need to address the issue of environmental tolerability;

d. They need to address the issue of cost effectiveness of environmental risk control options;

e. They need to recognise that there are aspects to the environmental risk decision making that are outside the responsibility of the IMO.

2.2 Link to Formal Safety Assessment Process and Terminology

2.2.1 To link to the FSA process the risk evaluation criteria need to:

a. Link to the 5 Step Process;

b. Have an environmental equivalent to:

(i) A Safety Hazard;

(ii) A Safety Consequence;

(iii) An Initiating Event;

(iv) A Causal Chain;

c. Link to the Human Element.

Link to the 5-Step FSA Process

2.2.2 The IMO FSA process is based around certain key concepts. The most fundamental of these is the 5-Step FSA Methodology.

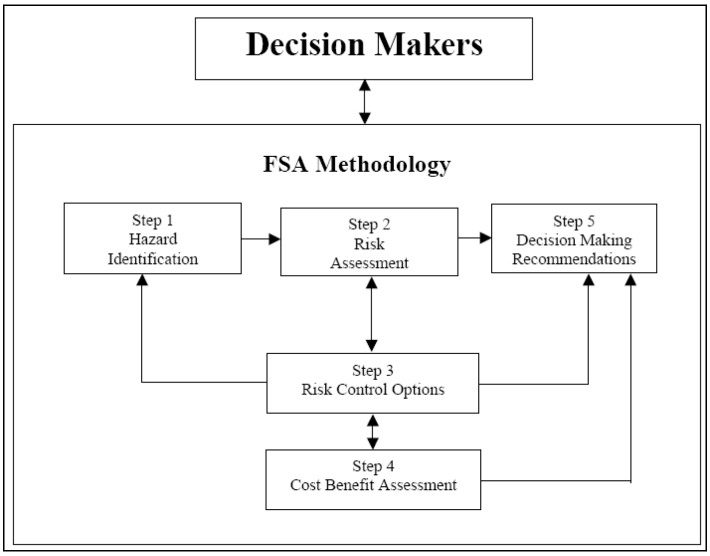


Figure 2.1 IMO 5 Step FSA Methodology

2.2.3 For Environmental Risk Criteria to be made broadly comparable to the Safety Risk Criteria then the process that leads to their use needs to also be broadly comparable.

2.2.4 The 5 step process is appropriate to environmental assessment but there are some important differences in terminology.

2.3 Comparison Between FSA and Environmental Terminology

2.3.1 In FSA a "Hazard" is described as "A potential to threaten human life, health, property or the environment". The term Hazard is not used in environmental studies, the term Environmental Aspect (from ISO 14000) is more broadly used.

2.3.2 In FSA a "Consequence" is described as "The outcome of an accident". Although the term "Consequence" is also used in environmental studies, the term "Environmental Impact" is more usual.

2.3.3 In FSA an "Initiating Event" is described as "The first of a sequence of events leading to a hazardous situation or accident". In environmental studies, the term "Environmental Activity" is more usual.

2.3.4 It is recommended that the current FSA safety terminology is retained but where it desirable to use environmental terminology then this should be used in conjunction with a clear definition of the relationship being described such as the one shown below:

a. Hazard → Environmental Aspect

b. Consequence → Environmental Impact

c. Initiating Event → Environmental Activity

2.3.5 In FSA, risk control options (and measures) are developed by considering a causal chain.

causal factors → failure → circumstance → accident → consequences

Figure 2.2 Causal Chain

2.3.6 The environmental equivalent is the Environmental Impact Chain

source → pathway → receptor

Figure 2.3 Environmental Impact Chain

2.4 Incorporation of the Human Element

2.4.1 The FSA guidelines [Reference 1] stress the importance of the human element in both the cause and avoidance of accidents

3.4 Incorporation of the human element

3.4.1 The human element is one of the most important contributory aspects to the causation and avoidance of accidents. Human element issues throughout the integrated system shown in Figure 3 should be systematically treated within the FSA framework, associating them directly with the occurrence of accidents, underlying causes or influences. Appropriate techniques for incorporating human factors should be used.

Figure 2.4 Extract from FSA Guidelines Regarding the Integrated System

2.4.2 The scope of the integrated system is widened when including environmental aspects.

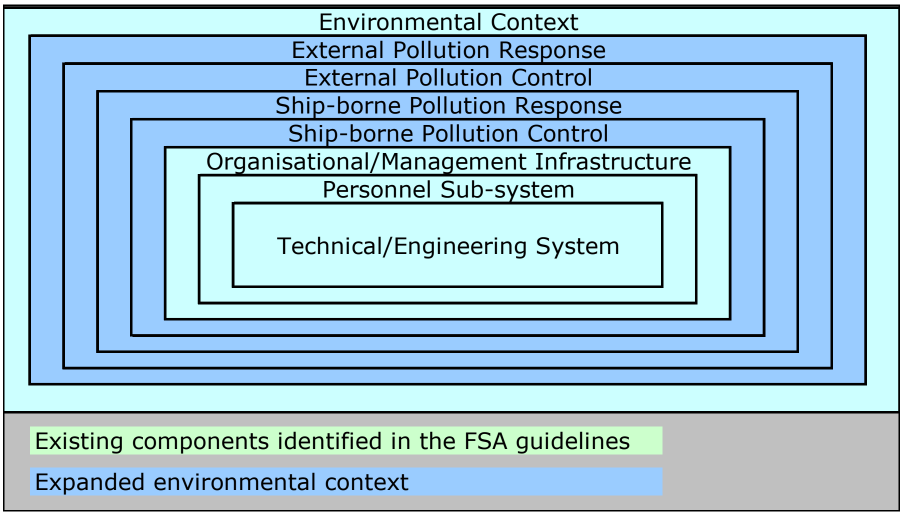


Figure 2.5 Components of the Integrated System

2.5 Required Scope of Environmental Risk Criteria

2.5.1 The required scope of Environmental Risk Criteria is significantly different to Safety Risk Criteria. Environmental Criteria have to include a much wider range of issues.

2.5.2 In assessing probability, these issues may include:

a. Acute and. Chronic Risks;

b. Accidental and. Deliberate Acts;

c. Legal and. Illegal Acts.

2.5.3 In assessing impact these issues include:

a. Multiple Species harm;

b. Persistence;

c. Reversibility;

d. Escalation/Concentration in the Food Chain;

e. Location and time of year/day;

f. Variety of pollutants;

g. Cumulative and in-combination effects;

h. Detection time;

i. Environmental Benefits v Environmental Harm.

2.5.4 These issues are discussed in detail in Annex B, Required Scope of Environmental Risk Criteria for Marine Operations and Annex C, Examples of Environmental Aspects of Marine Operations.

2.6 Environmental Tolerability

2.6.1 FSA uses the concept of As Low As Reasonably Practicable (ALARP) as the mechanism for deciding if the level of risk tolerable. The Environmental Risk Criteria need to be linked to an equivalent tolerability mechanism such as Best Practicable Environmental Option (BPEO) [Reference 7].

2.7 Effectiveness of Environmental Risk Control Options

2.7.1 FSA uses the concept of Gross Cost for Averting a Fatality (and Net Cost for Averting a Fatality) as a mechanism for assessing the effectiveness of a Risk Control Option. The Environmental Risk Criteria need to be linked to an equivalent effectiveness mechanism noting that the environmental cost is made up of:

a. The cost of the environmental damage;

b. The cost of the clean up.

c. This is described in more detail in Section 4.5.17c

2.7.2 Example of Calculation of Indices for Environmental Cost Effectiveness

2.8 Aspects of Environmental Decision Making outside the Responsibility of the IMO

2.8.1 In the Marine Safety Umbrella Operation (MSUO) report on Marine Risk Assessment and Acceptance, there is a discussion of the overall context of the management of public risks.

SCOPE OF METHODOLOGIES AND PROTOCOLS

Risk assessment and risk acceptance form part of the overall context of risk based methodologies used to manage (in its broadest term) public risks. The overall context can be summarised as the following interlinked levels[1].

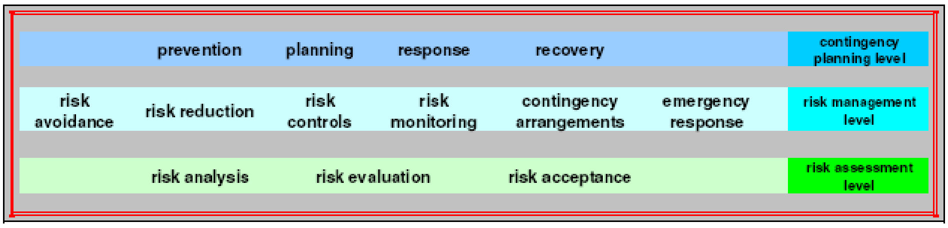


Figure 1 – Overall Context of Management of Public Risks

Figure 2.6 Extract from MSUO Document

2.8.2 What is significant about this is that while FSA is capable of addressing all levels the IMO responsibility is mostly at the risk assessment and risk management levels.

2.8.3 When analysing safety risks, the contingency planning level is important but it is usually not dominant in either the probability of the hazard, its severity or the resulting cost.

2.8.4 When analysing environmental risks the contingency planning level can be dominant, good contingency planning can reduce the risk and the environmental cost. For example, with an oil spill the severity is a direct result of the response taken (or not taken) and contingency planning, training and exercise are an important driver of efficient response actions. However, such planning is often the joint responsibility of Coast States as well as of the IMO through conventions such as ORPC and sponsorship of regional co-ordination centres such as REMPEC in the Mediterranean and REMPEITC in the Caribbean.

3 Overview of Research into existing Environmental Risk Criteria

3.1 Overview of Research

3.1.1 A number of industry and Government sources were researched and criteria identified which are currently used to conduct environmental impact assessments and identify environmental risk.

3.1.2 This section provides a generic "snap-shot" or starting point to identify Environmental Risk Criteria (ERC) for all seagoing vessels that could, by definition, be anywhere in the world and in a number of locations of varying sensitivity.

3.1.3 The criteria identified in Section 4 therefore represent initial indication or guidance as to whether a specific activity will pose a significant environmental risk. It may be necessary to investigate the risk further, once it has been identified, in order to ascertain the specific potential environmental impacts associated with that risk given the local environmental sensitivities.

3.1.4 Currently, there are a number of key industries and Government bodies worldwide that are concerned with identifying the environmental risk and potential environmental impact associated with their activities, which are summarised at Annex D.

3.1.5 The UK BERR, formerly the Department of Trade and Industry, is the regulatory body in the UK responsible for managing the environmental impact associated with the UK oil and gas industry.

3.1.6 The oil and gas industry is recognised both in the UK and worldwide as being particularly environmentally aware and operates to some of the highest environmental standards in the world. As such, both BERR and the oil and gas industry in general are good examples of an industry and associated regulatory body that are established in defining and assessing environmental risk criteria and associated potential environmental impact. For the purposes of this investigation, The Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) (Amendment) Regulations 2007 [Reference 8] and industry best practice have been used in the development of the environmental risk criteria.

3.1.7 The IMO is responsible for the international MARPOL 73/78 legislation that regulates the environmental performance of vessels at sea. This legislation identifies six Annexes that encompass the nature of environmental impacts that vessels may have. These Annexes have been used in this report as the basis for the formulation of these criteria.

3.1.8 The IMO is also responsible for the Ballast Water Management Convention and the Anti-fouling Systems Convention.

3.1.9 The UK Environment Agency and the Ministry of Defence have been referenced here as an example of Government departments that are well established in the assessment of environmental impacts of industrial activity and have been used here as a benchmark for the development of the environmental risk criteria.

4 Draft Environmental Risk Criteria

4.1 Existing Safety Ranking Criteria

Safety Ranking

4.1.1 The FSA guidelines require that at the end of Step 1 hazards are to be prioritised and scenarios ranked. The suggested method is to assign a Risk Index based on assigning:

a. A Severity Index based on a Severity Category (minor, significant, severe, catastrophic) using a Severity Table (Table 4.1);

b. A Frequency Index based on a Frequency Category (frequent, reasonably probable, remote, extremely remote) using a Frequency Table (Table 4.2);

c. A Risk Index (from 2 to 11) using a Risk Matrix (Table 4.3).

4.1.2 This process is summarised in the following flow diagram:

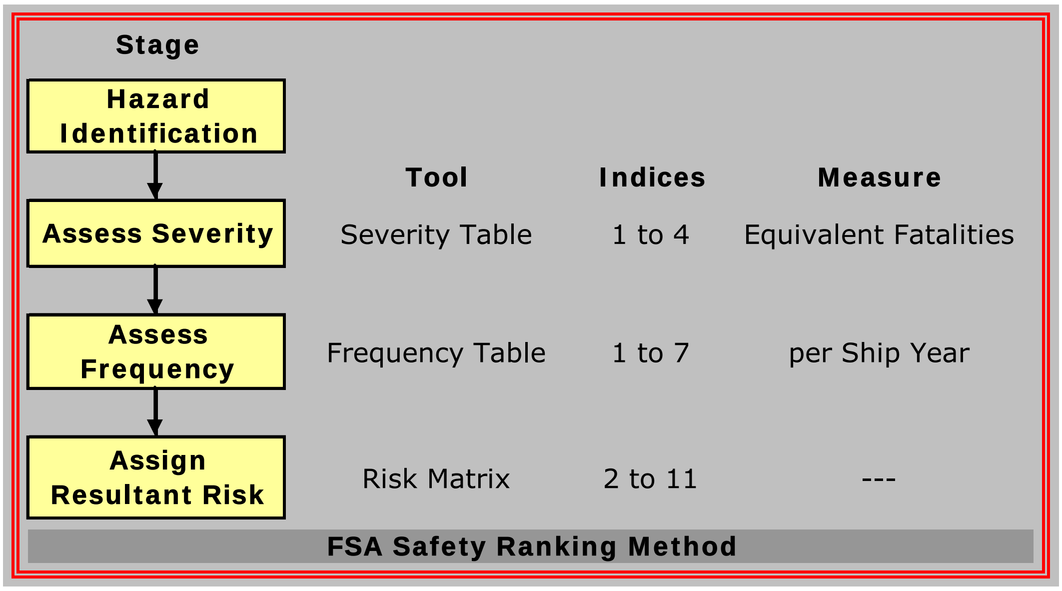


Figure 4.1 FSA Safety Ranking Method

4.1.3 The severity is based on equivalent fatalities and the frequency per ship year and are shown in the extracts from the FSA guidelines below.

Severity Table

Severity Index				
SI	SEVERITY	EFFECTS ON HUMAN SAFETY	EFFECTS ON SHIP	S (Equivalent fatalities)
1	Minor	Single or minor injuries	Local equipment damage	0.01
2	Significant	Multiple or severe injuries	Non-severe ship damage	0.1
3	Severe	Single fatality or multiple severe injuries	Severe damage	1
4	Catastrophic	Multiple fatalities	Total loss	10

Table 4.1 FSA Severity Table

Frequency Table

Frequency Index			
FI	FREQUENCY	DEFINITION	F (per ship year)
7	Frequent	Likely to occur once per month on one ship	10
5	Reasonably probable	Likely to occur once per year in a fleet of 10 ships, i.e. likely to occur a few times during the ship's life	0.1
3	Remote	Likely to occur once per year in a fleet of 1000 ships, i.e. likely to occur in the total life of several similar ships	10^{-3}
1	Extremely remote	Likely to occur once in the lifetime (20 years) of a world fleet of 5000 ships.	10^{-5}

Table 4.2 FSA Frequency Table

Risk Matrix

Risk Index (RI)					
		SEVERITY (SI)			
		1	2	3	4
FI	FREQUENCY	Minor	Significant	Severe	Catastrophic
7	Frequent	**8**	**9**	**10**	**11**
6		**7**	**8**	**9**	**10**
5	Reasonably probable	**6**	**7**	**8**	**9**
4		**5**	**6**	**7**	**8**
3	Remote	**4**	**5**	**6**	**7**
2		**3**	**4**	**5**	**6**
1	Extremely remote	**2**	**3**	**4**	**5**

Table 4.3 FSA Risk Matrix

Loss Implication of the Safety Ranking

4.1.4 Basic loss implications, both for world shipping losses and losses from a single accident, can be implied from these indices. These values can then be used as the basis for broadly equivalent environmental loss criteria.

4.1.5 An example, based on the value of preventing a fatality being broadly equivalent to the cost of harm from an accident is shown in the Table 4.4 below.

4.1.6 A value of preventing a fatality of $3,000,000 has been used, as it is a typical value used in FSA discussions at IMO. However it should be noted that this value is only appropriate for the types of risks currently being investigated by FSA. It is not appropriate to risks either significantly higher or lower but is appropriate to producing environmental risk criteria that are broadly equivalent to safety criteria.

4.1.7 The table calculates, for the ranges of risk index used in FSA (i.e. from 2 to 11):

a. The loss of life and cost of harm per accident;

b. The loss of life and cost of harm per ship year;

c. The loss of life and cost of harm from all shipping per year.

4.1.8 This shows that the FSA methodology includes risk indices for levels of risk that are not experienced in shipping. For example:

a. Risk Index 7 equates to 500 fatalities per year;

b. Risk Index 8 equates to 5,000 fatalities per year;

c. Risk Index 9 equates to 50,000 fatalities per year.

4.1.9 The implications of this analysis are:

a. That there is no credible marine safety risk that exceeds Risk Index 7;

b. The value for preventing a fatality is not appropriate as an estimate of the cost of harm for high probability - high severity events (i.e. above Risk Index 8) as it leads to massive values for the cost of harm.

Severity			Frequency		Risk		Loss			Comparators
Severity Index	Equivalent Fatalities	Cost of Harm	Frequency Index	Frequency (per ship year)	**Risk Index**	Loss of Life (per ship year)	Cost of harm to people (per ship year)	Loss of Life from shipping (per year)	Cost of harm to people from shipping (per year)	
4 Catastrophic	10	$30,000,000	7 Frequent	1.E+01	**11**	1.E+02	$300,000,000	5,000,000	$15,000,000,000,000	Outside Scope of FSA Individual Risk Criteria
3 Severe	1	$3,000,000	7 Frequent	1.E+01	**10**	1.E+01	$30,000,000	500,000	$1,500,000,000,000	
4 Catastrophic	10		5 Reasonably Probable	1.E-01	**9**	1.E+00	$3,000,000	50,000	$150,000,000,000	
2 Significant	0.1	$300,000	7 Frequent	1.E+01	**9**	1.E+00	$3,000,000	50,000	$150,000,000,000	
3 Severe	1		5 Reasonably Probable	1.E-01	**8**	1.E-01	$300,000	5,000	$15,000,000,000	Extreme Use of Criteria
1 Minor	0.01	$30,000	7 Frequent	1.E+01	**8**	1.E-01	$300,000	5,000	$15,000,000,000	
4 Catastrophic	10		3 Remote	1.E-03	**7**	1.E-02	$30,000	500	$1,500,000,000	Credible Use of FSA Individual Risk Criteria
2 Significant	0.1		5 Reasonably Probable	1.E-01	**7**	1.E-02	$30,000	500	$1,500,000,000	
3 Severe	1		3 Remote	1.E-03	**6**	1.E-03	$3,000	50	$150,000,000	
1 Minor	0.01		5 Reasonably Probable	1.E-01	**6**	1.E-03	$3,000	50	$150,000,000	
4 Catastrophic	10		1 Extremely Remote	1.E-05	**5**	1.E-04	$300	5	$15,000,000	
2 Significant	0.1		3 Remote	1.E-03	**5**	1.E-04	$300	5	$15,000,000	
3 Severe	1		1 Extremely Remote	1.E-05	**4**	1.E-05	$30	1	$1,500,000	
1 Minor	0.01		3 Remote	1.E-03	**4**	1.E-05	$30	1	$1,500,000	
2 Significant	0.1		1 Extremely Remote	1.E-05	**3**	1.E-06	$3	0.1	$150,000	
1 Minor	0.01		1 Extremely Remote	1.E-05	**2**	1.E-07	$0	0.01	$15,000	
						Value of preventing a fatality	$3,000,000			
						World Fleet Size	50,000			
Implied Loss from IMO FSA Risk Index										

Table 4.4 Loss Implication from the FSA Risk Index

4.2 Proposed Environmental Ranking Criteria

Environmental Ranking

4.2.1 Environmental ranking is different to safety ranking in that it has to address both Global Environmental Risk and Per Ship Environmental Risks.

4.2.2 The result of this is that some risks:

a. Have to be based on a direct assessment of the risk to the environment from shipping at the global level (e.g. CO_2 emissions);

b. While others can be based on the risk to the environment on a statistical per ship basis (e.g. Fuel spill from a collision).

4.2.3 This is shown in the following flow diagram.

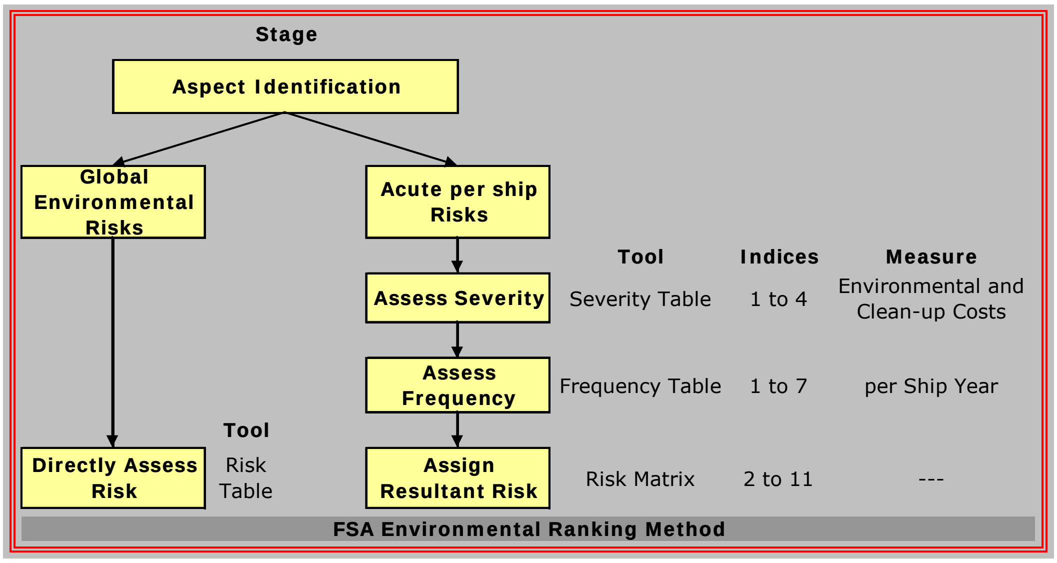


Figure 4.2 Proposed Environmental Ranking Method

Equivalence between the Environmental Risk Index and the Safety Risk Index

4.2.4 The Risk Indices used have been chosen so that there is a broad equivalence between safety and environmental risks with the same risk index allowing for ranking of risks on a combined safety and environmental basis.

4.2.5 The basis of this equivalence is financial. For a given value of risk index, the safety harm (based on a value of preventing a fatality of $3,000,000) is the same as the environmental harm (comprising environmental cost and clean-up cost).

4.3 Proposed Environmental Ranking Criteria – Global Environmental Risks

4.3.1 Global effects do not require the three stage process (as they are largely chronic effects and are therefore going to occur) and the Risk Index can be directly assigned from a Risk Index Table This Table is based on the effect of global shipping on the environment.

4.3.2 The first column (Description) is based on a financial value of the environmental harm (made up of the environmental costs and clean up costs) to the world environment from the world fleet of shipping.

4.3.3 It then gives additional information on:

a. The impact;

b. Examples appropriate to shipping;

c. The potential stakeholders.

4.3.4 The second column (Direction of Change) relates to whether the situation is deteriorating or improving based on existing trends in world shipping

4.3.5 The third column (Risk Index) is the value of risk index that matches the description.

Risk Table

4.3.6 A proposed Risk Table is shown at Table 4.5.

Risk Table for Global Environmental Risks		
Description	**Direction of change**	**Risk Index**
Indicative environmental harm (environmental and clean-up costs) to the world environment of the order of $1,500M per year	***Deteriorating situation***	7↑
	Status quo	7
Impact: Regional/federal scale impacts or impacts over extensive sea areas or coasts encompassing groups of nations. Direct and indirect impacts are generally very large scale and long-term. May be cumulative. Acute events may represent a national threat, or may have substantial trans-boundary implications. **Examples:** Use of non-renewable fossil fuels by ships worldwide contributing to cumulative resource depletion and climate change processes; introduction of invasive, non-native Zebra mussel into Canadian Great Lakes with persistent, massive indirect environmental and economic consequences. ***Stakeholders:*** Strong negative international responses. Investigation and mitigation involves international resources/co-operation and large environmental trade-offs.	***Improving situation***	7↓
Indicative environmental harm (environmental and clean-up costs) to the world environment of the order of $150M per year	***Deteriorating situation***	6↑
	Status quo	6
Impact: Regional/federal scale impacts or impacts over extensive sea areas or coasts, where chronic impacts arise from very high numbers of low level chronic processes (e.g. CO_2 or VOC emissions). Acute direct and indirect impacts may be large-scale, long-term, environmentally, socially and economically damaging or resource depleting. Unlikely to represent a national threat but may have trans-boundary implications. **Examples:** Energy loss from ships through inefficient recapture of waste heat , disproportionate transfer of environmental burden (pollution and wastes) from developed to transitional or developing states during certain ship decommissioning operations; internationally significant Tier 1 spills in highly environmentally sensitive or commercially important environments. ***Stakeholders:*** Negative national responses. Investigation or mitigation may involve national and/or international resources and environmental trade-offs.	***Improving situation***	6↓

Risk Table for Global Environmental Risks		
Description	**Direction of change**	**Risk Index**
Indicative environmental harm (environmental and clean-up costs) to the world environment of the order of $15M per year ***Impact:*** Mainly negative, larger-scale operational impacts that industry aims to control or maintain within prescribed limits or requirements. These are recorded/reported at a national level but generally occur in the vicinity of individual vessels at sea, in areas where vessels are concentrated (ports/shipping lanes), at ship yards, waste treatment or disposal sites, ship breakers yards, or in the supply chain. Chronic impacts involve localised nuisance, interference, pollution, environmental and social disruption, resource usage and low level inputs to cumulative processes. Also encompasses acute impacts arising from incidents such as maritime spills, collisions and overboard losses of cargo. May represent a local threat. **Examples:** Routine discharge of treated oily bilge water; leaching of chemicals from antifouling coatings (chronic); Tier 1 or Tier 2 spills in areas that are not particularly sensitive or vulnerable ***Stakeholders:*** Ranges from no response to negative local or national responses (depending on the issue). Mitigation may involve local or national resources (at worst).	***Deteriorating situation*** ***Status quo*** ***Improving situation***	5↑ 5 5↓
Indicative environmental harm (environmental and clean-up costs) to the world environment of the order of $1.5M per year ***Impact:*** Mainly negative, smaller-scale operational impacts that industry generally maintains within prescribed limits or requirements. Acute impacts are generally highly localised and short-term. Also encompasses smaller-scale chronic impacts. **Examples:** Routine discharge comminuted sewage in non-sensitive areas; Tier 3 spills in non-sensitive areas. ***Stakeholders:*** Strongly negative local responses (depending on the issue). Most issues will not evoke a response. Mitigation involves well established techniques.	***Deteriorating situation*** ***Status quo*** ***Improving situation***	4↑ 4 4↓
Indicative environmental harm (environmental and clean-up costs) to the world environment of the order of $150,000 per year ***Impact:*** Encompasses small localised negative impacts from very small scale acute and chronic events. ***Examples:*** Overboard loss of small quantities of lubricants washed off decks by rain or sea spray or impacts of anchors on sea beds in locations that the not environmentally sensitive. ***Stakeholders***: Generally not concerned. Mitigation often not required.	Not applicable	3
Positive ***Impact:*** *Beneficial change (improvement or enhancement) to environmental or social conditions.* ***Example:*** reinstatement of a previously polluted area of shoreline. ***Stakeholders:*** Approval or support. Level of confidence in solutions and outcomes depends in approach (some are experimental).	Not applicable	Positive

Table 4.5 Risk Table – Global Environmental Risks

4.4 Proposed Environmental Ranking Criteria - Per Ship Environmental Risks

4.4.1 Per ship risks require the same three-stage process as safety. The severity index is based on the severity of an event from a single ship and can be assigned from a severity table.

4.4.2 The table is based on the impact of a specific ship incident on the environment;

4.4.3 The first column (Severity Index) is the value of severity index that matches the description;

4.4.4 The second column (Description) is based on the financial value of the environmental harm (made up environmental cost and clean up cost) to the environment from a single ship.

4.4.5 It then gives additional information on:

a. Environmental costs;

b. Clean-up costs.

Severity Table

4.4.6 A proposed severity Table is shown below at Table 4.6.

Severity Table for Per Ship Environmental Risks	
Severity Index	**Description of the effect on the environment**
6	**Indicative environmental harm (environmental cost and clean-up cost) per ship of the order of $3,000M** <u>Environmental Costs</u> Internationally significant degradation, damage or loss of ecologically, commercially or culturally important habitats, species or biodiversity. Generally: impacts extensive; long-term with poor potential for recovery. Includes trans-boundary impacts. Internationally significant pollution of the atmosphere, marine environment, coast or land (including very damaging Tier 1 incidents in ecologically sensitive or commercially important environments). Massive usage, depletion or wastage of scarce or non-renewable resources; usage of toxic or noxious materials; transfer of hazardous wastes, pollution or other environmental problems to inappropriate locations or media with international implications; or constraints relating to the management of these impacts. Internationally significant effects on human health or well being. Internationally significant losses of income, public finances, amenity, cultural heritage or resources. Long-term or widespread social disruption (including other infrastructure, supply chain, users of the coast, seas, ports). Strong negative response from international or national stakeholders. <u>Clean-up Costs</u> Clean-up, remediation or abatement generally requires massive international resources.

Severity Table for Per Ship Environmental Risks	
Severity Index	Description of the effect on the environment
5	**Indicative environmental harm (environmental cost and clean-up cost) per ship of the order of $300M** Environmental Costs Nationally significant degradation, damage or loss of ecologically, commercially or culturally important habitats, species or biodiversity. Generally: Impacts extensive; can be long-term with poor potential for recovery. Potential for trans-boundary impacts. Nationally significant pollution of the atmosphere, marine environment, coast or land (including Tier 1 incidents). Large-scale usage, depletion or wastage of scarce or non-renewable resources; usage of toxic or noxious materials; transfer of wastes, pollution or other environmental problems to inappropriate locations or media with national implications; or constraints relating to the management of these impacts. Nationally significant or serious locally significant effects (affecting communities) on human health or well being. Nationally significant or serious locally significant losses of income, public finances, amenity, cultural heritage or resources. Nationally significant or serious locally significant social disruption (including other infrastructure, supply chain, users of the coast, seas, ports). Strong negative response from national stakeholders (may escalate to international level). Clean-up Costs Clean-up, remediation or abatement requires national resources (may escalate to international resources).

Severity Table for Per Ship Environmental Risks	
Severity Index	**Description of the effect on the environment**
4	**Indicative environmental harm (environmental cost and clean-up cost) per ship of the order of $30M** <u>Environmental Costs</u> Locally significant degradation, damage or loss of ecologically, commercially or culturally important habitats, species or biodiversity. Impacts may be extensive or localised; may be long-term with poor potential for recovery. Locally significant pollution of the atmosphere, marine environment, coast or land (including Tier 2 and 3 incidents). Locally significant usage, depletion or wastage of scarce or non-renewable resources; usage of toxic or noxious materials; transfer of wastes, pollution or other environmental problems to inappropriate locations or media with local or national implications; or constraints relating to the management of these impacts. Temporary effects on human health involving individuals or longer-term effects on human well being involving communities. Locally significant temporary loss of income, public finances, amenity, cultural heritage or resources. Locally significant social disruption. Strong negative response by local stakeholders (may escalate to national level). <u>Clean-up Costs</u> Clean-up, remediation or abatement requires local resources (may escalate to national resources).

Severity Table for Per Ship Environmental Risks	
Severity Index	**Description of the effect on the environment**
3	**Indicative environmental harm (environmental cost and clean-up cost) per ship of the order of $3M** Environmental Costs Locally significant degradation, damage or loss of ecologically, commercially or culturally important habitats, species or biodiversity. Impacts generally localised with good potential for recovery. Locally significant pollution of the atmosphere, marine environment, coast or land (including Tier 3 incidents). Small-scale usage, depletion or wastage of scarce or non-renewable resources. Usage of toxic or noxious materials; transfer of wastes, pollution or other environmental problems generally not an issue. Temporary effects on well being individuals and not communities. Short-term nuisance or local temporary loss of amenity, resources and income to individuals rather than communities, with no risk public finances or cultural heritage. Social disruption generally not an issue. Negative response by local stakeholders. Clean-up Costs Clean-up, remediation or abatement dealt with by company resources.
2	**Indicative environmental harm (environmental cost and clean-up cost) per ship of the order of $300,000** Environmental Costs Localised, transient ecological disruption, close to the source of the effect, generally with prospects of with rapid recovery. Localised deterioration in water quality, or shoreline/ground contamination . Small Tier 3 oil spill affecting a single shoreline area Transient nuisance. Local concern by stakeholders. Clean-up Costs Ship-borne and external response costs.

Severity Table for Per Ship Environmental Risks	
Severity Index	**Description of the effect on the environment**
1	**Indicative environmental harm (environmental cost and clean-up cost) per ship of the order of $30,000** Environmental Costs Very small tier 3 event. Clean-up Costs Ship-borne and external response costs
Positive	**Positive** Environmental or social improvement or enhancement.

Table 4.6 Severity Table – Per Ship Environmental Risks

Frequency Table

4.4.7 The proposed Frequency Table is unchanged.

Frequency Index			
FI	FREQUENCY	DEFINITION	F (per ship year)
7	Frequent	Likely to occur once per month on one ship	10
5	Reasonably probable	Likely to occur once per year in a fleet of 10 ships, i.e. likely to occur a few times during the ship's life	0.1
3	Remote	Likely to occur once per year in a fleet of 1000 ships, i.e. likely to occur in the total life of several similar ships	10^{-3}
1	Extremely remote	Likely to occur once in the lifetime (20 years) of a world fleet of 5000 ships.	10^{-5}

Table 4.7 Frequency Table - Per Ship Environmental Risks

Risk Matrix

4.4.8 The resulting Risk Matrix is an extended version of the safety risk matrix to accommodate severity indices 5 and 6

Risk Index (RI)							
		SEVERITY (SI)					
FI	FREQUENCY	**1**	**2**	**3**	**4**	**5**	**6**
7	Frequent	8	9	10	11		
6		7	8	9	10	11	
5	Reasonably probable	6	7	8	9	10	11
4		5	6	7	8	9	10
3	Remote	4	5	6	7	8	9
2		3	4	5	6	7	8
1	Extremely Remote	2	3	4	5	6	7

Table 4.8 Risk Matrix - Per Ship Environmental Risks

4.5 Measures and Tolerability of Environmental Risk

Safety Measures and Tolerability

4.5.1 The measures and tolerability for safety risk in FSA are based on:

a. There being two fundamental measures of risk, individual risk and societal risk;

b. The basic criterion for tolerability being that there are three levels of risk: Intolerable, Negligible and the area in-between where it has to be proved that the risks have been reduced to that which is As Low As Reasonably Practicable (ALARP);

c. The applicability of the ALARP criteria to both individual and societal risks can be applied.

4.5.2 The FSA guidelines do not set levels of intolerable or negligible risk or the range of risk that is required to be ALARP. These levels are implied by the decision making at the IMO which in turn is in part guided by the body of work outside FSA that seeks to put values on these.

Environmental Measures and Tolerability

4.5.3 Environmental risk does not make the split between individual and societal risk in the same way. Environmental risks are holistic in nature and are therefore more like societal risks.

4.5.4 The basic criterion for Environmental risks is similar to Safety but tends to use slightly different terminology. This is:

a. Intolerable (also intolerable in FSA);

b. Acceptable (negligible in FSA);

c. Tolerable for the region in between where the activity can continue if the trade-off between societal benefits and environmental/social penalties can be justified (ALARP region in FSA);

d. Beneficial which will or could potentially deliver benefits or improvements.

4.5.5 The criteria for tolerability can be based on ALARP (as with safety) or other techniques such as:

a. BPEO (Best Practicable Environmental Option);

b. BATNEEC (Best Available Techniques Not Entailing Excessive Cost);

c. BAT (Best Available Technique).

Best Practicable Environmental Option

4.5.6 The Best Practicable Environmental Option (BPEO) [Reference 7], is a set of procedures adopted by the UK with the goal of managing waste and other environmental concerns.

4.5.7 It was first introduced in 1976 by the Royal Commission on Environmental Pollution (RCEP) and "emphasises the protection and conservation of the environment across land, air and water. The BPEO procedure establishes for a given set of objectives, the option that provides the most benefits or the least damage to the environment, as a whole, at acceptable cost, in the long term as well as in the short term."

4.5.8 Noting that removal of pollution from air could result in increased pollution of land and water, the RCEP advocated an "optimum combination of available methods of disposal so as to limit damage to the environment [as a whole] to the greatest extent achievable for a reasonable and acceptable … cost".

4.5.9 The RCEP's 12th Report (1988) proposed a formal definition and procedure for BPEO, as: "the outcome of a systematic and consultative decision-making procedure .… the option that provides the most benefit and the least damage to the environment [across air, water and land] as a whole, at acceptable cost, in the long term as well as in the short term."

4.5.10 BPEO was included in Part 1 of the Environmental Protection Act 1990 as a basis for the authorisation of processes under the Integrated Pollution Control (IPC) regime – the only reference to BPEO in UK primary legislation.

Best Available Techniques Not Entailing Excessive Cost

4.5.11 The Best Available Techniques Not Entailing Excessive Cost (BATNEEC) principal is one of the key elements of the UK Environmental Protection Act 1990.

4.5.12 The application of BATNEEC normally means that the additional costs of avoiding environmental damage are justified by the benefits. Therefore, BATNEEC would not require the reduction of risk from 'low' to 'negligible' if that would require very expensive techniques.

4.5.13 Under the Environmental Protection Act 1990, the BATNEEC criterion is applied in Integrated Pollution Control (IPC) and in the management of risks from the release of genetically modified organisms to the environment.

4.5.14 Importantly, the application of BATNEEC means that the estimation of the risk associated with a particular activity can change over time as new techniques and technologies are developed, and the costs of existing techniques vary. Such changes may warrant another iteration of the whole risk assessment process. The BATNEEC criterion relies not only on technological solutions, but includes other approaches such as environmental management systems and staff training.

Best Available Technique

4.5.15 Best Available Techniques (BAT) are defined by European Commission (EC) Directive 96/61 as

'the most effective and advanced stage in the development of activities and their methods of operation, which indicates the practicable suitability of particular techniques for providing the basis for emission limit values designed to prevent, and where that is not practicable, generally to reduce the emissions and the impact on the environment as a whole'.

4.5.16 This definition implies that BAT not only covers the technology used but also the way in which the installation is operated, to ensure a high level of environmental protection as a whole. BAT takes into account the balance between the costs and environmental benefits.

4.5.17 Summary definitions of the meaning of BAT are given below:

a. "Best" means, in relation to techniques, the most effective in achieving a high general level of protection of the environment as a whole;

b. "Available Techniques" means those techniques which have been developed on a scale, which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the cost and advantages, whether or not the techniques are used or produced inside the United Kingdom, as long as they are reasonably accessible to the operator;

c. "Techniques" includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned.

4.6 Example of Calculation of Indices for Environmental Cost Effectiveness

Safety Calculations

4.6.1 The calculations in FSA is based on Gross Cost of Averting a Fatality (Gross CAF) and Net Cost of Averting a Fatality (NCAF). Their definitions are:

a. Gross CAF = $\Delta C/\Delta R$

b. Net CAF = $\Delta C\text{-}\Delta B/\Delta R$

ΔC is the cost per ship of the risk control option

ΔB is the economic benefit per ship resulting from the implementation of the risk control option (this may also include pollution prevented)

ΔR is the risk reduction per ship, in terms of the number of fatalities averted, implied by the risk control option

Environmental Calculations

4.6.2 The basis of the environmental calculations should be the same, namely cost of averting "environmental harm". However there is not a "unit of environmental harm" as there is with safety where the "unit of safety harm" is a fatality (or fatality per year).

4.6.3 The "environmental harm" has to be calculated based on cost and is made up of:

a. The Clean-up Cost;

b. And the Environmental Cost.

4.6.4 The equivalent calculation is then Gross Cost for Averting Pollution (Gross CAP) and Net Cost for Averting Pollution (Net CAP):

a. Gross CAP = $\Delta C/\Delta E$

b. Net CAP = $\Delta C-\Delta B/\Delta E$

4.6.5 ΔE is the environmental improvement per ship in terms of the reduction in clean-up costs and in the environmental cost, implied by the risk control option.

Clean-up Costs

4.6.6 The Clean-up Cost is the tangible cost associated with the clean-up and compensation for loss of business and amenity during the clean-up. An example of a calculation of Clean-up Costs for oil spills is $60,000 per tonne (SAFEDOR in 2005) but there is much debate about the appropriateness of this figure.

Environmental Costs

4.6.7 The Environmental Cost is the intangible value set on the damage to the environment from an activity and the loss of amenity to humans. These costs, sometimes referred to as appraisal values, are not universally agreed and the FSA submission will need to propose and justify the values used.

4.6.8 Some examples of values of Environmental Costs are shown in Table 4.9. together with and overview of why they are used and by who. However as these numbers are not agreed, until agreed numbers emerge it will be necessary for each FSA to propose and justify the values used.

4.6.9 This is not an exhaustive list, in a given FSA appraisal values may have to be derived for any of the environmental aspects listed in Annex C.

Environmental Aspect	Abatement Technology with an associated Cost to a Ship	Indirect Environmental Cost with an associated cost to Society	Appraisal Values for the Environmental Cost
CO2 emissions from fuel combustion	Development and implementation of lean burn engines.	Cost and implementation of development of carbon capture technology.	£15.09 per tonne (under the EU Emission trading scheme). £25 per tonne (the UK shadow price).[1]
SO2 emissions from fuel combustion	Conversion of existing fleet to adapt to USLD.	Energy and emissions costs associated with removal of sulphur from fuel.	$860 per tonne (2006).
Waste generated from vessels	Development of recycling receiving facilities in ports around the world, construction of more recycling facilities.	Energy costs associated with recycling.	£24 per tonne (in the UK as of 1st April 2007 for landfill).
Oil in produced water	Improvement in separation equipment on vessels. Development of legislation to reduce oil in water content discharged.	Energy costs associated with increased oil in water treatment mechanisms.	£140,000 per tonne (under the BERR Produced Water Trading Scheme).
Ballast Water (Australia)	Avoidance of damage to tourism, public health and aquaculture.	Damage to tourism, public health and aquaculture.	$2 per tonne of ballast discharged.

Table 4.9 Examples of Appraisal Values for Environmental Costs

4.6.10 There is a trend in national legislation for intangible environmental costs to be transferred to being tangible costs through taxation. Some of the examples above are based on taxation values.

4.6.11 If such taxation (or other cost measure) is introduced into international shipping then care must be taken to make sure the environmental cost is not double counted in both the environmental harm calculations and the business cost calculations.

[1] This is an example of how there are not agreed values of environmental costs

5 Conclusions

5.1 Overview

Aims

5.1.1 The aim was to research and develop Environmental Risk Criteria that can be used alongside safety criteria when applying the International Maritime Organisation's Formal Safety Assessment process to risk control options that have environmental consequences as well as safety, property and business consequences.

Nature of Environmental Risks

5.1.2 The Environmental Risk Criteria differs to safety as environmental risks are both chronic and acute while safety risks tend to be acute. Environmental risks tend to cover a wider range of issues including multiple species harm, persistence, reversibility, concentration by the food chain, location, time of day/year, variety of pollutants, cumulative and in-combination effects, detection times and the balance between benefits and harm.

5.1.3 This report explores these issues and more, which is supported by the annexes on the Scope of Environmental Risk Criteria (Annex B) and the Environmental Aspects of Marine Operations (Annex C).

5.1.4 There are many existing Environmental Risk Criteria used by a variety of organisations including some defined in international standards, which vary considerably in complexity.

5.2 Main Proposal Resulting from the Research

5.2.1 Using this research and experience at the Workshops as part of this study a method for assigning a Risk Index value to an environmental aspect of shipping operations has been proposed.

5.2.2 Two methods of assigning a risk index are proposed for further consideration and consultation. These are:

a. For the global environmental effect of all shipping on the environment from the every day running of a ship, such as emissions and discharges to the environment;

b. For the effect on the environment from unintended events which have a probability of occurring, such as an oil spill.

5.2.3 This process is a single step process for assessing the global environmental effect of all shipping

5.2.4 It is a development of FSA's current "severity x frequency = risk" process for assessing the per ship risks of unintended events.

5.2.5 The environmental risk criteria have been set so that environmental risk index values are broadly equivalent with safety for ranking purposes.

5.2.6 The environmental risk criteria are based on the consequence being defined in terms of Environmental Harm and that Environmental Harm is based on the sum of the "Clean-up Cost" and the "Environmental Cost".

5.3 Interface with Formal Safety Assessment

5.3.1 This document has been written to interface with the current FSA Guidelines, where the correlation can be shown in Figure 5.1. This indicates those sections of the FSA Guidelines that may have to be developed to introduce require Environmental Risk Criteria.

5.3.2 The Diagram at Figure 5.1 indicates the relationship between this document and the FSA Guidelines [Reference 2]].

	FSA Guidelines		
1	Introduction		
2	Basic Terminology		
3	Methodology		
4	Problem Definition	→	Problem Definition (Report Section 2)
5	FSA Step 1		
6	FSA Step 2		
7	FSA Step 3		
8	FSA Step 4		
9	FSA Step 5		
10	Presentation of Results		
	Appendices		
1	Guidance on HRA		
2	Examples of Hazards	→	Required Scope of Environmental Risk Criteria (Report Annex B)
		→	Examples of Environmental Aspects of Shipping Report Annex C)
3	Hazard identification and risk analysis techniques		
4	Initial ranking of accident scenarios	→	Initial Ranking of Environmental Aspects (Report Section 4.1)
5	Measures and tolerability of risks	→	Measures and Tolerability of Environmental Risk (Report Section 4.2)
6	Attributes of risk control measures		
7	Examples of calculation of indices for cost effectiveness	→	Example of Calculation of Indices for Environmental Cost Effectiveness (Report Section 4.3)
8	Standard format for reporting an application of FSA to IMO		

Relationship between Environmental Risk Criteria and the Formal Safety Assessment Guidelines

Figure 5.1 Relationship between this document and FSA Guidelines

6 References

1 International Maritime Organization Maritime Safety Committee 83rd session Agenda item 21MSC 83/INF.2. Formal Safety Assessment Consolidated text of the Guidelines for Formal Safety Assessment (FSA) for use in the IMO rule-making process (MSC/Circ.1023−MEPC/Circ.392) Note by the Secretariat. 14 May 2007

2 Guidelines for Formal Safety Assessment (FSA) for use in the IMO Rule-Making Process. International Maritime Organization (IMO) MEPC/Circ.392. Dated 05 April 2002;

3 SAFEDOR Risk Evaluation Criteria. Design, Operation and Regulation for Safety Project No.: IP-516278, Report Reference SAFEDOR-D-4.5.2-2005-10-21-DNV. Dated 21 October 2005;

4 Marine Environment Protection Committee 56th session Agenda item 18 MEPC 56/18/1 Formal Safety Assessment Environmental Risk Evaluation Criteria, Submitted by Greece. Dated 4 May 2007;

5 Marine Environment Protection Committee 56th session Agenda item 18 (MEPC 56/18) Formal Safety Assessment Outcome of MSC 82 on FSA Note by the Secretariat. Dated 22 February 2007;

6 Letter of contract award from the MCA, Reference MSA 10/9/261. Dated 22 October 2007;

7 Guidelines for Environmental Risk Assessment and Management Chapter 6. http://www.defra.gov.uk/ENVIRONMENT/risk/eramguide/07.htm. Accessed 30 November 2007;

8 The Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) (Amendment) Regulations 2007 Statutory Instrument 2007 No. 933.

ANNEX A
Methodology of the Task

Contents

Page No.

A1 Research Project 591

A1.1 BMT Approach to the task

A1.1.1 This project has been conducted in accordance with the programme outlined in the Tender Response [Reference 1].

A1.2 Stage 1 - Start Up Meeting

A1.2.1 A start up meeting was held at the MCA Offices on 18 August 2007 at Spring Place, Southampton. The aim of this meeting was to agree the source information used for the project and to agree the scope and timescales of the project. The meeting was attended by Project Staff from BMT Isis, BMT Cordah and the MCA. Meeting minutes were produced by BMT Isis and circulated to all attendees.

A1.3 Stage 2 - Research, Data Collation and Analysis

A1.3.1 The source information identified was analysed to assist in better understanding the history and current status surrounding the development of Environmental Risk Criteria in a snapshot of time. This data was used to collate issues for discussion at the Progress Meeting and Workshops where stakeholder consultation has taken place.

A1.4 Stage 3 - Drafting of Suggested Criteria and Progress Meeting 1

A1.4.1 Based on the research, data collection and analysis stage, BMT drafted example environmental risk criteria for inclusion in the FSA model, which was presented at Workshop 1.

A1.4.2 The draft criteria was circulated to relevant parties prior to Workshop 1 to allow foresight of the criteria. Any comments were discussed at Workshop 1 and a summary of the discussion points are provided at Annex E.

A1.5 Stage 4 - Workshop 1 - Criteria Development

A1.5.1 A one-day workshop was held at the MCA Offices in Southampton on 05 November 2007 chaired by BMT and attended by internal and external stakeholders and members of the BMT Project Team. A full list of stakeholders is available upon request.

A1.5.2 The aim of this workshop was to the refine the criteria based on the stakeholder expertise and experience.

A1.6 Stage 5 - Workshop 2 - Testing of Criteria

A1.6.1 The second one-day workshop held at the MCA Offices in Southampton on 12 November 2007 was designed to refine and test the criteria on a fictional scenario in order to gauge their effectiveness and adjust the criteria as necessary. A summary of the findings are presented at Annex E.

A1.7 Stage 6 - Peer Review of Report and Final Production

A1.7.1 This Report is the product of a Customer Comment/stakeholder review period where by stakeholder comments have been incorporated where applicable.

A1.8 Endorsement by Stakeholders

A1.8.1 This Report is based on a range of inputs from BMT, the MCA and external stakeholders. It therefore does not imply that the report is endorsed by either the stakeholders or the organisations they represent who may want to make formal comments when the report is presented at the IMO.

A2 References

1 Tender Response Research Project 591 - Environmental Risk Criteria
Reference: 50012/D0127/Issue 1 Dated September 2007

ANNEX B
Required Scope of Environmental Risk Criteria

Contents

Page No.

Figures

B1 Introduction

B1.1 Purpose of this Annex

B1.1.1 The purpose of this annex is define the range of issues that Environmental Risk Criteria should cover. Existing and proposed Environmental Risk Criteria can then be reviewed against this definition.

B1.2 Link to the FSA Guidelines

B1.2.1 This annex can be regarded as an environmental extension to the following parts of the FSA guidelines:

a. Appendix 4 – Initial ranking of accident scenarios;

b. Appendix 5 – Measures and tolerability of risks;

c. Appendix 7 – Example of calculation indices for cost effectiveness.

B2 Definition of Risk

B2.1 Definition of Safety Risk

B2.1.1 Safety risk is made up of three components:

a. Probability (referred to as frequency in FSA);

b. Consequence (referred to as severity in FSA);

c. Uncertainty (in the estimates of probability and consequence).

B2.1.2 The combination of probability and consequence is the level of safety risk (referred to as the risk index in FSA).

B2.2 Definition of Environmental Risk

B2.2.1 Environmental risk is made up of the same three components

a. Probability (often called likelihood);

b. Consequence (often called severity);

c. Uncertainty in the estimates of probability and consequence.

B2.2.2 The combination of probability and consequence is the level of environmental risk (often called environmental significance). An environmental risk criteria should cover all three.

B3 Purpose of Environmental Risk Criteria

B3.1 Safety Risk Criteria in FSA

B3.1.1 The use of well-defined and simple to use safety risk concepts has allowed the FSA model to be a powerful and flexible approach to addressing a wide range of issues that can improve maritime safety.

B3.2 The Need for Environmental Risk Criteria in FSA

B3.2.1 To extend this to environmental damage, well defined and simple to use methods of environmental risk concepts are also required. In particular, there needs to be a suitable method:

a. Of quantifying environmental risk;

b. For judging tolerability;

c. Of defining equivalence between safety risk and environmental risk;

d. Identifying of the cost effectiveness of environmental risk reduction.

B4 Issues Associated with Probability

B4.1 Overview

B4.1.1 There are issues associated with the probability of an event that leads to an environmental risk that make it very different from safety risk. These can be summarised as:

a. Acute and. chronic risk;

b. Accidental and deliberate acts;

c. Legal and. illegal acts.

B4.2 Acute and. Chronic Risk

B4.2.1 Safety events in shipping (and hence the risks of them) tend to be acute, i.e. they are the results of accidents. Shipping operations do not plan to deliberately break someone's arm even though there may be a measurable statistical risk of doing so.

B4.2.2 There are chronic risks in shipping, such as poisoning, cancer from exposure to materials, onset of hearing loss due to noise exposure, repetitive events, etc. These may be made worse by lack of available treatment. However the current FSA criteria are not targeted at these types of risk.

B4.2.3 The published FSA safety criteria are therefore, mostly aimed at acute risks.

B4.2.4 Environmental events in shipping are both acute events and chronic conditions and these will have comparable importance.

B4.2.5 The FSA environmental risk criteria need to cover both acute and chronic risks.

Example
An example of an event leading to an acute environmental risk is an accidental vessel collision that leads to an oil spill. As example of a condition leading to a chronic environmental risk is the Sulphur Dioxide emissions from engines.

B4.3 Accidental and Deliberate Acts

B4.3.1 In addition, both acute and chronic environmental events in shipping can be both accidental and deliberate.

B4.3.2 The FSA environmental criteria need to cover doth accidental and deliberate acts.

Example
An example of an accidental event leading to an acute risk is oil spill from a shipwreck (Sea Empress).
As example of a deliberate event leading to an acute risk is the emergency lightering of cargo from a stranded vessel.
An example of a accidental event leading to an chronic risk is bio-fouling.
An example of a deliberate event leading to chronic risk is ballast water exchange

B4.4 Legal and Illegal Acts

B4.4.1 In addition deliberate environmental events in shipping can be both legal and illegal.

B4.4.2 The FSA environmental criteria need to cover both legal and illegal acts.

Example
An example of a legal deliberate act is ballast water exchange.
An example of an illegal deliberate act is a discharge after a tank cleaning.

B5 Issues Associated with Consequence

B5.1 Overview

B5.1.1 There are issues associated with environmental risk that make it very different from safety risk. These are overlapping but can be summarised as:

a. Multiple Species Harm;

b. Persistence;

c. Reversibility;

d. Escalation/concentration by the food chain;

e. Location and time of year/day;

f. Variety of the pollutants;

g. Cumulative and in-combination effects;

h. Detection time;

i. Environmental benefits vs. environmental harm.

B5.2 Multiple Species Harm

B5.2.1 A safety event is an event that affects humans (i.e. a single species) and safety events are judged on the damage to a single species.

B5.2.2 An environmental event can cause damage that can be expressed at different levels such as organism level, population level, habitat level or ecosystem level. They can also cause harm to marine, land and atmospheric ecosystems.

B5.2.3 The event can cross habitat, species, distribution and time boundaries and affect multiple species in a wide range of ecosystems. An event in one area will not have the same effect as the same event in another. There are many contributing factors such as species composition, vulnerability etc that must also be taken into consideration.

B5.2.4 Environmental events may affect many species and there may be anthropological priorities between them.

Example
An example of multi species harm and priorities between species is the focus on the effects of pollution on marine mammals and birds.

B5.3 Persistence

B5.3.1 Safety events are generally fixed in time. This is not the case with environmental events where the pollutant may persist in the environment over a period. Therefore, the effects of an incident may be unknown.

Example
An example of short persistence is the release of a highly volatile liquid such as petrol. An example of long persistence is the release of Polychlorinated biphenyls (PCBs)

B5.4 Reversibility

B5.4.1 Many safety events are not reversible; the deceased are not recoverable whereas the environment potentially can be. In many instances, a habitat may undergo natural or human assisted remediation resulting in return to original conditions or close to them. The reversibility is variable and must be considered at ecosystem level i.e. habitats, species and all interacting factors. Some components of the ecosystem will be more able to recover naturally.

Example
An example of good reversibility is oil spill damage to a salt marsh. An example of poor reversibility is damage to an already threatened local population

B5.5 Escalation/Concentration by the Food Chain

B5.5.1 Apart from risk to rescuers, safety events in shipping do not generally physically affect anybody else, other than the people initially involved.

B5.5.2 Environmental events are different, environmental pollution can be concentrated by the food chain. This can lead to initially low levels of toxicity becoming high in higher animals in the chain including humans. This is not usually the case for single acute events but more likely to be caused by chronic conditions or a series of acute events. Environmental risk criteria need to recognise this effect.

Example
An example of concentration by the food chain is PCBs. While they have low concentrations in the sea they can, and do, concentrate in the food chain to the point that some dead whales have to be treated as toxic waste.

B5.6 Location and Time

B5.6.1 The impact of Safety events are often independent of location and time.

B5.6.2 Environmental events are often dominated by them. The impact of an environmental event is highly affected by its location, time of year, weather and numerous other geographical and climatic circumstances. An event in one area will not have the same effect as the same event in another area. An event at one time of year will not have the same effect as the same event occurring at another time of year.

Example
One tonne of oil spilt in a coastal environment during the breeding season will not have the same effect as the same spill at the same place outside a breeding season.

B5.7 Variety of the Pollutants

B5.7.1 While the range of pollutants from ships is reasonably well defined and understood, the range of pollutants from the cargoes carried by them may be very large and may not always be known at the time of an incident. The effect will also be dependant on the packaging of products.

Example
The contents of the containers on the MSC Napoli were not fully known to the SOSREP at the time that decisions had to be made on the actions to save the vessel.

B5.8 Cumulative and In-Combination Risks

B5.8.1 Safety events are usually isolated but environmental effects are not. Environmental harm can build up from the cumulative effects of many similar events. Separate events in-combination may have a dramatically different effect than if the events had happened in isolation.

Example
A population of birds and fish, already threatened by chronic pollution, is further affected by a bunker spill from a grounded cargo vessel.

B5.9 Detection Time

B5.9.1 The harm caused by the type of safety events typically addressed by FSA is usually apparent at the time though there may be long-term exposure effects.

B5.9.2 With environmental events there may be a significant length of time before the effect is noticed, let alone quantified. This time can be years, decades or even centuries.

Example
An example of an effect with a long detection time is the effect of CFC on the ozone layers. It was many decades before the effect was noticed and the harm quantified.

B5.10 Environmental Benefits and. Environmental Harm

B5.10.1 An environmental risk can be made up of aspects that create benefits as well as aspects that cause harm. Environmental risk criteria have to recognise this and provide a mechanism for prioritising environmental risk against harm.

B6 Issues Associated with Uncertainty

B6.1.1 The FSA guidelines deal with uncertainty during Step 2, determination of areas needing control, as shown in Figure 1.

7.2 Methods

7.2.1 Determination of areas needing control

The purpose of focusing risks is to screen the output of step 2 so that the effort is focused on the areas most needing risk control. The main aspects to making this assessment are to review:

.1 risk levels, by considering frequency of occurrence together with the severity of outcomes. Accidents with an unacceptable risk level become the primary focus;

.2 probability, by identifying the areas of the risk model that have the highest probability of occurrence. These should be addressed irrespective of the severity of the outcome;

.3 severity, by identifying the areas of the risk model that contribute to highest severity outcomes. These should be addressed irrespective of their probability; and

.4 confidence, by identifying areas where the risk model has considerable uncertainty either in risk, severity or probability. These uncertain areas should be addressed.

Figure 1 - Extract from FSA Guidelines Regarding Uncertainty

B6.1.2 Environmental risk criteria need to record information so that a similar set of decisions can be made. In particular to record the uncertainty in severity.

B7 Issues Associated with Tolerability

B7.1.1 The FSA guidelines address tolerability in two ways.

B7.1.2 The first is to recognise that there are two different types of safety risk, individual risk and societal risk. Individual risk is the risk to an individual in isolation while societal risk is the risk to society of a major accident.

B7.1.3 The second is to recognise that there are three levels of safety risk, intolerable, negligible and the region in-between where the risk needs to be demonstrated to be As Low As Reasonably Practicable (ALARP).

B7.1.4 In practice most marine safety risks investigated by FSA fall into the ALARP region.

B7.1.5 The environmental risk tolerability needs to be defined in similar ways with intolerable and negligible and an area in-between where a concept similar to ALARP will have to be applied. An example of such a criteria is Best Practicable Environmental Options (BPEO).

B8 Issues Associated with Equivalence to Safety

B8.1.1 The formal safety assessment guidelines provide only a general equivalence between safety risk and environmental risk.

B8.1.2 This is based on assessing the Ship Accident Loss in terms of Cost per Ship per Year.

B8.1.3 The Ship Accident Loss is made up of the sum of:

a. Ship Accident Cost (£)

b. Environmental damage and clean up (£/tonne x number of tonnes)

c. Risk to life (Fatalities x Cost of a fatality)

d. Risk of injuries and ill health (Disabled Adjourned Life Years x Cost of a DALY

B8.1.4 However the implication of this is that the equivalence to safely should be in terms of cost.

B8.1.5 The cost should be made up of:

a. The cost of clean up;

b. Cost of environmental damage.

B9 Issues Associated with the Cost Effectiveness of Risk Reduction

B9.1.1 The formal safety assessment guidelines describe a calculation method for calculating the Gross Cost of Averting a Fatality (Gross CAF) and the Net Cost of Averting a Fatality.

B9.1.2 The implication of this is that there should be an artificial and agreed unit of environmental harm and an equivalence between it and a fatality and that this unit should be based on cost.

B10 Checklist for Evaluating Environmental Risk Criteria

B10.1.1 The following checklist can be used for evaluating the suitability of an Environmental Risk Criteria.

Topic	If addressed (Y/N)	How Addressed?	Suitability for IMO
Probability			
Acute vs. Chronic Risk			
Accidental vs. Deliberate Acts			
Legal vs. Illegal Acts			
Consequence			
Multiple species harm			
Persistence			
Reversibility			
Escalation/concentration by the food chain			
Location and time			
Variety of the pollutants			
Cumulative and in-combination effects			
Detection time			
Uncertainty			
Uncertainty in probability estimation			
Uncertainty in consequence estimation			
Tolerability			
Definition of tolerability levels/bands			
Equivalence to Safety			
Cost of Environmental damage			
Cost of clean up			
Cost Effectiveness of Risk Reduction			
Measure of environmental harm			
Benefit vs. harm			

Suggested Checklist for Evaluating Environmental Risk Criteria

Figure 2 - Suggested Checklist for Evaluating Environmental Risk Criteria

ANNEX C
Examples of Environmental Aspects of Shipping

Contents

Page No.

C1 Purpose of this Annex

C1.1 Overview

C1.1.1 The purpose of this annex is to give examples of the range of environmental aspects, that may be identified by a Formal Safety (and Environment) Assessment and that therefore the Environmental Risk Criteria may have to address in an FSA. Each FSA will need to produce an appropriate list of environmental aspects.

C1.1.2 This annex lists examples of the following:

a. Substances that can lead to environmental risk;

b. Activities that can lead to environmental risk;

c. Events that can lead to environmental risk;

d. Life cycle aspects of environmental risk:

e. Example Receptors

C1.1.3 It should be noted that these lists are not exhaustive.

C1.2 Link to the FSA Guidelines

C1.2.1 This annex can be regarded as an environmental extension to Appendix 2 – Examples of "Hazards of the FSA Guidelines".

C2 Substances that can lead to Environmental Risk

C2.1 Ship-based Substances

C2.1.1 The substances on a ship that may pose a significant environmental risk include:

a. Bunker Fuels;

b. Lubrication Oils;

c. Hydraulic Oils.

C2.2 Cargoes

C2.2.1 The cargoes on a ship that may pose a significant environmental risk include:

a. Oil (both crude and refined products);

b. Noxious liquids in bulk;

c. Harmful substances in bulk form;

d. Harmful substances in packaged form;

e. Harmful substances in containers;

f. Radioactive material[1].

C3 Activities that can lead to Environmental Risk

C3.1.1 The activities that may lead to an environmental risk include:

a. Navigation on Passage;

b. Anchoring, berthing and waiting;

c. Maintenance;

d. Cargo Transfer;

e. Overboard deployment and operation of equipment;

f. Acts of terrorism.

C4 Events that can lead to Environmental Risks

C4.1 Acute Risks

C4.1.1 Acute environmental risks are generally the result of <u>unintended events:</u>

a. Foundering;

b. Capsizing;

c. Collision;

d. Contact;

e. Grounding and Stranding;

f. Fire and Explosion;

g. Loss of Hull Integrity;

h. Flooding;

i. Payload Related Accidents;

j. Hazardous Substance Accidents;

[1] The transport of radioactive goods is the subject of special regulation and risk assessment. It may be prudent to exclude it from FSA for the moment until a body of Environmental FSA work has been built up.

k. Loss of Cargo.

C4.2 Chronic Risks

C4.2.1 Chronic environmental risks are generally caused by intended actions:

Emissions to the air

a. Exhaust gas emissions (CO_2, NOX, SOX);

b. Particulate emissions/smoke;

c. Evaporation from cargo (VOCs);

d. Evaporation from bilges, flanges, drains and other equipment (VOCs);

e. Waste incineration;

Discharges to the Sea

f. Sewage (Grey water, black water);

g. Bilgewater (containing oil, chemical spills, etc.);

h. Ballast water (containing foreign organisms, containing oil, etc.);

i. Cooling water;

j. Operational chemical discharges;

k. Cleaning water (deck cleaning, tank cleaning, etc.);

Waste Products delivered Ashore

l. Garbage;

m. Oily wastes;

n. Reusable and recyclable materials;

Other Marine Aspects

o. Effect of anti-fouling paints;

p. Bio fouling;

q. Invasion of non indigenous species;

r. Seabed impacts from anchoring;

s. Garbage;

t. Litter;

u. Propeller scour in shallow water locations;

v. Bow wave and wake effects;

Other Non-marine Aspects

w. Noise pollution;

x. Light pollution.

C5 Life Cycle Aspects of Environmental Risk

C5.1.1 Environmental risk can materialise during all phases of a ship's life (and decagons affecting the risk may have been made during preceding stages) can be committed or including:

a. Design;

b. Manufacture;

c. Operation;

d. Maintenance;

e. Modification;

f. Change of owner/management;

g. Disposal;

h. Wreck.

C5.1.2 These phases are linked, a decision made in design can affect the environmental risk during operation, and a decision made during operation can affect the environmental risk during disposal.

C6 Example Receptors

C6.1 Overview

C6.1.1 These receptors in the marine environment include:

a. Living components of the environment (flora, fauna, human beings);

b. The media that support life (air, water, land, natural resources);

c. The 'infrastructure' that living organisms create or use (nests, burrows, migration routes, etc).

C6.1.2 More specifically the receptors can include:

a. The local and wider area of the water column;

b. The seabed surrounding the vessel/operation;

c. The local and global atmosphere;

d. Populations of birds;

e. Fish;

f. Sea mammals;

g. Invertebrates;

h. Specific marine or coastal habitats and protected areas.

C6.2 Stakeholders Concerned with the Wellbeing of the Receptors

C6.2.1 The stakeholders include

a. Fishermen;

b. Shipping;

c. Oil and gas installations and infrastructure;

d. Ports;

e. Coastal industries;

f. Marine leisure and recreational activities;

g. Manufacturers or suppliers of services that support the shipping/maritime sector;

h. Environmental groups;

i. Councils;

j. Government and government bodies;

k. Industry bodies and other stakeholders who have an interest in, or influence on, the sector.

ANNEX D
Existing Environmental Risk Criteria

Contents

Page No.

Tables

Figures

D1 Introduction

D1.1 Overview of Environmental Risk Assessment Criteria Research

D1.1.1 This Annex details a summary of the literature researched during this project.

D2 International Environmental Risk Criteria

D2.1 ISO 17776

D2.1.1 The International Standard ISO 17776 [Reference 1] describes some of the principal tools and techniques that are commonly used for the identification and assessment of hazards associated with offshore oil and gas exploration and production activities, including seismic and topographical surveys, drilling and well operations, field development, operations, decommissioning and disposal together with the necessary logistical support of each of these activities.

D2.1.2 It provides guidance on how these tools and techniques can be used to assist in development of strategies both to prevent hazardous events and to control and mitigate any events that may arise.

D2.1.3 It proposes a simple 5x5 matrix that includes risks to people, assets, environment and reputation and suggests tolerability levels.

CONSEQUENCE					INCREASING PROBABILITY				
Severity Rating	People	Assets	Environ-ment	Reputation	A	B	C	D	E
					Rarely occurred in E&P industry	Happened several times per year in industry	Has occurred in operating company	Happened several times per year in operating company	Happened several times per year in location
0	Zero injury	Zero damage	Zero effect	Zero impact	Manage for continued improvement				
1	Slight injury	Slight damage	Slight effect	Slight impact					
2	Minor injury	Minor damage	Minor effect	Limited impact					
3	Major injury	Local damage	Local effect	Considerable impact					
4	Single fatality	Major damage	Major effect	Major national impact	Incorporate risk reducing measures				
5	Multiple fatalities	Extensive damage	Massive effect	Major international impact				Intolerable	

Figure D.1 - ISO 17776 Environmental Risk Criteria

D2.1.4 The tolerability criteria highlight an important difference between safety and environmental standards. Safety standards are based on improving safety towards a level of risk to people that is regarded as broadly acceptable while environmental standards are based on levels of continuous improvement that are broadly acceptable.

D2.2 ISO 14001

D2.2.1 The International Standard ISO 14001 Environmental management systems [Reference 2] is intended to provide organisations with the elements of an effective Environmental Management System (EMS) that can be an integral part of existing management Systems to help organisations achieve environmental and economic goals.

D2.2.2 The standard specifies the requirements to enable an organisation to develop and implement policy and objectives taking into account legal obligations and information regarding significant environmental aspects.

D2.2.3 The methodology is based on a methodology known as Plan-Do-Check-Act (PDCA), described as follows:

a. Plan, establish the objectives and processes necessary to deliver results in accordance with the organisational environmental policy;

b. Do, implement the process;

c. Check, monitor and measure the processes against the policy, objectives, targets, legal and other requirements and report on the results;

d. Act, take actions to continually improve performance of the EMS.

D2.2.4 During the Planning Stages the environmental ‘aspects’ (element of an organisations activities or products that can interact with the environment) are identified and the environmental ‘impact’ (any change to the environment whether adverse or beneficial resulting from the aspect) recorded against environmental receptors (e.g. land, flora, fauna and water).

D2.2.5 ISO 14001 states that criteria should be established to determine the significant aspects, but states there is no single method to do this. However, it stipulates that the method used should provide consistent results.

D2.3 MARPOL 73/78

D2.3.1 MARPOL 73/78 is the International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978.

D2.3.2 MARPOL 73/78 is one of the most important international marine environmental conventions. It was designed to minimise pollution of the seas, including dumping, oil and exhaust pollution. Its stated object is: to preserve the marine environment through the complete elimination of pollution by oil and other harmful substances and the minimisation of accidental discharge of such substances.

D2.3.3 MARPOL 73/78 contains six Annexes which are concerned with and describe prevention of pollution from ships. As such, these Annexes can be viewed as internationally accepted environmental risk criteria and whether a marine activity has the potential to cause pollution can be determined by assessing whether it falls under one of the Annexes.

D2.3.4 The six MARPOL 73/78 Annexes are:

a. Annex I - Oil;

b. Annex II - Noxious Liquid Substances carried in Bulk;

c. Annex III - Harmful Substances carried in Packaged Form;

d. Annex IV - Sewage;

e. Annex V - Garbage;

f. Annex VI - Air Pollution.

D2.4 International Convention for the Control and Management of Ships Ballast Water and Sediments

D2.4.1 The International Convention for the Control and Management of Ships Ballast Water & Sediments was adopted by consensus at a Diplomatic Conference at IMO in London on Friday 13 February 2004, which will enter into force 12 months after ratification by 30 States, representing 35 per cent of world merchant shipping tonnage.

D2.4.2 The general obligations are for Parties to undertake to give full and complete effect to the provisions of the Convention and the Annex in order to prevent, minimize and ultimately eliminate the transfer of harmful aquatic organisms and pathogens through the control and management of ships' ballast water and sediments [Reference 3].

D2.4.3 The management and control requirements for ships are documented within the convention which include such measures that stipulate that ships are required to have on board and implement a Ballast Water Management Plan approved by the Administration and that ships must have a Ballast Water Record Book.

D2.5 International Convention on the Control of Harmful Anti-fouling Systems on Ships

D2.5.1 The International Convention on the Control of Harmful Anti-fouling Systems on Ships was adopted on 05 October 2001 and will enter into force 12 months after 25 States, representing 25% of the world's merchant shipping tonnage have ratified it [Reference 4].

D2.5.2 The Convention will prohibit the use of harmful organotins in anti-fouling paints used on ships and will establish a mechanism to prevent the potential future use of other harmful substances in anti-fouling systems.

D2.5.3 Under the terms of the new Convention, Parties are required to prohibit and/or restrict the use of harmful anti-fouling systems on ships flying their flag. This includes ships not entitled to fly their flag but which operate under their authority and all ships that enter a port, shipyard or offshore terminal of a Party.

D2.5.4 An initial survey will be required before a ship is put into service or before the International Anti-fouling System Certificate is issued for the first time for ships of above 400 gross tonnage and above engaged in international voyages (excluding fixed or floating platforms, FSUs and FPSOs). A survey when the anti-fouling systems are changed or replaced is also required. European

D2.6 Safety@Sea

D2.6.1 The EU Safety@Sea [Reference 5] was based on three thematic strands and six demonstration projects. These were:

a. Routing and Safe Seaways;

(i) Inventory, Classification and Risk Assessment of Oil Transport in the North Sea Region;

(ii) Automatic Identification System (AIS) Data and Risk Management;

b. Coastal Zone Management;

(i) Coastal Zone Management, Places of Refuge and Preparedness;

(ii) Offshore Wind Farm Risk Management;

c. Safety Awareness and Decision Making;

(i) Risk Assessment and Decision Making for a Maritime Rescue Coordination Centre;

(ii) Safety Awareness.

D2.6.2 The project used its work to produce a guidance document on Harmonised Risk Management. This document based definitions of risk on:

a. Risks to People (Safety);

b. Risks to the Environment;

c. Risks to Property;

d. Risks to business.

D2.6.3 It also recommended that risk should be geographically referenced.

D2.6.4 However, the project did not make much progress in developing harmonised environmental risk criteria, preferring to wait for the results of IMO activities, as shown at Figure D.2.

9.2 Risks to the Environment

Extending formal safety assessment to the marine environment is the subject of ongoing discussions at the IMO Maritime Safety Committee.

An extract of a background document under discussion was submitted by the chairman of the IMO correspondence group (MSC81/18). The documents were sent to the MEPC and flag states have been asked to submit comments for the next MEPC meeting. More information is not available at this stage.

It is recommended that Safety@Sea build on what results from IMO activities.

Figure D.2 - Safety@Sea Risks to the Environment

D2.7 Marine Safety Umbrella Operation

D2.7.1 The Marine Safety Umbrella Operation [Reference 6] did some work in 2006 to survey EU maritime projects to see which had a maritime risk component and if any common maritime risk and acceptance could be applied to EU projects.

D2.7.2 The main findings were that there was little or no commonality in risk assessment methods or values as shown in

1.5 Main Findings that Influenced the Direction of the Work

The main findings that influenced the work were that:

- there was little risk assessment or risk acceptance commonality identified in the Interreg projects surveyed. As a result, a higher level risk assessment methodology and risk acceptance protocol are recommended, based on the definitions of processes rather than specific techniques or numerical values
- there is no common understanding of an acceptable risk

Figure D.3 - Main findings of the Marine Safety Umbrella Operation

D2.7.3 However, the report had some findings that are relevant to environmental risk criteria, as follows:

a. On proportionality;

b. On tolerability;

c. On assessing change in risk due to traffic growth;

d. On assessing change in risk due to the change being proposed (e.g. in a development or a regulation change).

Proportionality

D2.7.4 One of the reports findings was that any risk assessment should be proportionate to the scale of the activity under investigation and the magnitude of the risk as shown in Figure D.4.

4.2 **Proportionality of a Risk Assessment**

The scope and depth of a risk assessment, together with the tools and techniques necessary to carry it out, should be proportionate to:

- the scale of the activity under investigation
- the magnitude of the risks.

Figure D.4 - Proportionality of a Risk Assessment

Tolerability

D2.7.5 The report based its findings on the three principles of tolerability from the UK Reducing Risk Protecting People. The importance of this is that it links rules, good practice and risk. Tolerability cannot be judged on risk alone.

3.6.8 Common Understanding of a Tolerable Level of Risk

There are numerous local, national and international tolerability criteria. These range from general principles to specific numerical values. However many of them can be described by the principles set out in Reducing Risks Protecting People[7] that risk tolerability is based on showing that:

- rules have been complied with
- relevant good practice risk controls are in place
- the risk has been reduced to that which is As Low As Reasonably Practicable" (ALARP)

Figure D.5 - Tolerable Level of Risk

Change in Risk due to Traffic Growth

D2.7.6 The report recommended that risk assessment should start by assessing not only the current level of risk but also the level of risk due to the predicted growth in marine traffic.

- the "Base Case" level of risk
  - i.e. the risk based on existing densities and types of traffic and the existing marine traffic environment
- the "Future Case" level of risk
  - i.e. the risk based on the predicted growth in future densities and types of traffic and reasonable foreseeable changes in the marine environment

Figure D.6 - "Base Case" and "Future Case" level of risk

Change in Risk due to Change in Circumstances

D2.7.7 The report then recommended that the risk assessment should be based on both the current situation and the predicted traffic growth.

- the "Base Case with the Major Change" level of risk
  - i.e. the risk based on existing densities and types of traffic and the existing marine environment but with the major change added

Figure D.7 - "Base Case with the Major Change"

- the "Future Case with the Major Change" level of Risk
    - i.e. the risk based on the predicted growth in future densities and types of traffic and the reasonable foreseeable changes in the marine environment but with the major change added

Figure D.8 - "Future Case with the Major Change

D2.8 SAFEDOR Project

D2.8.1 In the SAFEDOR project (Design, Operation and Regulation for Safety) [Reference 7] a report was produced that addresses the issue of Environmental Risk Acceptance Criteria in some detail.

D2.8.2 The report contains much detail which is relevant and identifies the range of environmental risks caused by shipping and attempts to set evaluation criteria for them.

D2.8.3 However it addresses only a sub-set of the issues required to be covered by Environmental Risk Criteria. In particular it excludes regular (chronic) risks, and this excludes it from addressing some of the major current environmental issues in shipping (NOX/SOX, ballast water, bio fouling, CO_2, etc.).

Environmental impacts from shipping activities may be caused by regular (both legal and illegal) and accidental releases. The regular releases (of e.g. CO_2, NO_X, sewage or garbage) are not considered here, as the estimation of quantities of regular releases may be done without involving the use of risk assessment, and the estimation of consequence is no different from releases from other sources. Risk assessment for regular releases is only relevant if the system is not defined as the ship, and the analysis go into analysing short and long term effects on the environment, habitat, biodiversity etc. For accidental

Figure D.9 - Regular (Chronic) Risks

D2.8.4 It also ignores the location of an incident even though it acknowledges that this is of paramount importance.

The focus of the present discussion will thus be limited to unwanted accidental environmental impacts. It is essentially the release of environmentally hazardous cargo into the sea that constitutes the principal part of this risk, and the risk is assumed to be proportional to the extent, i.e. volume and frequency, of these kinds of cargo shipments. Another very important factor is the geographical operational area, e.g. through which areas the shipments pass, but the present study will not study this issue in detail. For the purpose of this general study, no differences in trade routes are considered, although it is noted that this is of paramount importance when dealing with environmental risk.

Figure D.10 - Location of Incidents

D3 United States of America

D3.1 Marine Operations Risk Guide

D3.1.1 The US Coastguard, the US Passenger Vessel Association and the US Chemical Transportation Advisory Committee produced the Marine Operations Risk Guide [Reference 8] to help users "become more aware of the potential risks inherent in their operations and identify ways to control the risks".

D3.1.2 The guide assigns consequences by a simple matrix to:

a. People;

b. Damage;

c. Environment;

d. Operational disruption;

e. Financial loss.

Assign a rating of	if the impact could be
1	NEGLIGIBLE = Injury not requiring first aid, no cosmetic vessel damage, no environmental impact, no missed voyages.
2	MINOR = Injury requiring first aid, cosmetic vessel damage, no environmental impact, additional work, minor operational disruption, no missed voyages.
3	SIGNIFICANT = Injury requiring more than first aid, vessel damage, some environmental damage, longer operational disruption, or financial loss.
4	CRITICAL = Severe injury, major vessel damage, major environmental impact, major operational disruption missed voyages (up to and including the entire season).
5	CATASTROPHIC= Loss of life, loss of vessel, extreme environmental impact.

Figure D.11 - Impact Ratings

D3.2 Department Of Energy Transportation Risk Assessment

D3.2.1 The Department Of Energy (DOE) Transportation Risk Assessment Resource Handbook [Reference 9] is an example of the depth of analysis that may be provided in support of an environmental risk assessment (in this case for the transport of radioactive material) and which the Environmental Risk Criteria will have to interface.

D4 United Kingdom

D4.1 Reducing Risk Protecting People

D4.1.1 Reducing Risks Protecting People [Reference 10] is the UK Health and Safety Executive's (HSE) guide to their decision making process. As its name implies its focus is on safety and it only makes a passing reference to the link with the environment.

34 It has become a matter of course to request, for example, that taking into account undesirable consequences should include consideration of matters such as distributional or economic equity or ethical considerations[12,13,14] or, for those occupational risks that are often accompanied by secondary environmental risks, whether it is morally right to adopt policies without considering their effects on natural phenomena like the survival of species and the maintenance of ecosystems.[15] In short, the evaluation and management of hazards are evolving to include values that cannot readily be verified by traditional scientific methods. Techniques being produced for taking these values into account are at an early stage of development.

Figure D.12 - Environmental Link within the Document

D4.1.2 However, it does give some potentially useful information on the criteria for reaching decisions:

- an **equity-based** criterion, which starts with the premise that all individuals have unconditional rights to certain levels of protection. This leads to standards, applicable to all, held to be usually acceptable in normal life, or which refer to some other premise held to establish an expectation of protection. In practice, this often converts into fixing a limit to represent the maximum level of risk above which no individual can be exposed. If the risk estimate derived from the risk assessment is above the limit and further control measures cannot be introduced to reduce the risk, the risk is held to be unacceptable whatever the benefits;

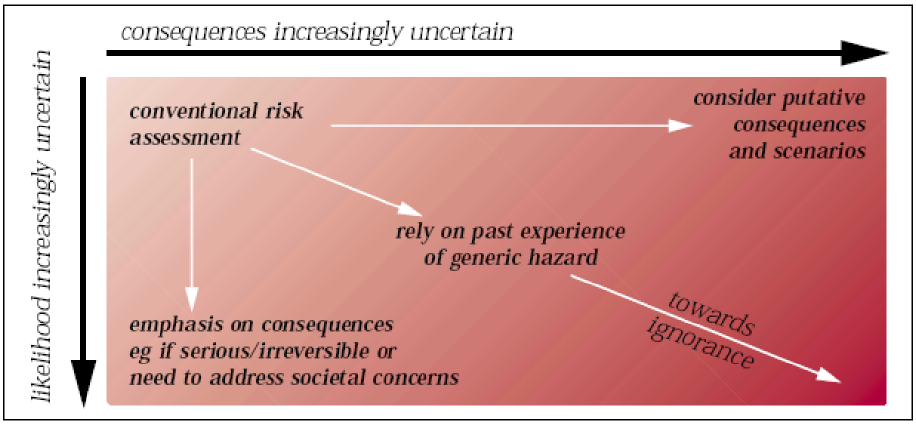
- a **utility-based** criterion which applies to the comparison between the incremental benefits of the measures to prevent the risk of injury or detriment, and the cost of the measures. In other words, the utility-based criterion compares in monetary terms the relevant benefits (eg statistical lives saved, life-years extended) obtained by the adoption of a particular risk prevention measure with the net cost of introducing it, and requires that a particular balance be struck between the two. This balance can be deliberately skewed towards benefits by ensuring that there is gross disproportion between the costs and the benefits;

- a **technology-based** criterion which essentially reflects the idea that a satisfactory level of risk prevention is attained when 'state of the art' control measures (technological, managerial, organisational) are employed to control risks whatever the circumstances.

Figure D.13 - Decision Reaching

D4.1.3 And dealing with uncertainty.

Figure 2: Procedures for tackling uncertainty when assessing risks



It is also worth noting that though more information frequently leads to a decrease in uncertainty, it does not necessarily change the probability of an event. For example, though frequent inspections of a critical component may reduce the uncertainty regarding the probability of the component failing within a period of time, the inspections do not reduce the probability of the component failing unless action is taken to remedy the situation.

Figure D.14 - Procedures for tackling uncertainty when assessing risks

D4.2 Marine Risk Assessment

D4.2.1 In 2001 as part of a series of reports on offshore technology Det Norske Veritas produced for the Heath and Safety Executive a report on Marine Risk Assessment [Reference 11].

D4.2.2 Again its focus is on safety but it does give useful guidance on the types of risk assessment that may be applicable, qualitative, semi-quantitative and quantitative.

2.1.2 Types of Risk Assessment

Risk assessment can be applied in approaches described as Qualitative, Semi-Quantitative and Quantitative, and the project manager needs to decide which is the right approach for the job. The basic aim is risk reduction and the key test is one of reasonable practicability.

In general, qualitative approaches are easiest to apply (least resource demands and least additional skill sets required) but provide the least degree of insight. Conversely quantitative approaches (QRA) are most demanding on resources and skill sets, but potentially deliver the most detailed understanding and provide the best basis if significant expenditure is involved. Semi-quantitative approaches lie in between these extremes.

Figure D.15 - Types of Risk Assessment

D4.2.3 The report also highlights the use of risk matrices as a qualitative risk assessment technique it does not develop Environmental Risk Criteria.

D4.3 Port Marine Safety Code

D4.3.1 The UK Department for Transport has developed a Port Marine Safety Code [Reference 12]. The code is aimed at port safety but the code puts an environmental duty on harbour authorities.

> **Environmental duty**
>
> 1.2.7. Harbour authorities have a general duty to exercise their functions with regard to nature conservation and other related environmental considerations [7]. They may now seek additional powers for these purposes. They also have an obligation, where a Special Protection Area for Birds or a Special Area of Conservation has been designated under the Wild Birds or Habitats Directives, to have regard to the requirements of the Habitats Directive so far as they may be affected by the exercise of those functions [8].

Figure D.16 - Environmental Duty

D4.3.2 And there is an implication that this should be met by applying the ALARP principle.

> **The 'ALARP' principle**
>
> 2.1.12. The aim of assessing and managing marine operations in harbours is to reduce risk **as low as reasonably practicable** ('ALARP'). It is important that the judgement of risk is an objective one, and the size or financial position of the authority are immaterial to making it. The degree of risk in a particular activity or environment can, however, be balanced on the following terms against the time, trouble, cost and physical difficulty of taking measures that avoid the risk. If these are so disproportionate to the risk that it would be unreasonable for the people concerned to incur them, they are not obliged to do so. The greater the risk, the more likely it is that it is reasonable to go to very substantial expense, trouble and invention to reduce it. But if the consequences and the extent of a risk are small, insistence on great expense would not be considered reasonable.
>
> 2.1.13. Risks may be identified which are **intolerable**. Measures must be taken to eliminate these **so far as is practicable**. This generally requires whatever is technically possible in the light of current knowledge, which the person concerned had or ought to have had at the time. The cost, time and trouble involved are not to be taken into account in deciding what measures are possible to eliminate intolerable risk.

Figure D.17 - "ALARP" Principle

D4.3.3 To develop a Safety Management System based on policies and procedures that manages the environmental risk.

> 2.2.7. Every harbour authority's policies should be supported by procedures to:-
>
> - regulate the safe arrival, departure and movement within the harbour of all vessels;
> - protect the general public from dangers arising from marine activities within the harbour;
> - carry out all its functions with special regard to their possible environmental impact;
> - prevent acts or omissions that may cause personal injury to employees or others, or damage the environment.

Figure D.18 - Support Policies with Procedures

D4.3.4 However there are no Environmental Risk Criteria.

D4.4 Ministry of Defence

Project Orientated Environmental Management System (POEMS) Manual

D4.4.1 The Ministry of Defence (MoD) like many Government departments is under increased scrutiny regarding environmental issues and procurement. The implications resulting from environmental issues can manifest into cost inflations, delays, reputation damage and security implications.

D4.4.2 As a result the MoD has implemented a Project Orientated Environmental Management System (POEMS) Manual [Reference 13], which covers all Integrated Project Teams (IPTs) across the MoD and is designed to comply with Government Policy while meeting stakeholder expectations.

D4.4.3 The aim of POEMS is to identify the significant aspects and risks of a project and demonstrate elimination, mitigation or management and continuous improvement of these throughout the life cycle of the project.

D4.4.4 POEMS is broken down into Environmental Management Procedures (EMPs), which is a step by step approach to the process.

D4.4.5 IN accordance with POEMS the activities and aspects associated with the project (be they normal, abnormal or emergency situations) are assessed, this procedure is known as EMP 04 Impact Priority Evaluation.

D4.4.6 During this process a defined set of criteria have been defined for severity (at Table D.1) and frequency at (at Table D.2).

IMPACT SEVERITY SCORE	IMPACT SEVERITY DEFINITION	DESCRIPTION
6	**Catastrophic**	Large scale use of very scarce resources or toxic resources e.g. use of heavy metals **or;** Very large amount of hazardous waste produced **or** ; Severe widespread irreversible environmental damage of international significance e.g. release of greenhouse gases or release of ozone depleting substances **or** ; Destruction of habitat of endangered species.
5	**Critical**	Large scale use of non-renewable resources, significant use of toxic substances **or** ; Large amount of hazardous waste produced **or** ; Large scale environmental damage with national significance e.g. release of acid rain gases NOx, SOx **or;** Permanent damage to habitat of endangered species.
4	**Serious**	Significant use of non-renewable resources, limited use of toxic substances **or** ; Notable amount of hazardous waste produced **or** ; Notable lasting environmental damage e.g. destruction of habitat of common species **or**; Temporary damage to habitat of endangered species.
3	**Noticeable**	Notable use of renewable resources, notable use of non-renewable resources **or** ; Notable non-hazardous waste disposal, hazardous waste recycled, small amounts of hazardous waste **or;** Environmental impact limited to a small area, **or ;** Widespread impact with minimal lasting damage e.g. permanent damage to habitat of common species only.
2	**Minor**	Low to medium use of renewable resources or low use of non-renewable resources **or** ; Non-hazardous waste produced and recycled or small amounts disposed of **or**; Notable but limited environmental impact, negligible but widespread e.g. temporary damage to habitat of common species only.
1	**Negligible**	Re-use of material or negligible use of renewable or non renewable resources **or;** Produces inert waste **or;** Negligible environmental impact e.g. temporary disturbance of common species only.

Table D.1 - Severity Table

Frequency / Duration		
Code	Frequency	Duration
1	Occurs Rarely	Short
2	Annually	0 - 5 hours
3	Monthly	5 - 50 hours
4	Weekly	50 - 500 hours
5	Daily	> 500 hours
6	Continuously	Continuously

Table D.2 - Frequency Tables

D4.4.7 The multiplication of the frequency and severity values provides a priority score for each identified environmental aspect considered, displayed at Table D.3

		SEVERITY CATEGORY					
		Negligible	**Minor**	**Noticeable**	**Serious**	**Critical**	**Catastrophic**
FREQUENCY CATEGORY	**Continuously**	**6**	**12**	**18**	**24**	**30**	**36**
	Daily	**5**	**10**	**15**	**20**	**25**	**30**
	Weekly	**4**	**8**	**12**	**16**	**20**	**24**
	Monthly	**3**	**6**	**9**	**12**	**15**	**18**
	Annually	**2**	**4**	**6**	**8**	**10**	**12**
	Occurs rarely	**1**	**2**	**3**	**4**	**5**	**6**

Table D.3 - Risk Classification Matrix

D4.4.8 These criteria are helpful as a guideline; however in the case of a piece of equipment being fitted onto a large project (e.g. a new Sewage Treatment Plant being added to a ship) it is advisable to align the methodologies. The repercussions of overlooking this is that the total number of high priorities may be distorted either way, which makes allocating resources effectively very problematic.

D4.4.9 Within POEMS there is a statement which makes the provision for using an alternative methodology to the above; however an alternative should be agreed with the Acquisition Safety and Environmental Group (ASEG).

Joint Services Publication 418

D4.4.10 The MoD also provides Guidance at Joint Services Publication (JSP 418) [Reference 14]. This Likelihood and Severity definitions is much more simplistic as displayed at Table D.4 and Table D.5.

Likelihood	Prompt	Score
Most Unlikely	Comprehensive control measures in place	1
Unlikely	Acceptable control measures in place	2
Likely	Minimal control measures in place	3
Most Likely	Ineffective control measures in place	4

Table D.4 - Likelihood of an Environmental Aspect Occurring

Consequence	Prompt	Score
Negligible	No noticeable environmental impact, contained within immediate area No nuisance to local inhabitants	1
Minor	Minor impact on the environment Minor nuisance to local inhabitants	2
Serious	Noticeable impact on the environment Creates public nuisance	3
Major	Major impact on the environment Media coverage, adverse public opinion	4

Table D.5 - Scale of Environmental Consequence

D4.4.11 A range of values between 1 and 16 provides an indication of priorities for action, categorised into the four bands (See Table D.6).

Value	Priority
1 or 2	Negligible
3 or 4	Low
6 or 8	Medium
9, 12 or 16	High

Table D.6 - Environmental Significance Priority Levels

Further MoD Resources

D4.4.12 The most simplistic of methodologies is that described in 'An Introduction to Environmental Management in the MoD Acquisition Process' [Reference 15] shown below in Figure D.19.

Severity							
	f	6	12	18	24	30	36
	e	5	10	15	20	25	30
	d	4	8	12	16	20	24
	c	3	6	9	12	15	18
	b	2	4	6	8	10	12
	a	1	2	3	4	5	6
		1	2	3	4	5	6
	Frequency						

Severity	Frequency	
a Negligible	1 Occurs rarely	low priority
b Minor	2 Annually	
c Noticeable	3 Monthly	medium priority
d Serious	4 Weekly	
e Critical	5 Daily	high priority
f Catastrophic	6 Continuously	

Figure D.19 - Simplistic Environmental Risk Assessment

D4.4.13 These three criteria are MoD guidance for Integrated Project Teams and yet all three are varying degrees of details. It is also worthy to note there are many more environmental risk criteria used as some projects are aligning the assessment of safety and environment together, which has its limitations.

D4.5 Department for Environment, Food and Rural Affairs (Defra)

D4.5.1 Defra recognise that the balance between environmental protection and economic and technological progress is difficult to address. However environmental risk assessment is a key element in the appraisal of these complex problems, and for formulating and communicating the issues so that transparent and equitable policy, regulatory or other decisions can be taken. [Reference 16].

D4.5.2 A common framework for risk assessment as a key part of the process of appraisal for environmental decision-making has therefore been produced, which builds on the UK Department of the Environment's 1995 publication A Guide to Risk Assessment and Risk Management for Environmental Protection [Reference 16].

D4.5.3 Defra recognise that in some cases there will be a high level of uncertainty in the estimation of the magnitude of consequences, and making some judgement on the possible consequences may be the best option. However, in such cases cost-effective measures to avoid serious or irreversible harm must be adopted, even in the face of uncertainty.

D4.5.4 Where there is no guidance regarding the significance, a rough scale can be developed, an example is as follows:

a. Negligible - Sub-lethal effects in individuals that do not cause a change in population structure or size;

b. Mild-Moderate - Effects occurring at the population level. Effects on ecosystems that are not regarded as being of high value for whatever reason;

c. Severe - Local extinctions (depending on the species) and local dysfunction of communities and ecosystems;

d. Very severe - Global extinctions (depending on species) and widespread effects on the functioning of communities and ecosystems;

e. Extremely severe - Impacts on the functioning of global ecosystems.

D4.5.5 Defra recommend that estimating the probability of consequences is likely to be at best semi-quantitative, based on three primary factors:

a. Whether the event will be initiated;

b. Whether exposure to the hazard will occur;

c. And whether harm will result following exposure.

D4.6 The Department of Business Enterprise and Regulatory Reform

D4.6.1 The UK Department for Business, Enterprise and Regulatory Reform (BERR, formally the Department of Trade and Industry) is the regulatory body in the UK responsible for managing the environmental impact associated with the UK oil and gas industry.

D4.6.2 The oil and gas industry is recognised both in the UK and worldwide as being particularly environmentally aware and operates to some of the highest environmental standards in the world.

D4.6.3 As such both BERR and the oil and gas industry in general are good examples of an industry and associated regulatory body that are established in defining and assessing environmental risk criteria and associated potential environmental impact.

D4.6.4 For the purposes of this investigation, the Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) Regulations 1999, (EIA Regulation) guidance notes have been identified as an example of environmental risk criteria through “Impact Identification” as detailed below.

4.5.3. Impact identification

The assessment process should identify those aspects of the environment that are likely to be significantly affected by the activity (including in particular, population, fauna, flora, geology and soil, water, air, climatic factors, material assets, including the architectural and archaeological heritage, landscape and the inter-relationship between the above factors). The description of the likely significant effects should encompass at least the aspects listed in paragraph (c) of Schedule 2 to the Regulations to the extent that they are relevant. Not all the aspects listed will be applicable to all activities: e.g. "landscape" is more likely to be relevant to activities near to land while "architectural and archaeological heritage" is likely to apply to activities near to land or in close proximity to archaeological sites (wrecks). The description of the impact on "climate" and "air" should include consideration of the impact on global warming and the ozone layer in addition to local and regional air quality and include the quantities of emissions to the atmosphere over the life of the activity. Emissions should be characterised into chemical species important in global warming, ozone layer depletion and local and regional air quality.

Figure D.20 - Impact Identification

D4.7 The UK Oil and Gas Industry - ConocoPhillips

D4.7.1 Further to the BERR EIA Regulation guidance notes outlined in Section D5.6, below is and example of the application of this guidance by ConocoPhillips (CoP) in the UK.

D4.7.2 CoP use an environmental risk assessment process to assess the impact of their activities during the production of an environmental impact assessment.

D4.7.3 The process identifies and ranks the environmental and socio-economic risks that could arise directly or indirectly from routine and emergency situations during the lifetime of the proposed development.

D4.7.4 The environmental risk assessment comprises two stages. The first comprises of the systematic identification of the environmental impacts or risks (potential environmental impacts) associated with each of the activities taking place during the project. The second involves classification of the environmental impacts or risks into the following categories according to pre-defined significance criteria: “not significant”, “significant” or “highly significant”.

D4.7.5 This assessment is presented in Table D.7 outlined below:

HIGHLY SIGNIFICANT	SIGNIFICANT	NOT SIGNIFICANT
• Substantial environmental, socio-economic and technical risks which cannot be reduced with the resources available to the project • Major data gaps and uncertainties • Serious concerns from consultees which cannot be resolved • Non-compliance with environmental legislation and company policy	• Discernible environmental and socio-economic risks which are well understood but require further investigation to establish the causes, consequences and/or provisions for risk management • Risk-reduction measures generally have a history of successful use and acceptance • Environmental impact generally localised, and readily assimilated by the receiving environment. Impact would not compromise the integrity, viability, conservation status, commercial use or social amenity of particular habitats or species • Socio-economic impacts represent inconvenience to third parties rather than loss or degradation of socio-economic or cultural assets • Evidence of adequate contingency planning and response capabilities for hydrocarbon spills or other emergencies • Concerns expressed by consultees that can be adequately resolved	• No or negligible environmental, socio-economic or technical risks • Risk-reduction measures not required or are industry standard • No concerns from consultees

Table D.7 - Classification of Environmental Impacts and Risks

D5 New Zealand

D5.1 Guidelines for Port and Harbour Risk Assessment

D5.1.1 Building on the UK Port Marine Safety Code the Maritime Safety Authority of New Zealand have produced guidelines for Port & Harbour Risk Assessment and Safety Management Systems in New Zealand [Reference 17]. This document proposes an integrated risk criteria based on risks to people, property, environment and harbour stakeholders.

Category	Description (AS/NZS 4360)	Definition
F1	Frequent	An event occurring once a week to once an operating year.
F2	Likely	An event occurring once a year to once every 10 operating years.
F3	Possible	An event occurring once every 10 operating years to once in 100 operating years.
F4	Unlikely	An event occurring less than once in 100 operating years.
F5	Rare	Considered to occur less than once in 1000 operating years (e.g. it may have occurred at a port or harbour elsewhere in the world).

Figure D.21 - Frequency Matrix for Use in Port Harbour Risk Assessment

Scale	People	Property	Environment	Harbour Stakeholders
C0	**Insignificant** Possible very minor injury (e.g. bruise).	**Insignificant** *(NZ$0-10,000).*	**Insignificant** Negligible environmental impact. Tier 1 may be declared but criteria not necessarily met. *(NZ$0-10,000).*	**Insignificant** *(NZ$0-10,000).*
C1	**Minor** Single slight injury.	**Minor** *(NZ$10K-100K).*	**Minor** Tier 1 to Tier 2 criteria reached. (small operational spill). *(NZ$10K-100K).*	**Minor** Bad local publicity or short-term loss of revenue, etc. *(NZ$10K-100K).*
C2	**Moderate** multiple minor or single major injury.	**Moderate** *(NZ$100K-1M).*	**Moderate** Tier 2 Spill criteria reached, capable of being limited to immediate area within harbour or port zone. *(NZ$100K-1M).*	**Moderate** Bad widespread publicity, temporary navigation closure or prolonged restriction of navigation *(NZ$100K-1M).*
C3	**Major** Multiple major injuries or single fatality.	**Major** *(NZ$1M-10M).*	**Major** Lower Tier 3 criteria reached, with pollution outside harbour or port zone expected. Chemical spillage or small gas release. Potential loss of environmental amenity. *(NZ$1M-10M).*	**Major** National Publicity. Harbour faces temporary closure of a navigation channel affecting movements to a port or ports for several days. Ensuing loss of trade. *(NZ$1M-10M).*
C4	**Catastrophic** Multiple fatalities.	**Catastrophic** *(NZ$10M+).*	**Catastrophic** Tier 3 criteria oil spill reached with support from international clean up funds. Widespread beach contamination or serious chemical/gas release. Significant threat to environmental amenity. *(NZ$10M+).*	**Catastrophic** International media publicity. Port closes, navigation seriously disrupted for an extended period. Serious and long term loss of trade. *(NZ$10M+).*

Figure 4: Consequence Matrix for use in Port and Harbour Risk Assessment

Figure D.22 New Zealand Maritime Safety Authority Environmental Risk Criteria

D5.1.2 It also proposes tolerability criteria.

Consequence						
	C4	5	6	7	8	10
	C3	4	5	6	7	9
	C2	3	3	4	6	8
	C1	1	2	2	3	6
	C0	0	0	0	0	0
	Frequency	F 5	F 4	F 3	F 2	F 1

Figure 5: Risk Matrix for use in Port and Harbour Risk Assessment.

A suggested definition of the numbers in the matrix is as follows:

0 & 1 Negligible Risk
2 & 3 Low risk
4 & 5 The extent of the As Low As Reasonably Practicable area (ALARP[2])
6 Heightened Risk
7 & 8 Significant Risk
9 & 10 High Risk.

Figure D.23 - Tolerability Criteria

D6 Criteria discussed at MEPC - Feedback Summary

D6.1 Overview

D6.1.1 This Section presents a summary of other nations responses to MEPC submissions relating to Environmental Risk Criteria.

D6.2 Germany

D6.2.1 Germany supports the establishment of justified risk acceptance and risk evaluation criteria for environmental protection. Establishing a severity index for ranking of hazards as well as a – still unnamed – diagram to present oil spills and their cumulative frequency of occurrence and the associated societal acceptance criteria to span an ALARP area.

D6.2.2 Severity index should only address oil spill volume, not recovery time, which is dependent on type of oil, location and weather) and that there is a logical step to address historical oil spill data, which can be used as a social acceptance criteria.

D6.2.3 They criticise the SAFEDOR Report [Reference 7] because it did not address social acceptability.

D6.3 ITOPF comments on FSA

D6.3.1 The International Tanker Owners Pollution Federation Limited (ITOPF) now regularly attends more bunker than cargo spills each year. In addition, these spills are not only becoming more important in terms of number, they are proving to be more likely to cause damage and require extensive clean-up operations. This is the result of larger-than-ever vessels carrying heavier-than-ever grades of fuel oil, as well as greater financial liabilities and heightened public sensitivity to oil spillage.

D6.3.2 ITOPF recognises that there is no “right” or “wrong” matrix for describing environmental risk. The severity labels, recovery times and curve slopes are not a matter to be strictly determined by objective scientific and economic study. They are a matter of subjective opinion and are properly dealt with in the forum of inter-governmental debate in the IMO.

D6.3.3 There is an agreement in the use of the value of $3m per person, although question whether the same can be achieved for environment. ITOPF state that there is no meaningful ‘average’ costs for oil spills and that there is a long list of factors that influence the impact of a spill, the cost of response and the level of residual damage that is best left for natural recovery.

References

1 ISO 17776 Petroleum and natural gas industries. Offshore production installations. Guidance on tools and techniques for hazard identification and risk assessment. Dated 15 February 2001;

2 ISO 14001 Environmental Management Systems. Dated November 2004;

3 International Convention for the Control and Management of Ships Ballast Water and Sediments. http://globallast.imo.org/index.asp?page=mepc.htm Accessed 30 November 2007;

4 International Convention for the Control and Management of Ships Ballast Water and Sediments. http://www.imo.org/Conventions/mainframe.asp?topic_id=529 Accessed 30 November 2007;

5 Safety at Sea Harmonised Risk Management, Issue 3, March 2007;

6 Maritime Safety Umbrella Operation. Maritime Risk Assessment and Acceptance Project to Project Co-operation Agreement PPC1a, Final Report. 21 April 2006, BMT Renewables;

7 SAFEDOR Risk Evaluation Criteria. Design, Operation and Regulation for Safety Project No.: IP-516278, Report Reference SAFEDOR-D-4.5.2-2005-10-21-DNV. Dated 21 October 2005;

8 Marine Operations Risk Guide, U.S. Coast Guard, Human Element and Ship Design Division Commandant (G-MSE-1);

9 A Resource Handbook on Department Of Energy Transportation Risk Assessment. Prepared for: U.S. Department of Energy Office of Environmental Management National Transportation Program. July 2002;

10 Health and Safety Executive Reducing risks, protecting people HSE's decision-making process;

11 Marine risk assessment Offshore Technology Report. Prepared by Det Norske Veritas for the Health and Safety Executive. 2001/063;

12 Department for Transport http://www.dft.gov.uk/pgr/shippingports/ports/pmsc/portmarinesafetycode;

13 Ministry of Defence, Defence Procurement Agency and Defence Logistic Organisation Acquisition Safety and Environmental Management System (ASEMS) Project-Oriented Environmental Management System Manual (POEMS), Version 2.1e January 2006;

14 Ministry of Defence Joint Services Publication (JSP) 418 MoD Sustainable Development and Environment Manual. Dated April 2005;

15 Acquisition Safety and Environmental Support Group (MoD) An Introduction to Environmental Management in the MoD Acquisition Process, Issue 2. Date July 2005;

16 Department for Environmental, Food and Rural Affairs Guide to Risk Assessment and Risk Management for Environmental Protection 19 September, 2002. (http://www.defra.gov.uk/environment/risk/eramguide/index.htm).

17 Final Guidelines for Port and Harbour Risk Assessment and Safety Management Systems in New Zealand. Maritime Safety Authority of New Zealand Kia Maau Kia Ora. 2004.

ANNEX E
Stakeholder Consultation Workshops

Contents Page No.

Tables

E1 Stakeholder Consultation

E1.1 Overview

E1.1.1 This annex provides an overview of the stakeholder consultation that took place during this project.

E1.1.2 Two workshops were held at the MCA Offices, Southampton on the 05 and 12 of November 2007.

E1.1.3 The aim of the workshops was to use stakeholder expertise in the development of the Environmental Risk Criteria and to use case studies to test the criteria.

E1.1.4 It must be noted that the examples used in this annex were used solely for the purposes of the workshop and not to be used as a template for future use.

E1.1.5 As noted at Annex A this Report is based on a range of inputs from BMT, the MCA and external stakeholders. It therefore does not imply that the report is endorsed by either the stakeholders or the organisations they represent who may want to make formal comments when the report is presented at the IMO.

E2 Findings from Workshop 1

E2.1 Workshop 1 Agenda

E2.1.1 As part of the research project Internal (MCA) and External Stakeholders (outlined in Annex A) were invited to attend a Workshop to discuss the draft criteria proposed by BMT. The Agenda for the Workshop was as follows:

a. Background to the Task;

b. Complexity of the Task;

c. Problem Definition;

d. Required Scope of environmental Risk Criteria for Marine Operations (Annex B);

e. Examples of Environmental Aspects of Marine Operations (Annex C);

f. Overview of the Research;

g. Examples of Criteria;

h. Stakeholder Feedback;

i. The Way Forward;

j. Recommendations and Conclusions.

E2.2 Attributes of Environmental Risk Criteria

E2.2.1 Following the initial background information the draft criteria were presented for discussion. Firstly it was established that a common language would be required as follows:

<u>Common Language</u>

a. ISO 14001;

b. FSA (IMO);

c. Probability v Consequence = Risk;

d. Parity with FSA;

   (i) With probability = possible;

   (ii) With consequence more difficulty (due to range of receptors, types of impacts, cumulative, acute, chronic);

e. Allowance for cost;

f. Allow for complexity of the issues;

g. Scaleable (ship to multi ship to industry, One consequence to multiple);

h. Calibration (Tolerability, acceptable/intolerable);

i. Holistic (including ship lifecycle);

j. Other Criteria e.g. Cost Benefit Analysis (CBA);

k. Implementation Process (to support submission to the IMO process);

l. Needs to be comparable with developing Goal Based Standards.

Attendees Comments

E2.2.2 Additional comments from stakeholders were provided, which included:

a. Needs to be feasible at IMO;

a. Reversibility timescale/technical/feasible;

b. Work with all environmental assessment processes;

c. Inclusion of societal risk;

d. Precautionary principle;

e. Integration of database of solutions around the world;

f. Market feasibility;

g. Universal application;

h. Implementation and Policy making.

Probability Scale

a. Frequency Descriptions;

   (i) Per ship per year;

   (ii) Scaleable to international shipping per year;

b. Definite or Continuous?

   (iii) Definite Continuous;

   (iv) Definite Occasional;

c. Differentiate between types of ships;

d. Probability of the event happening;

e. Chronic “events” and acute “events”;

f. Parity of Frequency definitions with FSA.

Consequence Scale

a. Note ratings against acute multi criteria but use the highest ratings;

b. Scalability from individual ships to all shipping;

c. Need “no impact” or “no known” impact”;

d. Difference between “no known” impact and “impact not known”;

e. Uncertainty in consequence v probability of consequence;

f. Fault Tree and Event Tree Approach;

g. Per ship or per international shipping;

h. Duration of consequence;

i. Should consequence be defined by sector;

j. Review “long term” & “short term”;

k. Set conditions per issue;

l. Comparability between effects on different receptors;

m. Top level evaluation framework;

n. Process to develop issue specific criteria.

Use of Environmental Risk Criteria as part of a wider FSA

a. Add reputation to criteria;

b. Define “large” and “serious”;

c. Link between “large” and “short term” v “small and long term “ in judging seriousness;

d. Cost in “Environmental cost” and “clean up cost”;

e. First and Second Order effects (second order effects on a case by case basis);

f. Issue of reversibility;

g. Impacts on the supply chain environment;

h. Interference on economic activity.

Cost

a. Environmental costs (CO_2 emissions, Appraisal values);

b. Clean Up costs (restoration, monitoring, clean up).

Environmental Index

a. Don’t include tolerability;

b. Don’t mention “intolerable”;

c. How to aggregate multiple risks;

d. IMO is not seeking permission.

E3 Findings from Workshop 2

E3.1 Workshop Agenda

E3.1.1 The Workshop 2 was conducted in accordance with the following agenda:

a. Review of the Draft Main Report;

b. Opportunity for Questions;

c. Selection of Case Studies;

(i) Identify an issue;

(ii) Give the issues a risk matrix (global [use criteria 4.6] and per ship) [use criteria 4.10];

(iii) Propose a risk control option;

(iv) Conduct a CBA (top level);

d. Report back on the findings with other stakeholders.

<u>Opportunity for questions</u>

a. The Level 11 (at Table 4.5 Global Environmental Risks) exceeds the reasonable scale in terms of international shipping, which is the same scale as safety, as stipulated in the FSA literature. The purpose of the table is to make it clear that this is the environmental equivalent of the safety data;

b. The value of preventing a fatality is $3,000,000. This value reflects that there are few accidents resulting in fatality, otherwise this value would be less;

c. Global Risk Index Names, Severity Index names, need to be reviewed for consistency and generic understanding;

d. Consider adding International (countries), Nationally (within one country) and Regional, Local (e.g. port or bay) significance;

e. Ensure that a section is added to explain why there are two tables for ‘global’ and ‘one ship’ severity;

f. The costs are generic to the location, as ships are mobile/trading internationally although there is an agreement that there may be differences between mitigation costs in developing/developed world;

g. It should be made clear that these criteria are being developed to add environmental aspects to the FSA criteria by means of a tool kit;

h. Positive impacts should still be included;

i. There was concern that the numerical values were too high however, these have been carried across form FSA criteria;

E3.2 Case Studies

E3.2.1 The workshop applied the criteria to the introduction of High Speed Container Ships, by identifying the following, which are displayed at Table E.1:

a. Environmental Aspects;

b. Whether a global or per ship issue;

c. Scoring Severity and Frequency;

d. Ascertaining the Risk Value;

e. Prioritise.

Risk Control Options (mitigation measures)

E3.2.2 Following ranking of the aspects, the risk control options were identified as follows:

a. Wave Damage = Reduce vessel speed close to land/shelving/vessels;

b. Collision Risk = Extra licensing (STCW endorsement).

Cost Benefit Analysis

E3.2.3 What is the loss (cost $) of reducing the speed of a high speed craft? Based on FSA definition categories?

a. Safety (Decreases);

b. Environment (The Problem);

c. Business More ships required to meet the needs (Increases and decreases);

d. Property (Increases).

E3.2.4 Clean up costs and environmental loss could include sea defences, habitat loss, loss of land and coastal erosion.

Conclusions

E3.2.5 The session concluded that the exercise was useful at brainstorming the aspects and impacts associated with a scenario although this was only a high level example.

E3.2.6 On this occasion the highest ranked aspect was not the predicted outcome, which caused interesting debate. Care must be taken not to dismiss those that scored slightly lower, so it may be the case of applying adjustment criteria to capture borderline impacts.

E3.2.7 It is essential that relevant Subject Matter Experts (SMEs) are included in the assessment process, any facts and data are drawn into the process and a record of the assessment discussion held for future purposes.

Environmental Aspects	Globally?	Ship?	Comments	Global Risk Index	Severity Assessment	Probability	Risk (probability x severity)	Rank
Higher speed = greater emissions (So, Nox PM)	Y		Assume speed increases & fuel increases & emissions increase (x3), Same containers, same trade.10,000 ships, 500 of them to be high speed.	5+ (Top end of minor)	>	>	5	4
Higher collision risk = Releases to receptors		Y	Experience says that the risk of collision will go up	>	5	3	8	2
Grounding risk		Y		>	3	3	6	3
Wake damage		Y		>	2	7	9	1
Oil Sewage and garbage mgt		Y		>	0	n/a		>
Noise damage to marine life	Y		Localised	3	>	>	3	6
Anti fouling paint release			Greater speed = less bio fouling = positive impact (n/a)	n/a	>	>	>	>
Ballast Water Management	Y		Transfer of organisms faster, have a shorter time for orgnisms to survive if journey is shorter	4	>	>	4	5

Table E.1 - Case Study: High Speed Container Ships