EUROPEAN COMMISSION

Directorate-General for Transport
Directorate Development of Transport Policy;
Research and Development
VII-E

THE ?EMARC? PROJECT
Contract No: WA-95-SC.097

MARPOL RULES AND SHIP GENERATED WASTE

FINAL REPORT FOR PUBLICATION

Project Funded by the European Commission
under the Transport RTD Programme
of the 4th Framework Programme

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EXECUTIVE SUMMARY

This report is the ?Final Report for Publication? of the EMARC Consortium. Under the 4th Framework Programme for Research and Technological Development, the EMARC Consortium, a group of twelve organisations from France, The Netherlands, and the United Kingdom, was formed to assess the effects of the MARPOL Regulations on the port environment throughout Europe and to investigate present and future systems for the management of ships? waste both ashore and afloat. With partners drawn from port authorities, shipping companies, ship builders and the waste industry the Consortium has been well placed to consider the complete waste cycle from generation to ultimate disposal.

The project has been jointly funded by the consortium partners and the European Commission under the Transport RTD Programme of the 4th Framework Programme.

The aims of the research have been to examine:

- what sorts of shore based waste management systems are currently in operation?
- what are the perceived waste management needs of vessels?
- are there improvements that could be made to either, or both, of the above?
- what constraints prevent waste management systems operating effectively?
- is the interface between ship and shore effective?
- is the environment benefitting?

These questions are not new. Considerable research, much of which is the result of questionnaires, has already been carried out, but apparently dominated by sectoral interest groups. A new cross-sector survey was therefore implemented to collect data on existing waste control systems both on ships and in ports. A database of prevailing facilities, practices, and attitudes was created in order to determine just how effective the MARPOL Regulations were at dealing with all types of ships? waste. This has been achieved by looking at waste generated on ships and at the facilities provided both on ships and on shore for its control and disposal. Included in this are an actual inventory, an assessment of communication methods, and the impact of economic, environmental and health and safety aspects.

The problems of quantifying the total amount of waste generated by shipping in the European area and the increasing complexity of waste management faced by the marine industry will continue to grow as MARPOL oriented legislation evolves. As no comprehensive information on total amounts of waste are available, data on vessel callings, rates of waste generation, crew sizes, scheduled service timetables and other information were obtained from a number of different sources. Subsets of the data have been validated using independently sourced additional data. This generalised approach has enabled total quantities of generated waste to be estimated and a geographically based analysis performed.

Undoubtedly more efficient waste management operations than those currently in use can be achieved, but, as a preliminary step to proposing new systems, an inventory of all the applicable constraints have been drawn up. Three major areas were been examined using, where appropriate, case studies of ports, terminals and types of ship as illustrations.

One of the main objectives of the EMARC project has been to assess the success or otherwise of MARPOL in reducing marine pollution and improving the natural environment. In order to achieve this objective, the main types and mechanisms of pollution from ships have been identified. Despite the increasing levels research being undertaken, there remains a lack of co-ordinated projects which are producing reliable and comparable data. In this respect the effectiveness of MARPOL remains undetermined.

Compliance with MARPOL implies committing money, time and personnel. Ports have invested in physical and organisational infrastructure and ship operators have invested in equipment to control and prevent pollution from taking place in the first place. There has been a significant effort to meet the Regulations by responsible organisations. Detailed case studies have been undertaken in order to identify indicators of progress, or otherwise, in the provision of facilities. The conclusion from this part of the study is that MARPOL can be shown to be having positive results.

Trials were carried out on a cruise liner and a container ship, in order to validate the waste management systems used on each vessel. Two substantially different vessels were chosen for the trials. A container vessel, built in Korea in 1988, and a state-of-the-art cruise liner, built in 1993, were audited. Not unexpectedly both vessels operate under highly efficient waste management systems although with very different results. The container vessel delivers virtually all its waste to shore while the cruise liner aims to meet a zero discharge policy

An extensive review of the many options available for the management of waste in all forms and in all marine locations has been carried out. Future possibilities in the management of waste have also been examined. In most cases only a small number of the options considered will be needed in any one circumstance. In the future, there will be a step change in the management and treatment of many wastes on board compared to current practices. Waste minimization and materials replacement will have a significant impact on the volume and composition of many of the wastes. A specification for a demonstration of the use of standardised containers has been proposed

A conceptual model has been developed to allow a logical approach to be made to what at first sight appears to be a set of rather illogical or random operations. The operation of waste management systems ashore and afloat are too interwoven with other factors to permit clear cost and/or efficiency cases to be made, but the model allows a knowledgable user to estimate the effects of changing existing operations or introducing new procedures.

The MARPOL Regulations are extensive and comprehensive and there is already sufficient effort being expended by the EU, IMO and many others to keep the necessary technology and equipment up to date and relevant in the current environmental climate. The Regulations are having an effect although to what degree is less easy to assess. There is no doubt that if awareness of the regulations alone was used as a measure, then MARPOL would certainly be judged a success. Nevertheless, there is some evidence to show that the marine environment is improving and that the maritime community is playing its part. However, there is no room for complacency and there is an urgent need for much more focussed and independent research.

It is important to note that the actual work of the consortium was carried out by persons actively involved in the day-to-day operation of MARPOL and waste management in ports and on ships. This was intentional. The whole project therefore has benefitted from a considerable background of practical knowledge. The interpretation of data and suggestions for the future development of solutions and policies have been made from the basis of this knowledge and experience.

A bibliography of publications used during the course of the project is included at the end of this report.

A shorter version of this report has been prepared by the consortium as the final deliverable of the project (Deliverable 11).

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1. INTRODUCTION

This report presents an overview and summary of the work of the EMARC project. The work has been carried out, and partially funded, under the Transport RTD Programme of the 4th Framework Programme of the European Commission. The EMARC Consortium, made up of a group of twelve environmentally conscious commercial and research organisations from France, The Netherlands, and the United Kingdom, was formed to assess the effects of the MARPOL Regulations on the port environment throughout Europe and to investigate present and future systems for the management of ships? waste both ashore and afloat. The approach has been to consider port and ship operations and environmental effects in parallel. The economic, technical and legislative constraints on port waste management systems have been examined together with the perception of their efficiency. Present and possible future waste management technologies have been compared against secondary research to give measurable and/or quantifiable results. Conclusions and recommendations emerging from the EMARC research are seen to provide a practical solution to waste management problems which will both conform to legislation and make that legislation workable in the commercial context without prohibitive expense.

2. PROJECT OBJECTIVES

All transport operations produce waste. Ships are no exception. The crew produces waste, as does the operation of the engines and cargo handling. In other words, ships are just like trucks, trains or aircraft. Where ships differ, is frequently in their size and certainly in their operating environment. Unlike other modes of transport they are often out of touch for days or even weeks with the sort of services, such as supplies, medical facilities and waste collection, which the rest of us take for granted. What happens to the waste they produce? The historical solution has been to dump it into that infinite waste amenity site - the sea. In today? s justifiable atmosphere of environmental concern this solution is no longer acceptable.

The operation of ships, therefore, gives rise to the potential for the pollution of the marine environment. The potential is reduced if there are adequate facilities on board to manage waste effectively and adequate and convenient facilities ashore to receive the waste when the ship reaches port. Adequate and practical waste management systems will only be implemented if suitable regulation and control measures exist.

Regulations have been developed over a number of years in order to prevent the pollution of the marine environment by ships discharging harmful substances or effluents into the sea. A Convention adopted as long ago as 1973 and modified by a 1978 Protocol has become known as the MARPOL Regulations. These regulations are recognised as the most comprehensive initiative to regulate and minimise pollution from ships and continue to be monitored, amended and augmented vigorously under the auspices of the International Maritime Organisation (IMO).

A series of Annexes (I - V) sets out the regulations for the prevention of maritime pollution by oil, noxious liquids, harmful substances in packaged form, sewage and garbage respectively. A further annex, Annex VI, is being developed to extend MARPOL 73/78 to cover air pollution from ships. All the other annexes are in force although Annex IV only came into effect in some European countries on 1 January 1998. Annex III is mainly a cargo handling problem and is generally handled effectively by the cargo handling organisation whether port authority or private company. The harmful substances concerned are covered by the International Maritime Dangerous Goods Code. Indeed there is a move to separate cargo waste generally from ship? s domestic waste under the Regulations. Therefore it is Annexes I, II, IV and V with which the maritime world is primarily concerned.

The rules and regulations are in place, but do they work? Are they workable? Are they achieving the desired effect of reducing pollution? Is there anything else that could be done? Are more regulations needed?

With partners drawn from port authorities, shipping companies, ship builders and the waste industry the EMARC Consortium has attempted to assess the problem even-handedly. The nature of the problem is the translation of the MARPOL Regulations into practical, but not punitive, systems of ships' waste management both ashore and afloat under an evolving legislative framework.

The initial baseline programme for the project was broken down into three major areas of research.

X the collection and synthesis of data on waste and pollution resulting from routine maritime operations,

X the design of a model to describe environmental changes resulting from improved technologies and the widening application of MARPOL Regulations, and

X the definition and testing of possible solutions for the improved management and treatment of ship generated waste.

Developing these general areas into more specific objectives the following work programme was proposed:

X to analyse operational waste produced by ships

X to investigate current operational procedures in ports and on ships

X to assess the impact of MARPOL on the port environment

X to develop a conceptual model to investigate the effects of changes to procedures or legislation

X to identify the constraints on possible improved waste management systems

X to define, evaluate and test possible solutions for improved treatment and management of ship generated waste, and

X to propose policy guidelines.

The aims of the research therefore were to provide answers to specific questions:

X what sorts of shore based waste management systems are currently in operation?

X what are the perceived waste management needs of vessels?

X are there improvements that could be made to either, or both, of the above?

X what constraints prevent waste management systems operating effectively, ship and shore?

X is the interface between ship and shore effective?

X is the environment benefitting?

The basic methodology was devised drawing on the practical and operational knowledge of consortium members and can be described as follows:

X to identify the types of shore based waste management systems currently in operation, by comparing secondary research in specific ports with corresponding primary research from the questionnaires

X to identify the perceived waste management needs of vessels, identified by asking specific questions of ships' masters on a rolling basis and comparing the results with secondary data available in the rest of Europe

X to identify the constraints on waste management systems by looking at economic, technical and legislative aspects throughout Europe (both primary and secondary data has been used)

X to consider the operation of on-board waste management systems by conducting limited trials on specific vessels

X to examine environmental data in order to identify trends in the improvement or otherwise of the port environment

Existing information has been closely studied but considerable new data has been collected for EMARC. Information has been gathered from the following sources:

X searches of literature and existing databases

X enquiries to national and international statutory authorities

X enquiries to national and international trade organisations

X questionnaires to ports

X questionnaires to ships and shipping companies

X questionnaires to port users and waste disposal companies

X detailed audits in specific ports

X personal contact with port users and waste disposal companies

3. EXISTING SHIP AND PORT WASTE MANAGEMENT SYSTEMS

A number of existing datasets resulting from questionnaires and surveys were examined when the specification for the EMARC project was drawn up. It was considered that these would provide the project with sufficient baseline data and information. On closer examination this proved not to be the case. Information was either incomplete or biased towards one or another sections of the maritime industry.

A new survey was therefore designed and implemented to collect data on existing waste control systems on ships and in ports. The objective was to create a database of prevailing facilities, practices, and attitudes in order to determine just how effective the MARPOL Regulations were at dealing with all types of ships? waste. This has been achieved by looking at waste generated on ships and at the facilities provided both on ships and on shore for its control and disposal. Included in this are an actual inventory, an assessment of communication methods, and the impact of economic, environmental and health and safety aspects.

As only limited EU wide information was available, it was decided that a core focus of this study would be two questionnaires, one for ships and one for ports/terminals, with a simultaneous creation of a databases for handling the incoming data.

Eight hundred questionnaires were sent to shipping companies and 200 to ports within the EU. The ports were categorised by the number of movements per annum. Information was recorded country by country in order to highlight local customs and systems as well as on an overall basis. Shipping companies were recorded by the type of vessel owned, and were also analysed overall.

X Definitions and interpretation of the terms, particularly of ? waste? were liable to be varied and, in order to overcome this, it was decided to limit the definitions to garbage, oil and sewage, as per the MARPOL Annexes. This is an important point. Even though great care is taken when framing Directives and parallel national legislation to ensure that wording is as unambiguous as possible, industry ? jargon? frequently takes over at the operators level. One operators ? slops? is another? s ? sludge? , for example.

X Appropriate identification of questionnaire recipients, and distribution, had to be addressed. There was a high level of response from ports and this was achieved through identifying a named individual within each organisation. However, for the shipping companies, the questionnaires were distributed through the representative national organisations, and this double handling delayed the process.

X The validity of responses is a constant caveat. While the response level to both questionnaires was considered good, it has to be borne in mind that those responding are likely to be content for their policies and procedures to independently examined. Those that did not respond could be operating with no policies with regard to waste disposal, or that they were just too busy or not sufficiently interested.

The replies to questionnaires have, of course, always to be taken at face value. Independent surveys are the only way to obtain really meaningful data. In this context ? independent? means that the survey must be carried out on the ground (or ship) by a small team consisting of representatives from several states excluding the one in question. An unlikely scenario but survey results will be not wholly accurate until this happens.

A number of conclusions can be drawn from the analysis of the data. European shipping companies and European ports are able to demonstrate an understanding of, and conformance to, MARPOL Regulations. It would appear that a significant percentage of shipping companies now use shore reception facilities and this, in conjunction with on-boars systems has reduced the quantity of waste being discharged to sea by ships. Countries in the Baltic Sea are demonstrating responsibility in designated Special Areas, but as there has been a limited response from the Mediterranean area, it is somewhat unclear as to how requirements are being met here.

The survey findings indicate that tank washings and dirty ballast from tankers is well controlled with slight variations between small and large ports in their capability to deal with engine room bilges or slops.

Similarly there is no identifiable difference in the ability to deal with sewage. An increasing number of ships have on-board treatment facilities so there is a lesser requirement for shore-based discharge. Demand and supply appear to be matched at present.

Critically effective communication has been shown to be of paramount importance throughout the entire ship-shore waste management chain as is the case with any control system. The perception of the quality and cost of the reception facilities provided varied both among ports and among ships and this may stem from a failure in communications. This problem arose repeatedly during the course of the project.

In a recent study of port reception facilities, the following references were made to communications:

> ? Improved lines of communications lead to better recognition of the capabilities and limitations associated with any waste management system by interested parties ? .
>
> ? ..... there is little communication (liaison between port authority and port user) ? .
>
> ? Language barriers are known to cause communication difficulties, and ways to ensure foreign ships, who do not have agents in a port, of the waste disposal arrangements should be improved ? .
> (UK Marine Safety Agency, Project 352, Survey of UK Reception facilities for Oil and Garbage)

The management of waste from ships is very similar to any other management system, and to work properly is highly dependent on good communications. Where ships' waste management

differs, is in the number of actors taking part in the programme. Owing to the possible number of communication links eg. ship, agent, port authority, contractor, transport, it is imperative that a communication system is established which takes everyone's needs into account.

In the maritime industry the mobility and international operation of the waste producer - the ship - raises a problem. Although detailed legislation varies in EU member states, there is a generally accepted duty of care that the producer of the waste retains an on-going responsibility to ensure that the waste is disposed of correctly.

The ship, because of its mobility, must rely on local agents to ensure that its duty of care is carried out. The ports, however, do not want to be held responsible for someone else's rubbish, as in the event, for example, of some hazardous waste being put in a skip, the cost of disposal can become prohibitive. Port Waste Management Plans or similar documents can, to a degree, overcome this problem by providing guidance on communication:

X Ports must make the shipping community at large, aware of the range of waste reception facilities available at their ports and just as important, the types of waste which they are not capable of handling, the normal disposal rates and the disposition of the reception facilities.

X Ships should give notice of their waste disposal requirements prior to arrival

X Local pictorial signs need to be in place at the berths/terminals to communicate to the ships' staff the location of skips etc, and what can and cannot be placed in the skips

X Shipping companies have a duty to report ports/terminals to the Flag State which have inadequate facilities, and equally the ports should report ships and companies which flout the rules and law on waste disposal.

X Arrangements should be made for the removal of full skips on a regular basis to ensure at the ships make full use of them.

X The possibility of local arrangements where ships call at regular intervals for skips to be made available.

In this manner, ships will be encouraged to use the facilities provided, and ports will not need to "own" the waste under the duty of care, but can ensure that adequate reception ties exist.

Control of environmental issues with respect to the interface between ship and shore is not dissimilar to that of any other shore industry. Any activity on board a vessel will result in the production of waste materials which must be disposed of. The main difference is the potentially long period of time that vessels on deep sea passages will have to store their waste until a convenient port is reached and local disposal companies can dispose of the waste.

Historically, the "sea" was viewed as a large waste receptacle. Ships' waste was routinely disposed of at sea with little or no regard to the environmental implications of this act. Shipping companies, ports and other land based activities were equally to blame and few had an infrastructure or facilities in place to cope with the waste in any other way. Such waste disposal methods have now been severely curtailed, thanks to the introduction of the MARPOL Regulations, with waste wherever possible being landed to shore facilities. It should be noted, that economically, when comparing modern operations with those previously practised, there is a cost implication relating to the correct method of disposal. However, waste disposal costs are now seen as a routine running cost of the ship and taken into account when forecasting profitability.

A unique aspect of shipping related waste disposal is the opportunity that ships have to dispose of waste in different locations or countries, it should be noted that an effect of particularly high charges is that they may result in shipping owners waste being stored on board until a more cost effective port is reached, which, in turn, could create local or national waste disposal problems.

Germany has a large recycling programme, which requires all household waste to be recycled wherever possible. In 1995, such a large quantity of waste was returned for recycling that German waste companies could not deal with it. This resulted in quantities of that waste being shipped to other countries for recycling, which, in turn, created an unnaturally large amount of waste at the receiving countries. The price paid for such waste the dropped significantly and stopped the collection of re-recyclable materials in the receiving countries.

It is felt that a similar situation could, in theory, arise in the marine community, if the costs of waste disposal were seen to be prohibitively high in one particular area, ships would retain waste on board until a cheaper port was reached.

Approximately 50% of those ports responding to the questionnaire have incorporated the costs of waste disposal into port dues. From the ships' perspective, this would appear to be an attractive option, it is therefore interesting to note that the shipping companies perception of the quality and cost of reception facilities does not bear this out. It is suggested that, in many cases, this may be due to a failure of communication. However, if the cost of waste disposal is incorporated into port dues or to agency fees, it is a significant incentive to ships to make best use of the facilities available. A restraint to further develop this practice is noted from the ports' response that indicate that in some cases there is an unwillingness to take responsibility for waste, especially when the exact nature of the waste is not known, and the associated high costs of disposal.

Rotterdam Port Authority took an initiative some time ago with the introduction of the "Green Award" for vessels which complied with established standards regarding environmental management. The result of such a scheme is that there are reduced costs to the ship owner for services not necessarily connected with waste management, and here, perhaps, lies a method of ensuring total compliance with legislation with, better equipped ships, better trained crews, higher standards of waste management and recognition for the effort in controlling the waste. Enthusiasm for the implementation of this and similar schemes by other ports is very variable -

the difficulties quoted very largely being centred on commercial considerations and the impact on the competitive ? level playing field? .

The environmental impact of ships and shipping as a means of transport is acknowledged to be extremely favourable compared to alternatives. However, the stigma of oil tankers running aground, seals being caught in plastic nets, and birds heavily oiled, is probably the way in which the shipping industry is perceived.

Within the EU, shipping companies and ports alike, have both responded very positively as new requirements came into force. Modern ships have various levels of waste control on board, and appear to manage their waste fairly effectively, and ports (not necessarily the port authority) are willing to supply whatever is required to contain ships' waste.

Health and safety are aspects which have a bearing on the disposal of waste. On smaller vessels, for instance, there is very little space available for stowing waste products, and also some products may be prone to spontaneous combustion in certain conditions, whilst others may cause problems owing to seagulls trying to reach food scraps.

The real issues, in respect to ships are, where the waste is stored, how it is stored and the disposal methods are correctly followed. Simple wheelie-bins with lids may be all that is necessary to make the job of waste management safe and free from health risks. Shipping companies need to have procedures for the handling and disposal of all waste materials, and the crews must be trained in carrying out these procedures.

A Manual on Shipboard Waste Management has been finalised by IMO MEPC 38 (10 July 1996) in order for shipowners to prepare a garbage management plan in time for implementation of the new Regulation 9(2) of Annex V of MARPOL 73/78 expected to enter into force on 1 July 1997 for new ships and 1 July 1998 for ships built before 1 July 1997. This manual provides guidelines and offers information and technical data and suggested tools to assess, develop and implement a waste management plan. It is designed to meet the objective of the International Safety Management (ISM) Code.

Ports, on the other hand, have similar problems to any other shore-based industry, and must apply best practice when dealing with such products. The main concern on land, is the waste if left lying for some time will encourage vermin to collect in the area with the attendant health risks to anyone within the vicinity. Provision of reception facilities has been discussed during the last session of IMO MEPC38. A comprehensive Manual on Port Reception Facilities, which provides guidance on the provision of reception facilities for ship generated waste, as part of the implementation of MARPOL 73/78, has been published by IMO. A document has also been prepared by the European Commission, on aspects related to the Development of a Directive for Shore Reception Facilities.

However, waste, properly managed by both ships and ports need not be too expensive to deal with, can create little impact on the environment and have no undue inherent health or safety risks attached.

In summary, the key influencing factors derived from answers to the questionnaires concerning the disposal of waste were:

X the nature of the waste; where it could be discharged; its quality and quantity; whether or not it is special or hazardous; whether there is a market for it; whether it can be recycled the nature and size of the vessel; storage space; on-board disposal/treatment facilities

X the geographical parameters of where the ship operates, and the port is located

X the technical limitations, that is, capabilities of the equipment

X in cost terms, there is a positive incentive to make use of facilities where they are included in the port dues, and where a ship operates regularly between two ports in different countries, the cost of disposal will be significant

4. QUANTIFYING THE PROBLEM

Quantifying the total amount of waste generated by shipping in the European area and establishing the magnitude of the problem faced by the marine industry will continue to grow as MARPOL oriented legislation evolves and is ratified. It has been established that reliable data is not universally available. Nevertheless, a statistical approach to the calculation of overall quantities of waste generated has been considered necessary. To this end data on vessel callings, rates of waste generation, crew sizes, scheduled service timetables and other information have been obtained from a number of different sources. Subsets of the data have been validated using independently sourced additional data. This generalised approach has enabled total quantities of generated waste to be established and a geographically based analysis by area of origin and vessel type is presented and discussed.

A considerable amount of useful data has been collected by the EMARC partners both in the course of their normal activities and specifically for the study. However, there are a number of reasons why supplementary information is required. In some cases only a small number of vessels have been sampled and in many ports the quantities of waste recorded includes waste from general port activities. In other cases the detailed data provided by large ports may not be representative of the situation found in smaller ports or other countries.

Notwithstanding the overall lack of detailed information one reasonably comprehensive and accurate dataset is available from a single source. Records of callings by ships at EU and other ports have been obtained which include extensive information on the ship, the most recent voyage and the ports visited. Thus, using waste factors already researched and a combination of time spent at sea, ship size and type, crew and passenger complements and so on, the total quantity of waste produced on an annual basis by ships has been estimated.

The quality of the outcome of this approach is dependent on a number of constraints imposed by the source data. Although relatively comprehensive, the data does not cover 100% of all port callings. There are a number of classes of vessel where record keeping, data compilation or handling are impractical. For example, the data set does not include vessels below 500grt and thus the activities of fishing vessels (with the exception of factory ships) are not recorded. Fishing vessels, together with pleasure craft, have therefore been excluded from the study.

By far the most serious omission from the initial data are passenger/car ferries on regular services. It was decided that, while the overall outcome of the exercise would not be invalidated by ignoring small vessels, the exclusion of ferries would result in unacceptable inaccuracies. Ferry data has therefore been sourced elsewhere.

Input data for the study was acquired from various sources. To allow the aims of the study to be met information on the following was needed:

X callings? data for all EU ports
X passenger/car ferry traffic
X ? waste factors? for a range of vessel types
X records of ? waste landings?

Following a validation exercise using ports represented in the EMARC partnership it was concluded that, on average, about 10% of the overall data appeared to be missing from the main data set. An allowance has been made for this deficiency in subsequent calculations.

The three MARPOL Annexes, I, IV and V which relate to oily waste, sewage and garbage respectively are considered in this analysis. To enable the most efficient calculation of quantities of waste generated the ? waste factor? for each type of waste has been determined for a number of different vessel types.

Table 1 shows the waste factors derived for each of the vessel types and the source of the information. Data supplied by the Rotterdam Port Authority on factors for waste actually landed has been included for comparison and used to estimate overall quantities landed.

A synopsis of the findings, Table 2, provide an estimate of the geographical distribution of the generation of ships? waste. The results demonstrate the very large quantities of waste produced during the normal activities of the shipping industry in the European area. The contribution of ferry traffic to the overall calculated waste quantities has been of major significance in the ongoing analysis. The management of waste on these vessels is normally highly organised and the quantities treated and landed can be established with some confidence.

The utmost care should be taken in interpreting these data. The assumption that the difference between waste generated and waste landed equals pollution is totally unsound. Substantial reductions in quantities to be transferred ashore will be achieved by on board treatment and, in the case of ocean voyages, by legal discharge.

Table 1. Waste factors and their sources

Vessel type	EMARC Project Deliverable 1	Generated MSA Project 365		Landed LMIS/RPA		Value adopted for EMARC Project Deliverable 2		
	Garbage Annex V (kg/head/24 hrs)	Sewage Annex IV (l/head/24 hrs)	Garbage Annex V (kg/head/24 hrs)	Oily waste Annex I (cum/1000 GRT/24 hrs)	Garbage Annex V (kg/head/24 hrs)	Oily waste Annex I (cum/1000 GRT/24 hrs)	Sewage Annex IV (l/head/24 hrs)	Garbage Annex V (kg/head/24 hrs)
Animal Carrier	-	-	-	-	-	1.00	200	2.50
Container	3.40	200	2.50	0.91	0.28	1.00	200	2.50
Cruise	0.50	250	3.25	1.12	-	1.00	250	3.25
Dry Cargo	2.80	-	-	1.55	0.10	1.00	200	2.50
Ferries	-	200	2.13	-	0.02	1.00	200	2.50
Fish Factory	-	-	-	-	-	1.00	200	1.50
Fishing Vessel	-	-	1.50	-	-	1.00	200	1.50
OBO/Bulk	0.20	200	2.75	0.40	0.14	1.00	200	2.75
Refrigerated	-	-	-	0.71	0.16	1.00	200	2.50
Research	-	-	-	-	-	1.00	200	2.00
Tanker (Small)	1.40	200	1.75	2.85	0.09	2.14	200	1.75
Tanker (Large)	-	200	-	30.2	0.09	1.07	200	1.75
Tugs	-	-	-	-	-	1.00	200	1.50
Others	-	-	-	-	1.00	1.00	200	2.00

Notes: 1. Greater than 15,000 GRT
2. Shaded values estimated from available data.

Table 2. Total quantities of waste generated annually (Revised)

Area	Callings from same area			Callings from other EU areas			Callings from outside EC			Total		
	Annex I (m^3x10^6)	Annex IV (m^3x10^3)	Annex V ($tx10^3$)	Annex I (m^3x10^6)	Annex IV (m^3x10^3)	Annex V ($tx10^3$)	Annex I (m^3x10^6)	Annex IV (m^3x10^3)	Annex V ($tx10^3$)	Annex I (m^3x10^6)	Annex IV (m^3x10^3)	Annex V ($tx10^3$)
Eastern Med.	0.02	540	7	0.02	334	4	0.001	42	0.54	0.04	916	12
Iberian Peninsula	0.44	1175	15	2.52	1480	19	1.47	783	10	4.73	3437	44
Northern Europe	1.26	891	11	2.32	2749	34	4.43	502	6	8.00	4141	51
Southern Europe	2.24	6835	81	0.81	978	13	1.90	1488	19	4.94	9300	112
Scandinavia	0.82	3943	49	0.44	770	10	0.11	175	2	1.37	4887	61
UK / Eire	0.97	1190	14	1.60	2144	26	0.95	353	4	3.52	3667	45
Total	5.75	14574	177	7.71	8455	106	8.861	3343	41.54	22.6	26348	325

5. MARPOL IN EUROPE

A major factor in the operation of MARPOL in a pan-European context is how individual countries have interpreted the various Regulations and Directives. In the following paragraphs the MARPOL Regulations as they are operated are briefly described for each country for which information has been forthcoming. Firstly the various international codes and guidelines which make up the MARPOL rules are reviewed. This is followed by a country by country survey of how MARPOL has been variously adopted.

Within Europe, there are examples of regional Conventions which deal with pollution on a regional, or individual, maritime basis:

- X Barcelona Convention for the Protection of the Mediterranean Sea against Pollution (1975)
- X Convention for the Protection of the Black Sea (1992)
- X Oslo and Paris Convention for the Protection of the North East Atlantic (1992)
- X Helsinki Convention, Baltic Marine Environment Protection Convention (1992)

In addition, there are two global conventions: the London Dumping Convention (now the London Convention) and the MARPOL Convention. The former deals with direct disposal of waste into the sea and the latter with ship-borne operations. Both are administered by the International Maritime Organisation (IMO). The London Convention came into force in 1975 and enforcement is undertaken through national legislation by the contracting parties.

The International Convention for the Prevention of Pollution from Ships 1973 and its 1978 Protocol (MARPOL 73/78) is recognised as the most comprehensive initiative to regulate and minimise pollution from ships. MARPOL 73/78 deals not only with oil, but with all forms of ship generated marine pollutants. Over 90% of world shipping tonnage is regulated by this Convention. The MARPOL Regulations as applied to ships are summarised below.

MARPOL 73/78 contains five Annexes

- X Annex I: Regulations for the Prevention of Pollution by Oil
- X Annex II: Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk
- X Annex III: Regulations for the Prevention of Pollution by Harmful Substances carried by Sea in Packaged Form or in Freight Containers, Portable Tanks or Road and Rail Wagons
- X Annex IV: Regulations for the Prevention of Pollution by Sewage from Ships
- X Annex V: Regulations for the Prevention of Pollution by Garbage from Ships

Annexes I, II, IV and V cover specific requirements regarding the handling and discharge of ship generated wastes. A further Annex (Annex VI) is also being developed to extend MARPOL 73/78 to cover air pollution from ships.
Annex I contains measures to prevent or reduce operational pollution from oil by the regulation of its discharge. This takes into account water mixtures resulting from tank cleaning and the requirement for segregated ballast tanks in tankers built since 1976, as well as accidental pollution. Annex I came into force on 2 October 1983 and covers all aspects of the carriage of oil, either as fuel, engine room slops, or cargo or dirty ballast. For this survey, the traditionally separate areas identified in Annex I, i.e. engine room bunkers, lube oil, engine room slops and tanker operations, are kept separate.

Annex I also specifies:

X criteria for design, construction, equipment and operation of ships (including double hulls and equivalent environment protective designs)

X recording and reporting procedures to keep account of amounts of oily waste generated and in what way it is disposed, details of how much waste can be discharged, and the requirements for provision of reception facilities for oily mixtures in ports

Regulation 26 of Annex I requires ships to carry on board a Shipboard Oil Pollution Emergency Plan. This regulation came into effect for new ships, on 4 April 1993, and for ships built before that date, on 4 April 1995.The plan must be available to assist personnel in dealing with an unexpected discharge of oil and to set in motion the necessary actions to stop or minimise the discharge and to mitigate its effects. The plan must go beyond providing for operational spills and must also include guidance to assist the master in meeting the demands of a major discharge. The plan must also include the procedure to be followed by the master to report an oil pollution incident.

Each vessel, whether motor driven or steam ship, must comply with requirements of Annex I, with regard to storage, record keeping and disposal of oily wastes. The important aspect of this is whether the vessel has the ability to handle the slops on board by means of an incinerator, or whether it relies entirely on shore facilities.

Annex II is the international instrument regulating the disposal of chemical wastes derived from bulk chemical transportation. It came into force on 6 April 1987.

These regulations have been published in a separate booklet, Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk. General advice and guidance on ways of assessing hazards associated with chemical spillages and response to such spillages is provided in the IMO Manual on Chemical Pollution. The IMO publications, Provisions Concerning the Reporting of Incidents Involving Harmful Substances under MARPOL 73/78, and Control of Ships and Discharges, as well as the International Chamber of Shipping (IS), Tanker Safety Guide (Chemical) also provide advice.

Regulation 7 of Annex II obliges Governments to ensure the provision of facilities for the reception of residues and mixtures containing noxious substances according to ships needs. As with oily wastes, further action by Governments to provide these facilities would assist greatly in the reduction of pollution from this source. Special regulations also apply to the disposal of chemicals at sea. Pollution from this source is considered to be minimal.

The International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code), the Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in bulk (BCHC Code) and the Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) are made mandatory by MARPOL 73/78 and SOLAS 74. These codes provide an international standard for the safe carriage by ships of dangerous cargoes, liquefied gases and noxious chemicals in bulk.

Annex III deals with pollution by harmful substances carried in packaged form. It applies to all ships carrying harmful substances in packages, including freight containers, portable tanks or road and rail tank wagons. It came into force on 1 July 1992. These harmful substances are also listed in the International Maritime Dangerous Goods Code.

The IMO Code of Safe Practice for Solid Bulk Cargoes (BC Code) provides guidance to ship owners and masters on the standards to be applied in the safe stowage and shipment of solid bulk cargoes. It includes general advice on the procedures to be followed whenever bulk cargoes are to be shipped, and describes the hazards associated with certain materials.

Annex IV is concerned with sewage. The discharge of sewage into the sea is prohibited except when it has been:

X discharged through an approved system, or
X stored in holding tanks and discharged in an approved manner, or
X processed in approved treatment plant

For all vessels it is imperative that the ships can deal with the sewage on board, either by retaining in holding tanks until beyond the 12 mile limit, disinfecting and comminuting and retaining in holding tanks until 4 miles from the coast, or having an approved sewage treatment plant fitted on board which can discharge within port limits.

While Annex IV has not yet come into effect, many ships already meet these discharge requirements and are operated in accordance with good practice, ahead of international legislation. Many port States have adopted local legislation to control the discharge of sewage from ships, and entry into those ports is conditional upon compliance with such legislation.

Regulation 10, covering reception facilities, requires the Government of each party to the convention to ensure the provision of facilities at ports and terminals for the reception of sewage, without causing any undue delay to ships, and being adequate to meet ships needs

Under Annexes I, II and IV, most vessels are subject to regular and complete surveys to ensure full compliance with the MARPOL 73/78 Regulations.

Annex V came into effect on 31 December 1988, and lays down conditions to prevent pollution by garbage from ships. It prohibits the dumping of all plastics overboard and regulates the disposal of other ship-generated garbage into the sea at specified distances from land, prohibiting it all together in designated Special Areas, which include the Baltic Sea, the Mediterranean Sea, the Black Sea, the Red Sea, Gulfs area, North Sea, Antarctic and the Wider Caribbean Region.

In 1995, amendments were adopted requiring all ships of 400 gross tonnes and over, and all ships certified to carry 15 or more persons, to have a garbage management plan and a Garbage Record Book. In addition, the amendments require every ship of 12m or more in length to display placards notifying both crew and passengers of the ship's disposal practices. These new regulations will come into force on 1 July 1997 for new ships and on 1 July 1998 for ships built before 1 July 1997.

The regulations apply to all types of ships, from coastal vessels to large cruise vessels, and the arrangements for particular ships will therefore vary considerably, hence the need for individual plans for each ship. The vessel's trade and sailing schedule will also exert a major influence on the garbage management policy and procedures.

The IMO document, Guidelines for the Implementation of Annex V of MARPOL 73/78, includes advice on minimising the amount of potential garbage, on shipboard garbage handling and storage procedures, and shipboard equipment for processing garbage.

Annex VI to the MARPOL Convention will be the instrument for the prevention and control of air pollution produced by ships. This Annex, Regulation for the Prevention of Air Pollution from Ships, was discussed during the meeting of Maritime Environmental Protection Committee (MEPC) held in July 1996. It covers NOx (Nitrogen Oxides) and SOx (Sulphur Oxides) emissions from diesel engines. The exhaust emissions from shipboard incinerators and the emission of ozone-depleting substances (Chlorofluorocarbons and Hydro chlorofluorocarbons) used in vessel refrigeration systems, and halons used in fire extinguishers are also included in the Annex VI regulations, as are the emissions of volatile organic compounds from tankers.

The Annexes of the MARPOL Convention are supplemented by a number of codes and recommendations designed to complement the requirements contained in the Annexes, or to assist their implementation.

IMO has developed an International Safety Management Plan (ISM) Code to ensure safety at sea, prevention of human injury or loss of life, and avoidance of damage to the marine environment and to property. Every company should establish a safety and environmental protection policy, and masters should implement this policy into the daily routine.

Special protection from potential damage by shipping is provided in larger enclosed or semi-enclosed areas being designated as Special Areas under the MARPOL Convention, placing

more restrictions on the discharges allowed from ships. As previously identified, these include the Antarctic, Mediterranean Sea, Black Sea, the Gulfs area and the Gulf of Aden, North Sea, Baltic Sea, Red Sea and the Wider Caribbean region

Special protection to smaller sea areas can be provided by a scheme adopted by IMO, identifying Particularly Sensitive Areas which require special protection to ensure that the delicate marine environment of these areas is not disturbed. In November 1990, the Great Barrier Reef (GBR) Area was declared a Particularly Sensitive Area by the IMO. The declaration of a Particularly Sensitive Area means that special protective measures can be applied to shipping activities and no discharge of any type is permitted. The GBR is the first area in the world to obtain this status. MARPOL 73/78 is being amended continually to ensure that maximum protection from shipping pollution is achieved for the marine environment.

Worldwide the provisions of MARPOL have been implemented in various ways, each country taking account of local its own laws and practises.

Austria has implemented MARPOL in its national legislation by BGBI.Nr.434/1988, in 1988 and updates are also implemented in national law. As Austria does not have any coast line or harbours, there are no other regulations concerning the landing and disposal of ships' wastes.

Denmark subscribes to the MARPOL Regulations and the Helsinki Convention and brought in the first Danish Marine Environment Protection Act in 1975, now superseded by the 1993 Act (act 476 of 2 June 1993). The Helsinki Convention covers the eastern part of Danish marine waters, while the western part is regulated by the 1972 Oslo Convention and the 1974 Paris Convention as well as the 1972 London Convention. The specific rules cover oils, chemicals, sewage and refuse. To combat oil pollution there is a contingency unit comprising several large ships. Reception facilities are provided in Danish harbours for sewage and garbage. Under the Act, dumping, as a rule, is forbidden. The exception is dredged spoil, which is dumped in marine areas where it is least likely to cause damage.

Ships which cause oil pollution in Danish open marine waters and then enter Danish harbours can expect to have to provide a guarantee to cover the clean up costs. In the case of other ships, the question of payment is directed at the flag state. The Municipality cleans up if the coast is polluted and expenses are shared between the Municipality and the State. Strict liability for damages applies to pollution from ships.

Progress on the regulation of ship based pollution is difficult to assess. There is no clear tendency with respect to oil leaks, but there are numerous incidents of illegal discharges eg emptying and rinsing tanks. The Danish EPA contingency unit receives approximately 250 more or less well founded reports of oil pollution each year and the unit's ships go into action about 50 times a year. Dumping has not taken place in Danish waters since 1983 and incineration at sea has never been permitted by Danish authorities.

The Minister makes the rules on reception facilities. Ports may be ordered to establish facilities for the reception of ballast and tank washings containing oil or chemicals. The Minister lays down the rules for payment of charges.

Eire has ratified both the Oslo and the London Conventions, the general purpose of which is to prevent parties from dumping specified dangerous wastes at sea and to control strictly the dumping of other pollutants. The Minister for the Marine has power to grant permits for dumping, taking account of the provisions of both Conventions, attaching any conditions he thinks fit, amending or revoking accordingly. It is a summary offence to dump within the territorial waters of the State, from an Irish vessel anywhere at sea outside the territorial waters, or to load anything for dumping in State or Irish territorial waters. There are various defences to this, such as: the act was carried out on the orders of an employer; it was a mistake; the Minister for Transport had granted a permit; that the dumping constituted a life-saving activity. The system has its faults: the Minister does not have any guidance as to what is appropriate, there is no right of appeal, ordinary citizens are unable to participate in decisions.

Dumping of sludge and sewage sludge is being phased out. Under the Harbours Act 1946-1947, harbour authorities have jurisdiction over their harbour areas. Bye-laws are not really motivated by pollution prevention considerations, except perhaps oil pollution. Hazardous goods must be properly marked and harbour authorities give permission for anything to be discharged into the waters.

The Sea Pollution Act 1991 and the Regulations made under this Act in 1994, relating to the pollution by oil, the control of pollution by noxious liquid substances in bulk and the prevention of pollution by garbage from ships, enable Eire to meet its obligations under the MARPOL Regulations. In January 1995, Eire ratified this, and it came into force in April 1995.

The MARPOL Convention was ratified by France in September 1981, forming the general legislative framework for disposal of ships? waste. Except Annex IV, all the MARPOL Annexes have been implemented in national legislation through orders made under the Ministry of Infrastructure and Transport, Directorate for Ports and Maritime Navigation : The French Merchant Shipping Regulation for the ships, the French Seaport Regulation and the General Police Regulation as regards to the ports.

The Annex I of MARPOL Convention was implemented in national legislation through the decree of 27 September 1983; delivery of certificate stating that the ship is designed in compliance with MARPOL Convention, principle that discharges into the sea are prohibited with exceptions depending on the area of discharge, the type of ship and its equipment.

The discharges into the sea of other substances, accidental or during ship operations, are regulated by decrees: decree of 24 September 1987 for Annex II, decree of 21 February 1989 for the Annex V. These decrees require that the harbours provide adequate reception facilities.

The law of 5 July 1983 is directly applied from MARPOL Convention. It gives the conditions to deliver certificates of prevention of pollution, and the conditions to control ships calling in

French ports. Ships can be prohibited from sailing if control show that the ship can be a hazardous for marine environment. This law provides also the sanctions if there are infringement.

The inspections in France are the responsibility of the Maritime Affairs, Maritime Safety Agency under direct authority of the Ministry of Infrastructure and Transport.

France is also a party to the Bonn Convention and then the Barcelona Convention for Prevention and combatting pollution of North Sea and the Mediterranean Sea by Oil and Other Harmful Substances.

While German Federal legislation provides the framework, the management of ships' waste is mainly regulated by the Länder (Federal States). The Closed Substance Cycle and Waste Management Act was adopted definitely by the Bundesrat and came into force in October 1996. The Act takes up the plans of the EU and integrates product responsibility into economic decision-making processes. The Act clearly and unequivocally states who is responsible for what. Whoever produces, markets, and consumes goods is responsible for the avoidance, recovery, and environmentally-sound disposal of the wastes occurring. The Act represents the consistent implementation of the polluter-pays principle in the field of waste. Responsibility is geared towards the beginning of the process, to the principle of prevention. The Act fully implements the scope of the EU Waste Directive.

Where avoidance is not possible, waste is to be recovered as its component parts or as energy, and in an environmentally friendly way. Priority is given to the most environmentally compatible form of recovery. If recovery is not possible, waste must be disposed of in an environmentally friendly way. The owners or generators of the waste are in the first instance responsible for waste avoidance, recovery and disposal. The polluter has to assume responsibility and costs for recovering and disposing of waste. Commercial waste owners and contractors set up associations to deal with this. The responsibility has been taken out of the public sector.

There are also regional variations. In Lower Saxony, all vessels are issued with information about MARPOL Annex I. It has been possible to discharge residues and mixtures containing oil free of charge in the ports of Lower Saxony since 1988. Solid waste contaminated with oil can also be disposed free of charge. There are conditions attached to this free disposal, however depending on the vessel having some form of commercial activity in the port.

The ship must have equipment which corresponds to MARPOL requirements. Residues must originate from the vessel's normal activities. Pumping capacity is as a rule supplied by the vessel. Disposal must be done by authorised firms and discharge must take place during normal working hours. Any additional expenses must be borne by the ship. There is also a ship garbage management plan to complete.

In Greece the legislative framework for disposal of ships' waste are the MARPOL Regulations (Annex IV is not yet in force). The relevant Greek law is 1186/82 and 743/77, the provisions of which regard the protection of the marine environment and related matters. This overall

legislation provides certain preventive and pollution combatting methods and also describes the obligations for both ships and onshore installations.

There are also marine pollution prevention measures and a description of the obligations for oil tankers and other vessels arriving at Greek ports or anchorages. Delivery of oily wastes, residues and mixtures containing noxious liquid substances and garbage to shore reception facilities is mandatory for all ships before leaving port, and ships can be prohibited from sailing if discharge has not taken place. Port management authorities are obliged to establish and operate adequate port reception facilities to meet ships' needs. Those facilities receive only oily wastes, residues and mixtures containing noxious liquid substances from cargoes unloaded in Greek ports or terminals, and garbage from ships.

Pollution caused intentionally is punished by fines or imprisonment: where the polluter eliminates the pollution by his own initiative, he is exempted from imprisonment. Greek seafarers are also subjected to disciplinary action. The law defines that the person responsible for the prevention or elimination of damage caused by the pollution, and the expenses incurred, is the person who caused it - the Greek interpretation of the polluter pays principle.

The Netherlands has ratified Annexes I, II, III and V of the MARPOL treaty. The implementation of the annexes is carried out under the authority of the Ministry of Transport and Public Works and the Act to Prevent Pollution from Ships, 1996 (de Wet ter Voorkoming van Verontreiniging door Schepen, WVVS). The act requires ships to comply with the MARPOL annexes and requires ports to provide adequate reception facilities for ship generated waste and for waste from cargoes handled by the port.

Companies, both private and public, providing waste reception facilities have to be licenced. Licences are issued either by the Ministry of Public Housing and Environment, under the Environmental Protection Act or by the local Port Authority under the Port Bye-laws.

Ships have to notify their intention to dispose of slops to the Port Authority. This notification should contain a description and quantity of the slops to be discharged and the name of receiver of the slops. The receiver has to fill out a reception form giving details of the discharge received. Copies of this form are sent to the master of the vessel, the Ministry of Public Health and Environment and the Port authority. Disposal of the slops takes place on the "polluter pays" principle with a direct charging mechanism.

Enforcement of the relevant legislation is carried out by the Netherlands Shipping Inspectorate and takes place under the Port State system. In the Port of Rotterdam part of the enforcement is delegated to the Rotterdam Port Authority.

Currently the Ministry of Transport and Public Works, together with the ports, are working on the format of a new draft policy with respect to the disposal of ships waste. Key items in this draft policy are a strict distinction between ship-generated waste (engine room, garbage) and cargo related waste. Compulsory discharge of waste under certain conditions and a system of a mixed direct and indirect charging are also under consideration.

Norway also adopts the "free of charge" principle whereby every ship pays for engine room waste and domestic waste whether it lands it or not. Norway intends to develop a system for sewage. The government is not involved in operational matters such as treatment and collection of waste.

Information about Portugal is scant and varies. Some domestic waste and dry cargo waste is collected by port authorities using their own equipment and personnel on public terminals. Contaminated waste is deposited in an adequate and controlled area of the port. Galley waste is deposited in a municipal area and sewage deposited in water treatment facilities. Port and maritime authorities regulate waste disposal, and only pleasure boats and local craft are exempted.

Sweden subscribes to the MARPOL and Helsinki Conventions. The Law (1980:424) regarding measures against water pollution by ships forbids discharge into the sea of "harmful substances originating from or otherwise relating to the operation of ships". The law also prescribes that shipowners may not be charged for reception facilities. The Ordinance of Refuse Collection (1979:204) says that the municipality shall collect and remove such oily wastes, sewage and garbage from ships that may not be discharged into the sea.

The National Maritime Administration's Proclamation (1985:19) regarding measures against water pollution by ships regulates, among other things, where ships are permitted to discharge wastes into the sea, what kinds of wastes and at what quantities, the onboard equipment necessary to make such discharges, who shall provide reception facilities, the onboard equipment necessary to discharge to reception facilities and the way ports shall be notified of the need to discharge.

Swedish ports oppose the free of charge principle. They say that the shipping community is transferring the operational costs to the ports. Initially, Swedish ports chose the free of charge principle to avoid ships discharging to sea for economic reasons, but believe that the approach is now outmoded. They think that the free of charge principle means that ports are receiving a disproportionate amount of waste. Ports can increase their dues to cover the costs of providing reception facilities, but it is not easy to do so because of the competition element. They can also claim a subsidy if their costs exceed 3% of the combined ship and goods dues. Ports say that it is hard to spare 3% of its income, and, also, that ship and goods sues have to stay separate.

In the United Kingdom the Environmental Protection Act 1990, s34, imposes a duty of care upon any person who imports, produces, carries, keeps, treats or disposes of controlled waste, or, as a broker, has control of such waste, to take all such measures applicable to him in that capacity as are reasonable in the circumstances to prevent the escape of waste and to ensure waste is only transferred to an authorised person (i.e. a person who is the holder of a waste management licence under s35 of the Environmental Protection Act 1990, or of a disposal licence under s5 of the Control of Pollution Act 1974.

The secondary legislation bringing all those MARPOL Annexes adopted, into operation in the UK, is the Prevention of Pollution (Reception Facilities) Order 1984 (SI No. 862), which requires

harbour authorities and terminal operators to provide reception facilities for ships which, in their opinion, are using the harbour or terminal for a primary purpose other than using the reception facilities. The facilities must be adequate to meet the needs of ships using them without causing undue delay to ships.

In general, it can be said that the facilities provided must be of sufficient capacity and appropriate design to enable all ships which may be expected to use the harbour or terminal for a primary facility other than utilising the reception facilities, to be able to do so without suffering any undue delay. They can be fixed installations or mobile conveyances, as appropriate. In assessing what facilities are to be provided, factors to be taken into account are numbers, types and sizes of vessels, the trades in which they are engaged and any prospective changes. It is for the operator to decide which combination or types of facilities would be most suitable. A reasonable charge may be made for the use of the facilities.

The governing legislation to bring MARPOL Annex V into operation in the UK comprises the Merchant Shipping (Prevention of Pollution by Garbage) Regulations 1988 (SI No.2292), the Merchant Shipping (Prevention of Pollution by Garbage) (Amendment) Regulations 1993 and the Merchant Shipping (Reception Facilities by Garbage) Regulations 1988 (SI No.2293).

The regulations collectively apply to all UK ships, other ships in UK or territorial waters, and harbour authorities and terminal operators within the UK. They have application to all ships including small craft and yachts, fishing vessels, passenger ferries, cargo ferries and offshore platforms.

The disposal of any plastic garbage into the sea, including synthetic fishing nets, ropes and plastic rubbish bags is prohibited. Dunnage, lining and packing material which floats, can only be disposed of at sea more than 25 nautical miles from land.

Food waste and all other garbage (including paper products, rags, glass, metal, bottles and crockery) cannot be discharged within 12 miles of land unless they have first been passed through a grinder or comminuter so as to be capable of passing through a screen with openings no greater than 25mm. Even at this, the minimum distance from land at which discharge is permitted is set at 3 nautical miles. There must be space on board to store garbage until it can be disposed of to shore facilities and it is incumbent upon owners, masters, skippers or managers to arrange this in order to meet the needs of each vessel.

When a "special area" is declared, the disposal of any garbage, other than food wastes, into the sea, is prohibited, and food wastes can only be disposed of at sea more than 12 miles from land. For UK purposes, the "North Sea area" is a designated special area.

In the United Kingdom, the disposal of dunnage, which the Forestry Commission defines as "loose wood used to wedge or support part of a cargo", is governed by the Plant Health (Forestry) (Great Britain) Order 1993. The Forestry Commission (Plant Health Business Unit) is responsible for administering these regulations and has powers to order detention, treatment, destruction or re-export of the offending material at the importer's expense. Dunnage has to meet the same

landing requirements as for sawn wood material of the same species and origin, although there is no documentary requirement for it, and it should not be assumed that it has been checked.

Although Northern Ireland is a part of the United Kingdom, the secondary legislation is somewhat different. The governing regulations are the Prevention of Pollution (Reception Facilities) Order 1984 (SI no 862), which requires harbour authorities and terminal operators to provide reception facilities for ships which, in their opinion, are using the harbour or terminal for a primary purpose other than using the reception facilities. In Northern Ireland, special waste is governed by the Pollution Control (Special Waste) Regulations (Northern Ireland) 1981 (Statutory Rules of Northern Ireland no 252).

6. CONSTRAINTS

Undoubtedly more efficient waste management operations than those currently in use can be achieved, but, as a preliminary step to proposing new systems, an inventory of all the applicable constraints must be drawn up. Three major areas have been examined using, where appropriate, case studies of ports, terminals and types of ship as illustrations.

The full treatment cycle for each category of waste has been considered, taking into account equipment, personnel and the operations to be performed, with the aim of assessing the waste management techniques best suited to the particular problems of handling and disposal of ships? wastes.

The study used specific cases of ports, terminals and types of ship as illustrations:

X constraints from the point of view of port operators in the UK and France. The study of these particular cases gave an overall view on constraints applicable to EU ports, that is, port activity, local port regulations and port organisation

X constraints owing to ship operation. An assessment was made of the constraints arising through ship building, the normal operation of ships and the areas within existing waste management practices where improvements are possible with regard to the reduction of operating costs and personnel. These include:

- improvement of ships? equipment for handling, minimising, storage and disposal of waste as well as the regular maintenance of this equipment
- system design that avoids health and safety hazards which may result from waste handling and processing
- regulations for the protection of the natural environment, compliance with the international requirements of MARPOL 73/78 and local regulations relevant to the ship? s operational area
- cost of waste management on board and for wastes discharged to port reception facilities
- crew training and education

X constraints owing to land based waste management procedure. A review was carried out of the legislation applicable in the various member states of the EU concerning waste producers/holders.

The work carried out under the latter heading demonstrated that constraints due to legislation and **the understanding of legislation** are frequently the most difficult to overcome. There are very

few instances when problems of a technical nature cannot be solved either using existing technology or some development or adaptation of existing technology.

Technical and financial constraints show that the methodology for improvement in waste management is not necessarily found in a common solution, but in an individually tailored approach. The main problem areas which have to be addressed are common to both the improvement of the implementation of MARPOL and to the development of practical waste management strategies and are:

X geographical and commercial diversification of port facilities and operations
X diversification of charging structures
X variable communications
X availability of records

There are many things a ship owner/operator can do to improve waste management - waste minimisation, education and training, investment in new disposal techniques. Integrated waste collection and reception systems using standardised, multi-purpose receptacles, are being studied to enhance the use of port reception facilities. It is essential that ship and port operators collaborate fully in the improvement of current systems and the design and implementation of new systems in order to reduce pollution owing to ship generated waste.

7. THE ENVIRONMENT

One of the objectives of the EMARC project has been to assess the success or otherwise of MARPOL in reducing marine pollution and improving the natural environment. In order to achieve this objective, the main types and mechanisms of pollution from ships have been identified, including emissions not yet subject to control, such as the atmospheric contaminants nitrogen oxides and sulphur dioxide. Quantifiable environmental parameters were selected for each type of ships? pollution currently and potentially regulated under MARPOL. The framework adopted for the investigation is set out in Table 3.

Table 3. Framework for the investigation of pollution from shipping and its environmental impacts

MARPOL Annex	Ships Pollution	Data source	Environmental parameters and data details
Annex I	Oil	Oil spill records	Numbers of reported and suspected operational oil spill incidents in ports and coastal waters, including quantities, oil types, source, clean up costs and oiled bird counts
Annex I	Oil	Oil monitoring programmes	Total Hydrocarbon (THC) and Polycyclic Aromatic Hydrocarbon (PAH) concentrations in: I) water; ii) sediments; iii) animal tissues
Annex II & Annex III	Noxious liquid substances and packaged dangerous goods	Chemical spill records & coastal packaged goods monitoring studies	Numbers of reported and suspected noxious chemical spill incidents or loss of packaged dangerous goods overboard in ports and coastal waters, including quantities, types, source and clean up costs
Annex IV	Sewage	Water quality monitoring	Water quality data, microbiological parameters
Annex V	Garbage	Coastal/beach litter monitoring and marine debris studies	Quantities of litter recorded on European beaches, coasts and seafloor, including type, distribution, source and clean up costs
Annex VI	Atmospheric emissions	Air quality studies	Nitrogen oxides, carbon monoxide, hydrocarbons, particulates and sulphur dioxide inputs in to the atmosphere from shipping and port activities

Oil is the most widely publicised and studied form of pollution from shipping which is estimated to contribute approximately 45% of the total anthropogenic oil inputs into the marine environment. It is not surprising that different researchers, often depending on their affiliation, produce widely differing data, but a useful indication of trends over recent years is demonstrated in Table 4.

Table 4. Estimates of inputs of oil per year into the world? s oceans from shipping (in million tonnes) [adapted from GESAMP, 1993]

Shipping	**1981**	**1985[1]**	**1988[2]**	**1989**
Bilge and fuel oil discharges	0.3	0.3	0.283	0.253
Tanker operations	0.7	0.7	0.398	0.159
Tanker accidents	0.4	0.4	0.089	0.114
Non-tanker accidents	0.02	0.02	-	0.007
Marine terminals	0.022	0.02	0.022	0.03
Dry docking	0.03	0.03	0.024	0.004
Scrapping of ships	-	-	-	0.003
Total	1.472	1.47	0.816	0.57

[1] 1985 Data adapted from US Nat. Acad. Sci., 1985 cited in UNEP/IOC, 1988: Assessment of the state of pollution of the Mediterranean Sea by Petroleum Hydrocarbons, Table I, p.11

[2] 1988 Data adapted from Blake, G.C. (1990): Conference presentation from ? Tanker 90', London, March 1990; ? The world tanker fleet - still going strong or cause for concern??

The reduction over 10 years is impressive, especially as the average 1990 ship is 40% larger than its 1970 counterpart.

The Mediterranean is another area of particular concern. It is reported that as much as 75% of the 650,000 tonnes of oil pollution entering these waters every year comes from operational shipping discharges. However, another report suggests that the most noticeable reduction in quantities of oil floating in the sea has occurred in the Mediterranean where 1987 values were only 3% of the corresponding 1969 values.

Oiled bird mortality is an emotive issue and is frequently taken as a measure of marine pollution. The assumption that oil contamination has been the source of death has not been widely questioned. One study undertaken on oiled bird mortality found that 50% of the corpses had become contaminated after death. The statistics, as always, must be treated with great caution.

Two years after the ? Sea Empress? oil spill in the United Kingdom, reports show that oiled bird mortality was not catastrophic.

Attempts to generate European wide interest in an oil pollution survey have met with a poor response and the general inadequacy of the data so far produced is an indication of the difficulties faced in attempting to access data on a European basis.

Hydrocarbon monitoring programmes have improved greatly in recent years. However, there are several problems associated available data:

X difficulty in accurately identifying the actual source
X no consistent studies of the same areas leading to a ? snapshot? view of the situation
X sparse pre-MARPOL data
X changing sampling and analysis technologies
X varying methodologies of different organisations

There has been little or no research made on the amounts of sewage discharged into port areas during operational shipping activities. Not all ports provide appropriate facilities and it has been noted that facilities in Italy, Greece and North Africa are particularly poor.

Numerous environmental parameters, particularly microbiological, are continuously monitored throughout Europe and although water quality data is available for port regions it would be impossible to distinguish inputs from land based and ship based sources. Any observed changes could be driven by a number of international regulations as well as MARPOL.

Litter (garbage) concentrations appear to be greatest in coastal areas and have led to the launch of international, national and regional coastal litter collection programmes. These programmes provide records of the distribution, amounts and sources of marine debris.

The results from one major litter research programme strongly suggest that, in terms of the majority of non-container litter types, the frequency of occurrence of beach litter items in the north east Atlantic and North Sea has worsened subsequent to MARPOL. In addition, the number of container litter types has also increased. The programme estimated that at least 65% of litter came from fishing vessels. Consideration, however, must be taken of the offshore oil industry activity during the period of the research programme.

By analysing the actual individual samples, it has been deduced that merchant shipping accounts for 15-35% of the total litter.

Contrary to popular belief, there was no evidence from samples collected during a litter survey of Scottish beaches to demonstrate that those port and flag states which had implemented the most stringent enforcement policies for MARPOL Annex V had achieved any greater success in preventing discharges of plastics garbage to sea than those which had not.

Atmospheric emissions will come under increasing scrutiny in the future. The main source of atmospheric emissions from vessels comes from the combustion of fuel in the main and auxiliary engines, the exhausts from which contain sulphur oxides (in amounts which are directly related to the composition of fuel used), nitrogen oxides, hydrocarbons, carbon monoxide and particulate matter. All of these are potentially harmful substances. An amending document to MARPOL 73/78 has been prepared in draft by the IMO and submitted to the EC which will introduce Annex VI, "Regulations for the prevention of air pollution from ships". The new regulations will prohibit the use of halogens and CFCs on board and will control emissions of Nitrogen oxides, Sulphur oxides and Volatile Organic Compounds (VOCs), emissions from shipboard incinerators and the quality of fuel oil used. In view of the impending adoption of these rules, it was considered important to gather baseline information on inputs into the atmosphere from shipping and port activities from which any future changes in levels within the ports can be assessed.

Data on atmospheric emissions from ships is generally sparse. Until recently there have been no comprehensive studies to investigate ship emissions and all statistics have been derived from rough estimations. However, within the last ten years, several research programmes have been launched which have monitored atmospheric quality in port areas and investigated gaseous inputs from shipping.

MariTerm AB has undertaken an in-depth study, focused on the Baltic Sea, on behalf of the Swedish Transport Research Board (TFB) into the environmental impacts of exhaust gas emissions from sea transportation which identifies the sources, types, levels and distributions of emissions from ships in port and at sea (Alexandersson *et al*, 1993; Alexandersson, 1991). Not surprisingly, given the very high density of traffic movements, ferries were found to be the largest producer of emissions. In total, Swedish shipping produced less than one third of the nitrogen oxide emissions than Swedish road traffic and domestic shipping produced significantly less pollution than trucks for all atmospheric contaminants, with the exception of sulphur dioxide. It was concluded that shipping in the Baltic Sea produced less pollution than other modes of transport studied and that the majority of emissions are made away from coastal areas at sea.

CONCAWE has undertaken a similar study in the Channel and Southern North Sea which investigated the impact of sulphur dioxide emissions from ships on air quality and deposition (Lyne *et al*. 1993). A somewhat different conclusion reached by this study was that measures to reduce emissions from ships in major port areas would be of greater environmental and economic benefit than the control of all at-sea operations.

The Lloyd's Register Marine Exhaust Emissions Research Programme commenced towards the end of 1989 largely in response to the initiation of discussions at the International Maritime Organisation (IMO) on the restriction of air pollution from ships. Many of the major air pollutants were targeted (including chlorofluorocarbons (CFCs), halons and volatile organic compounds (VOCs)), however interest focused on proposals for the restriction of the exhaust gases, NOx (oxides of nitrogen) and SO_2 (sulphur dioxide) from shipping. The programme set out to find accurate means of monitoring and calculating gaseous and particulate exhaust emissions. These findings were then applied to the quantification of marine emissions (along with measurements of ambient air quality surveys and a Gaussian plume emissions dispersion

model) on a local scale, for the port of Vlissingen, the Netherlands and on a regional scale, for the northeastern Atlantic Ocean. Details of the results from this study are shown in the table.

Table 5. Daily emission inputs in the study area of Vlissingen, Netherlands (tonnes)
[adapted from Lloyd's Register Marine Emissions Research Programme 1995]

Pollutant	Value	Shipping	Industrial
NOx	mean range	4.84 4.22 - 6.22	26.0 -
SO_2	mean range	2.77 2.65 - 3.54	39.3 -
CO	mean range	0.97 0.82 - 1.11	73.5 -

The results presented above demonstrates that shipping emissions of the three pollutants shown are more than five times **less** than the tonnage emitted from industrial sources in the area.

Generally, however, there is no systematic comparable data available to determine the effects of MARPOL. The same problems reoccur regularly. Methodologies vary - in many cases litter surveys rely on volunteers who, while being totally conscientious, invariably have little or no training. The identification of individual litter items is complicated and time consuming, leaving a large proportion unidentified. Thus there is a need for the standardisation of techniques if such sources of data are to be used in proving or disproving the value of MARPOL.

Studies undertaken on emissions from ships in the Baltic Sea, the southern North Sea and the English Channel provide an important source for the provision of baseline data from which to monitor environmental changes as Annex VI is ratified and implemented. Further studies are necessary.

Despite the increasing levels of research currently taking place, there remains a lack of projects undertaken on a European wide basis which are generating reliable and comparable data. The effectiveness of the MARPOL Regulations in improving the environment remains undetermined.

8. IMPACT OF THE MARPOL REGULATIONS

Compliance with MARPOL implies committing money, time and personnel. Ports have invested in physical and organisational infrastructure and ship operators have invested in equipment to control and prevent pollution from taking place in the first place. There has been a significant effort to the Regulations. Detailed case studies have been undertaken in order to identify indicators of progress, or otherwise, in the provision of facilities. A number of environmental indicators have also been examined to judge the impact which MARPOL has had on the natural environment since implementation in the mid 1970's.

In order to measure the effects of a regulation, clear and measurable goals have to be defined. The definitions of goal and measurement cannot be separated and in any situation they are in continual interaction. There is obviously no point in looking for specific goal related data prior to that goal being formulated.

A number of indicators of effort and commitment on the part of ports and ship operators have been examined. MARPOL is considered to be just one of a number of environmental and safety issues in ports and is therefore rarely, if ever, costed separately. Nevertheless, one of the main indicators of the impact MARPOL has on ports is considered to be staff and budgets allocated to MARPOL activities. The costs for the shipping industry can be more easily identified. The costs of retrofitting or equipping new vessels can be established fairly accurately. Routine operating and labour costs are less easily identified.

Those organisations which participated in the case studies can be considered to be front runners in the implementation of their environmental policies. The results could therefore considered be to be heavily weighted towards presenting a too optimistic picture of the situation. In fact it could be argued that these front runners provide a yardstick, say 100%, against which to measure the effort which is being expended by other organisations.

The ports or port states investigated allocate significant resources to the implementation of MARPOL. There is at least some self interest is this commitment. There is a high degree of public awareness in environmental issues, especially oil pollution. Most organisations are very conscious of bad publicity and their standing in the local community. Less high minded, but with more immediate effect, some of the cost of clean up operations may fall at least initially to the port, where the culprit cannot be identified.

This leads naturally to the matter of general enforcement of the Regulations. MARPOL compliance is often thought of as something running along cultural barriers. Is there any evidence to support this proposition? Compliance should be a matter of management philosophy, both in ports and with owners and operators. However, the human element cannot be discounted. Perhaps the most illustrative comparison is that, with road speed limits, there are those who keep to them and those who do not - except, possibly, when under observation by a monitoring system (police, cameras etc.).

Data on Port State Control may illuminate this aspect of MARPOL. The Paris Memorandum of Understanding (MOU) on Port State Control came into effect in 1982. There are 17 present members: Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Norway, Poland, Portugal, the Russian Federation, Spain, Sweden and the United Kingdom. The United States Coast Guard and the maritime authorities of the Republic of Croatia and Japan participate as ? cooperating maritime authorities? . There is also a Caribbean MOU on Port State Control. The Secretariat of the Paris Memorandum is provided by the Dutch Ministry of Transport. Statistical information and inspection results on Port State Control operations are drawn up by the Centre Administratif des Affaires Maritimes (CAAM) at Saint Malo.

It is widely supposed that there are port states that are more effective and persistent in controlling MARPOL compliance than others. Similarly, it is supposed that owners of vessels of certain flags or based in certain countries have higher moral standards than others, that is, those that comply with the rules as opposed to those that flout the rules.

But is this true? If the data from Port State Control for the period 1992 - 1995 is examined, several facts stand out.

Table 6. Port state control in European ports, 1992-1995

Year	**1995**		**1994**		**1993**		**1992**	
	No.	%	No.	%	No.	%	No.	%
Inspections carried out	16381		16964		17294		14783	
Individual ships (of which in:)	10563	64	10455	62	11252	65	10694	72
France	1690	16	1572	15	1781	16	1522	14
The Netherlands	2087	20	2338	22	2269	20	2449	23
The United Kingdom	2098	20	2153	20	2218	20	2132	20
Deficiencies identified	54451		53210		43071		27136	
Number of delays/detentions (of which in:)	1837		1597		926		588	
France	185	10	158	10	126	14	69	12
The Netherlands	312	17	410	26	290	31	242	41
The United Kingdom	206	11	212	13	174	19	124	21
% of delays vs. ships inspected	17.3%		15.2%		8.2%		5.4%	

Source: The Memorandum of Understanding on Port State Control, Annual Report 1995

The table shows that over the years, the share of PSC inspections in The Netherlands and the UK has slightly declined. Together the three countries under consideration make up for approximately 50% of all inspections in 1995. If the detention rate is considered as a measure of toughness on the part of the port state, then the three toughest port states in 1995 were The Netherlands, Italy and Spain, as set out below.

Table 7. Share of delays and detentions, 1995

Country	Delays / Detentions	Delay / Detention percentage
The Netherlands	312	17
Italy	300	16
Spain	218	14
Other countries	1007	53
Total	1837	100

Source: The Memorandum of Understanding on Port State Control, Annual Report 1995

Clearly, there seems to be no cultural divide apparent from the share of delays and detentions. The same is true when inspection rates are examined, below. The highest reported rates are from Spain, Norway and Italy.

Table 8. Share of reported inspections, 1995

Country	Individual ships	Inspection percentage
Spain	5040	37.6
Norway	1650	37.1
Italy	5190	33.5
Other countries	51399	23.6
Total	63279	25.9

Source: The Memorandum of Understanding on Port State Control, SIRENAC, 1996

Is it possible to conclude from these figures that certain flag states in Europe are performing badly and that this has to do with a certain supposed mentality? Not directly, although Malta and Cyprus exceed the average percentage of detention by a fair amount, as do the other common offshore registers, below.

Table 9. Flag states with detention percentages exceeding 3-year rolling average percentage of 13.4%, to be targeted as priority cases for inspection in 1996 and 1997, selected flags

Flag state	No. of detentions, 1993-1995	Total no. of individual ships involved, 1993-1995	Detention percentage, 1993-1995	Excess of average percentage 1993-1995
Syrian Arab Republic	47	97	48	35
Romania	133	276	48	35
Honduras	183	410	44	31
St. Vincent and Grenadines	199	762	26	13
Malta	394	1637	24	11
Cyprus	504	2665	19	5
Panama	400	2496	16	3

Source: The Memorandum of Understanding on Port State Control, Annual Report 1995

Those registers count a significant number of vessels from owners and operators from other parts in Europe, including the northern Europe. This implies that instead of focusing on supposed differences in mentality on either side of some notional geographical border, individual owners/operators of the vessel should be investigated. This same principle must naturally also be applied to ports.

Table 10. Share of MARPOL deficiencies in total deficiencies, 1993-95

Deficiency	**1995**	**1994**	**1993**
MARPOL Annex I	2950	2801	1781
MARPOL Annex II	112	142	85
MARPOL operational control	201	268	130
Other	51188	49999	41075
Total	54451	53210	43071
MARPOL as % of total	6	6	5

Source: The Memorandum of Understanding on Port State Control, Annual Report 1995

However, too much weight must not be assigned to these findings. MARPOL deficiencies are not the main reason for detention of vessels by port states. Deficiencies for MARPOL infringements reported by Port State Control amount to only 6% of total deficiencies, above.

The financial impact of MARPOL on the responsible shipping sector appears to be high, significantly so for tankers. However, the ? green? image is more obvious here than it is for ports. Some companies see a direct link between compliance and their ability to attract business. Investment in equipment and management systems is often made in advance of legislation in order to maximise the useful life of a vessel. At the other extreme, as for ports, many operators probably wait until the final moment and install just enough equipment to comply with the letter, rather than the spirit, of the law. Even then actual compliance may be limited. Nevertheless, the results from the EMARC questionnaire indicate a significant penetration and hence compliance with the MARPOL Regulations.

The biggest problem facing the researcher is to devise a methodology to measure, or at least indicate, a degree of success in the aims and aspirations of MARPOL. Reduction in garbage on beaches, heavy metals in dredgings or oil in the sea could all be used as indicators if these were independent of pollution sources other than shipping. Despite the fact that shipping is estimated to account for 25% of oil pollution, changes in the number of oil spills in ports and discharges of waste to shore have been chosen as the least inaccurate indicators.

Although, for the reasons already outlined, pre-MARPOL data is very sparse, changes in the various indicators examined do indeed point to improvements and positive reactions to the implementation of MARPOL. ? Fear of the law? , unsurprisingly, has been identified as a significant factor in compliance. There is a complex relationship between the adequacy of facilities, capital financing and the charge set for their use. This relationship is further complicated by the installation of waste reduction and treatment facilities on ships and, thus, by the quantities of waste discharged. Lower, rather than higher, quantities discharged may be an indication of the success of the Regulations.

From the available evidence MARPOL seems to be having positive effects. Spills in ports are low, quantities spilled are relatively low, the degree of penetration of special equipment on board vessels seems high and the number of prosecutions limited.

However, environmental investments will be justified more easily if they result in additional benefits for either ports or ship operators or both. These could be in the form of operational savings, avoiding costs or lowering turnaround time in port. Other examples are lower fuel costs from the use of vapour that results when loading oil, income from the sale of treated waste oil that is discharged, avoiding high costs or time delays because discharge facilities are expensive or inadequate. The same principle applies to ports. If they are faced with substantial costs because of clean up or storing contaminated silt, they may be inclined to give reductions in port dues to vessels that comply with the strictest of regulations, in which both parties stand to gain.

As repeatedly stated, there is virtually no relevant universal environmental data, especially prior to MARPOL, so it is difficult to prove conclusively that there has been an overall improvement

due to the Regulations. However, subjectively, the impression is that the marine environment has benefitted from the efforts made as a result of actions on ships? waste.

9. SHIP TRIALS

Trials were carried out on a cruise liner and a container ship, in order to validate the waste management systems used on each vessel. The two vessels chosen for the trials (one voyage duration on each) were substantially different. The container vessel, m.v. Pérouse, was built in Korea in 1988 and is a deep-sea vessel. The m.v. Oriana is a state-of-the-art cruise liner built for P&O (an EMARC partner), in 1993, and it is important to note that in some respects, the Oriana is atypical, in that it was designed to reflect specifically best practice and best technology in all aspects of its operations.

In order to demonstrate the magnitude of the waste management task on board a modern cruise liner the following statistics are of interest. The ship includes 14 decks, nine of which are dedicated to passengers, with facilities including:

X 9 bars,
X 2 restaurants,
X 3 swimming pools plus (1 for children),
X 4 shops,
X 5 dance floors,
X 3 cinemas,
X a buffet,
X a theatre,
X a night club,
X a discotheque,
X a casino,
X a library,
X a card room,
X a children's club,
X a nursery,
X a games room,
X a table tennis room,
X a hairdressing salon,
X a massage and beauty salon, and
X a fully equipped medical centre.

Prior to the trials undertaken by the EMARC team almost 100 tonnes of stores were loaded including the following:

Table 11. Typical List of Stores for Cruise Liner

Meat	14 600 kg	Molluscs, shellfish	1 700 kg
Fish	3 700 kg	Poultry	6 900 kg
Ham, bacon	3 500 kg	Butter, fat, cheese	4 600 kg
Fruit and vegetables	28 000 kg	Flour	8 500 kg
Potatoes	18 000 kg	Coffee	650 kg
Sugar	1 900 kg	Milk and cream	10 500 litres
Ice cream	4 000 litres	Fresh eggs	51 000

All of the above are required for the preparation of almost 116500 meals. In addition, such a cruise requires the shipment of:

X 2 600 bottles of champagne and white wine.
X 1 200 bottles of red wine.
X 1 600 bottles of whisky.
X 1 200 bottles of gin, rum, vodka.
X 400 bottles of cognac.
X 33 000 cans of beer.

The results of the trials have borne out the findings of other EMARC research. In terms of the container vessel, it complies with the MARPOL Regulations for equipment and management of waste. However, owing to the relatively small amount of waste generated (crew sizes having diminished over the years), it is more efficient at the moment to discharge to shore rather than use the on-board equipment. Were circumstances to change because of lack of shore facilities or facilities at excessive cost, the on-board equipment will be adequate.

In direct comparison, as can be inferred from the above list, the m.v. Oriana generates not insignificant amounts of waste, particularly solid waste, owing to the increased levels of personnel (2900) over the container ship (24). For obvious reasons of cleanliness, passenger comfort, and, especially, space requirements, the waste is incinerated. As already noted, current MARPOL Regulations do not require monitoring of discharge overboard or emissions to air (as yet). More stringent Regulations might require a revision of the on-board equipment but at the moment, waste is controlled in the best possible way, meeting all national and international Regulations, and using best practice as its benchmark.

For waste processing, the ship is equipped with:

X 2 incinerators with a thermal capacity of 1000kW.
X 4 sewage treatment units.
X 2 shredders.
X 1 compactor for metal cans.
X 1 glass crusher.
X 2 fresh water generating units.
X Food grinders in all galleys.

Although driven by a combination of commercial, health and safety and environmental factors the cruise ferry is obviously able to draw on a vast range of waste management technology to achieve the company? s targets. If the technology is available it can only be a management strategy that is required for MARPOL to be successful.

By conducting the limited trials on the two different vessels it has been established that the MARPOL Regulations are well established and are being followed by the owners of the vessels. It has also proven that the amount of waste generated and treatment available, as indicated in

other deliverables of the EMARC project, as being fairly accurate, which in turn gives both ship owners and ports the necessary confidence in calculating the level of equipment to supply ashore and afloat.

Although ships may be fitted with modern treatment plant for handling the waste produced on board, the trading pattern, number on board and availability of shore based facilities may make the use of ships' equipment unnecessary, and perhaps the best environmental option may be for disposal ashore. This option can confuse the estimation of waste delivered ashore. However, in many cases, vessels follow regular tracking patterns and the providers of port waste reception facilities should take past practice into account when estimating the capacity of their facilities.

Whatever the chosen method of treatment, the ship operator must have plans and procedures to deal with all of the waste generated. Both vessels showed that their respective operators use the method best suited to their particular trade.

10. IMPACT OF NEW SYSTEMS

An extensive review of the many options available for the management of waste in all forms and in all marine locations has been carried out. In most cases only a small number of the options considered will be needed in any one circumstance. (An exception, perhaps, is the cruise liner and cruise ferry vessel). In the future, there will be a step change in the management and treatment of many wastes on board compared to current practices. Waste minimisation and materials replacement will have a significant impact on the volume and composition of many of the wastes.

For solid and liquid wastes, there are a number of relatively straight-forward measures which can be introduced within a shipboard waste management strategy which will result in a reduction in the volume of waste generated, for example, bulk packaging against individual packaging, vacuum collection systems against gravity systems for black water, improved engine and machinery space operating procedures to reduce contamination of the bilges and the selection of primary treatment processes which generate minimal or no secondary wastes/residues.

Minimisation of solid wastes is influenced primarily by the increasing restrictions for overboard discharge and thus a potentially increased requirement for storage space and treatment. The minimisation of liquid waste is necessary to reduce the holding capacity required.

Although benefits may be derived from the generation of lower volumes of waste and the associated reduction in the requirement for storage or treatment, negative aspects, such as the generation of a more concentrated waste, must also be considered prior to implementation of changes in waste management aimed at waste minimisation. The largest expected reduction in solid wastes is in plastics due to packaging and use of alternative materials.

The appropriate system approach must to achieve a balance of waste minimisation, treatment, holding, and discharge capability. All waste categories, primary or secondary, can be treated by existing or emerging technologies to achieve compliance with present and future regulations. The increasing restrictions on discharge may require an increase in holding capacity for certain categories of ships. This may be balanced by improved onboard reduction procedures. The implementation of treatment for liquid wastes and some specific solid wastes will reduce the dependence on ? collect and hold? , and thus, significantly reduce, or eliminate, the need for large holding tanks and storage areas.

Volume reduction features high in the treatment/pretreatment of solid waste. Future shipboard waste management will involve elements of waste minimisation, retrofitting of upgraded or new treatment systems for individual wastes, replacement of hazardous materials with more environmentally sound alternatives.

Degradable materials would require some changes in waste management. Biodegradable polymers are an available alternative for plastic products. An evaluation of their advantages and disadvantages needs to be carried out in order to generate the data required to consider replacing various categories and uses of conventional plastics.

A number of measures can be implemented onboard ship, which would lead to a reduction in the volume of freshwater, which becomes waste water. The installation of treatment technologies reduces the volume of waste water held in tanks, by producing low volumes of concentrated sludges and treated water suitable for discharge. The future waste management system must address every aspect of the waste management process and system design, that is, it must address waste generation (and minimisation), waste flow, waste treatment, storage, discharge and potential reuse. The development should take into account the total waste generation of all different waste streams and use the inherent synergistic system capabilities to combine primary and secondary waste streams in the treatment process to achieve the operationally required destruction, discharge and/or reuse capabilities. Educating and motivating officers and crew is crucial to the success of a waste management programme.

Waste minimisation and pretreatment emerge as areas for future development and waste audit is a tool which could also reflect an innovative route. Treatment technologies (compactors, shredders, pulpers, and heat compaction devices) exist for shipboard volume reduction of plastics, paper, metals, glass and food waste. Complete waste treatment systems are available for cruise liners and merchant ships. Owing to a lack of space for most of the technical installations on board, manufacturers have developed new standards for minimising space requirements. A waste treatment plan should be designed for the flexible treatment and storage of waste. **The aim should be to reduce, reuse and recycle.**

Although a wide range of technologies are suitable for treatment of the various waste streams, many years will be required for advanced waste treatment technologies to be developed for shipboard installation. The key technology areas, which will contribute the most to waste treatment are membrane filtration, bioreactors, and thermal treatment such as plasma incineration. Improvements in the accuracy and reliability of overboard discharge monitoring systems (oil content meters) under shipboard conditions, is also a main aspect of modern oily liquid waste treatment. Integrated waste collection and reception systems using multipurpose receptacles, are being studied to enhance the use of port reception facilities.

This review has demonstrated that there is an enormous range of technologies and management systems ashore and afloat which are, or can be made, available for the treatment and control of virtually all shipboard waste. The impact(s) of almost any development can be established using the conceptual model. An example of the process is shown in Section 10. A user knowledgable in port or ship operations could easily adapt the model to suit the requirements of a particular development.

Table 5 further summarises, in respect of garbage, some of the steps, and possible impacts, needed to generate a strategy for the management of shipboard waste. However, it is essential to remember that technology and management systems rely on people to operate them and thus for the regulations to work **in practice**, communication and education are the keys.

Table 12. Strategy for Managing Shipboard Waste (Annex V)

POSITION	STRATEGY	METHODOLOGY	IMPACT	FINAL DISPOSAL
On shore prior to delivery	Reducing packaging at source	Ensure minimum delivery of packaging to ship	Less packaging on board means less waste for ship to manage	
	Reduce packaging at delivery point	Unnecessary packaging removed when stores delivered to vessel	Packaging removed on delivery means less waste for ship to deal with	
On board subsequent to use	Separation on board, especially of special or hazardous waste	Dry waste products separated at collection point. Wet waste e.g. galley waste separated from dry waste	Each vessel with the exception of the smaller vessels, can separate waste produced on board into several categories	To shore
	Minimise on board	Make use of such facilities as compactors, shredders, incinerators, comminutators etc	All waste will be much reduced in volume, allowing for easier handling and storage onboard	To shore
	Recycle/re-use on board	Products for recycling/re-using on board identified and laid aside	Recycling of products on board reduces the eventual amount to be landed	To shore
	Recycle/re-use on shore	Products for recycling/re-using on board identified and laid aside	Recycling of products ashore, although not beneficial to the ship benefits the environment as a whole	To shore
	Storage on board	Storage of all wastes in standardised containers for ease of disposal	Ships/ports work an exchange programme	To shore
Ashore	Disposal ashore	All wastes disposed to shore facilities	Improved sea environment	To shore
At sea	Disposal at sea (where and when allowed)	Although certain categories are allowed to be dumped at sea, it is preferable that **all** waste be landed to shore facilities	Due to the possible harm to aquatic life and others who depend on the sea all nations are being urged to consider shore based disposal of ALL shipboard waste.	

11. CONCEPTUAL MODEL

A conceptual model has been developed to allow a logical approach to be made to what at first sight appears to be a set of rather illogical or random operations. Why construct a model? Will a model provide any answers? What sort of model should be used? The operation of waste management systems ashore and afloat are too interwoven with other factors to permit clear cost and/or efficiency cases to be made. One thing is evident, the present, almost frantic, activity by influential groups and, ultimately, legislators may result in a massive increase in the cost of operating MARPOL without any resulting measurable reduction in marine pollution. Some way of estimating the effects of these measures is required.

There are a limited number of ways in which a port or shipping operator can fulfil his obligations with respect to MARPOL. Many of these have been identified during the course of this project and research carried out by other organisations, for example the IAHR/IMO survey confirms a broad similarity in the methods and systems used. The main difference is in the level of commitment. This means that sufficient information is available to develop a logical structure identifying as many of the systems or influences as possible so that they can be considered individually.

The problem which remains is deciding on the effect of adopting a particular course of action. There are rarely any yes/no answers but experience will usually enable a judgement to be made - good/bad, better/worse - as a result of the chosen action. Decisions will be demanded for which it is not even possible to guess at the probable effect. The available data may be insufficient or non-existent. Knowing that this is the case enables the correct research to be carried out.

The aims of the model, therefore, are to begin to identify the systems involved in MARPOL as a whole, so that the effects of a change in one of the systems or the imposition of a Regulation can be estimated. The model will not produce clear cut answers but it will show where more information is required or where the structure is inadequate. The modular structure can be changed, by adding or changing modules, to take account of modified or new management systems. Additional data can be incorporated into the model as it becomes available.

It is envisaged that the ? user? of the model will be the organisations involved in the legislative process rather than, say, an individual port or shipping company where highly specific local considerations will play a major role in decision making. (A version of the model could be produced for this purpose which would allow, say, local costs of implementing a procedure to be estimated.) The model was therefore conceived to investigate high level potential implications and responses of a new rule or constraint in the shipping/port operational system.

Since the initial design of the model (Sheets 1-8, following), during the early stages of the project, a number of changes in operational methods have taken place and the proposal for the use of standardised containers (MEPC 38/11 Appendix 10) has been taken forward by the project team in a simplified and practical fashion towards a possible demonstration. In addition, the gradual introduction and acceptance of port waste management plans has produced evidence,

albeit in one port, of the importance of communications in the perception of the efficiency of reception facilities. The model has been rerun in order to take these developments into account.

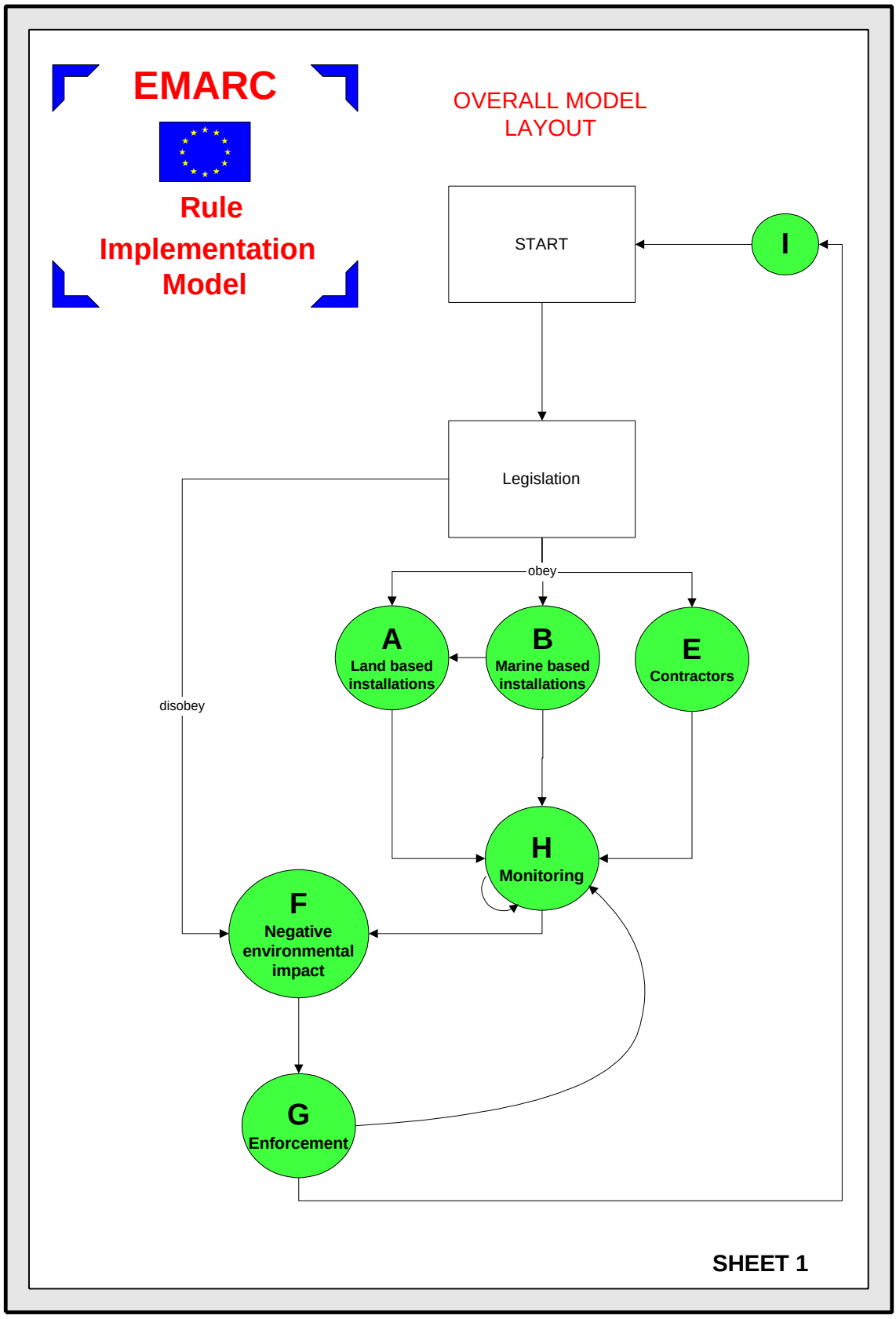
The model shows on Sheet 3 and Sheet 4 (bottom of pages) the effect that either poor or good communication has upon a number of factors such as efficiency, cost and time spent in the transfer of waste. If communication is poor between ship and shore, then it is likely that it will take longer to off-load the waste due to lack of the correct information, poor scheduling and so on. This, in turn, could incur either party with added expense and of course the efficiency of waste transfer will be detrimentally effected. The model suggests that if the communication links between shore and ship were to be improved then both the time and cost of waste transfer (implying efficiency will increase) will be decreased.

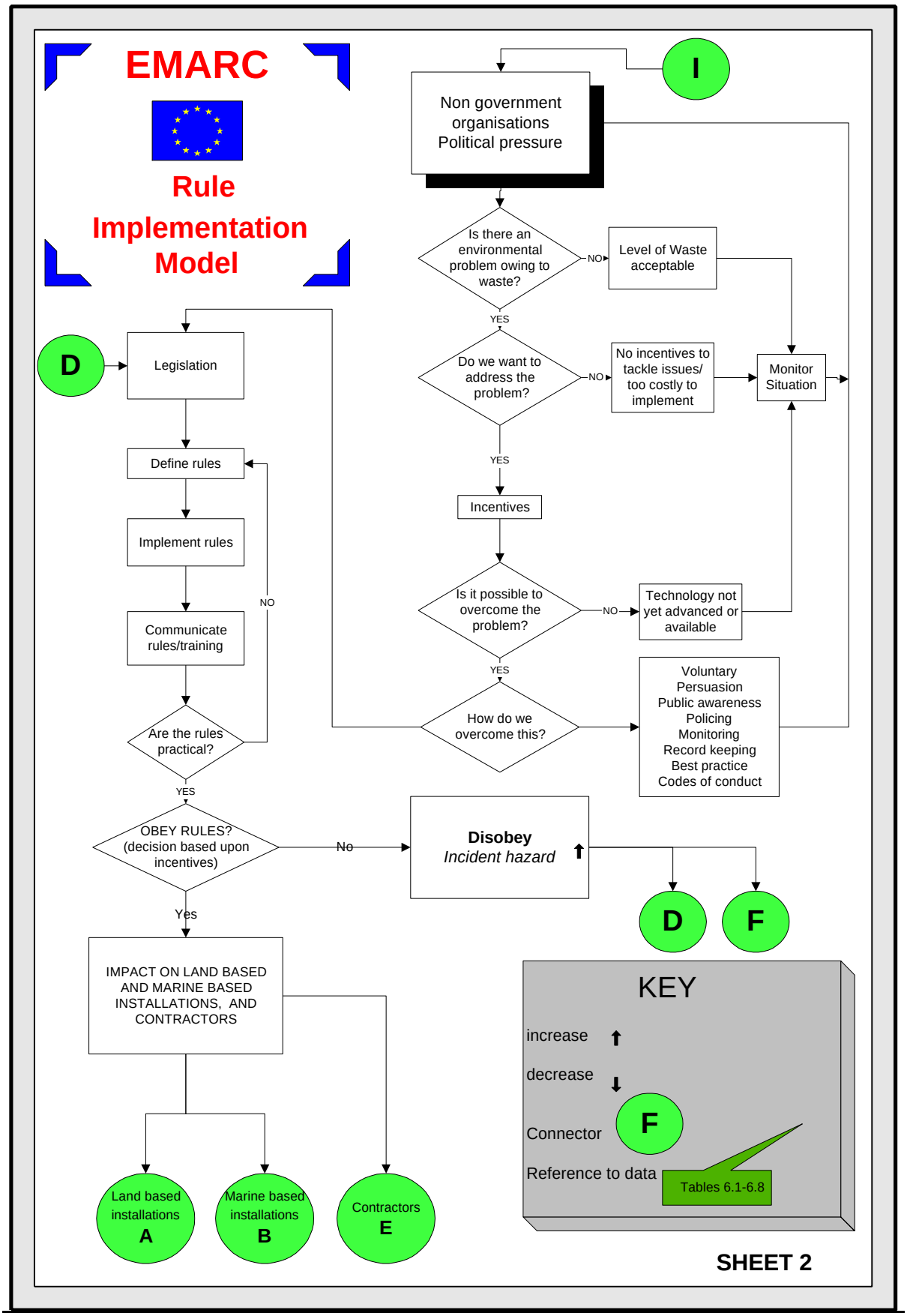
Although, as is invariably the case, no actual cost, time or efficiency figures are available, an illustration can be made of the benefits of improving communications with the following example. In one port, users of reception facilities were asked in 1996 and again in 1997 for their views on the adequacy of the facilities. During this time their perception was that the adequacy had risen from fair to good. In fact, the reception facilities themselves had not changed, the only difference between the two years was the development of a port waste management plan which raised awareness of the existing facilities. This case illustrates that facilities may be of a sufficient standard, but if information about them is poor then the perception of the facilities is likely to be poor. Sheet 3b, which is based on a modified subset of Sheet 3 of the model, demonstrates this result.

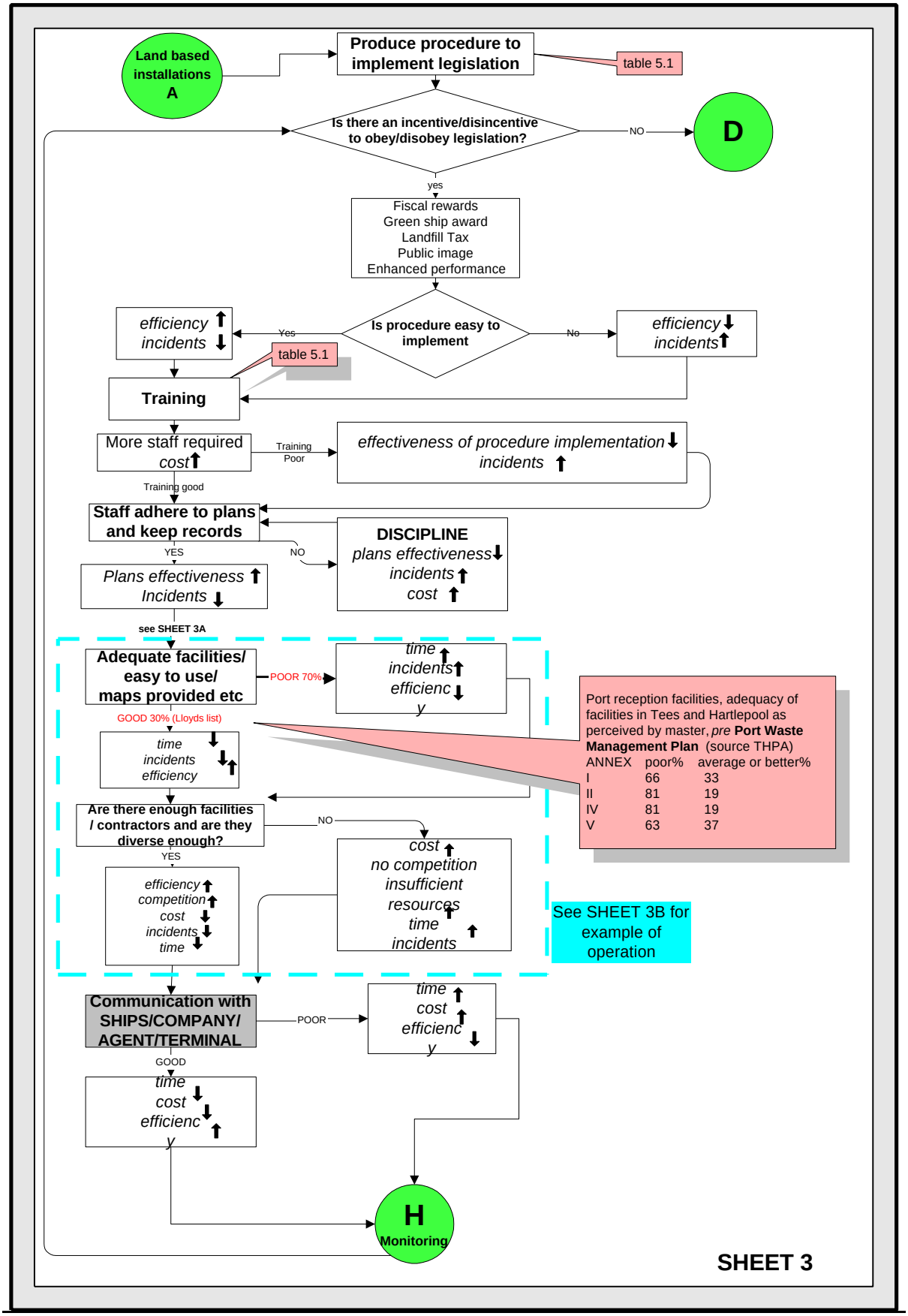
This, however, leaves no room for complacency. If communications between ship and shore are good in both directions, then the adequacy of the facilities themselves still has to be examined. If the facilities themselves are not adequate then the model suggests that the number of incidents (spillages/accidents) may increase, together with the time and cost taken to off-load and process any waste. The model suggests that if facilities were to be improved, then these adverse effects could be reduced.

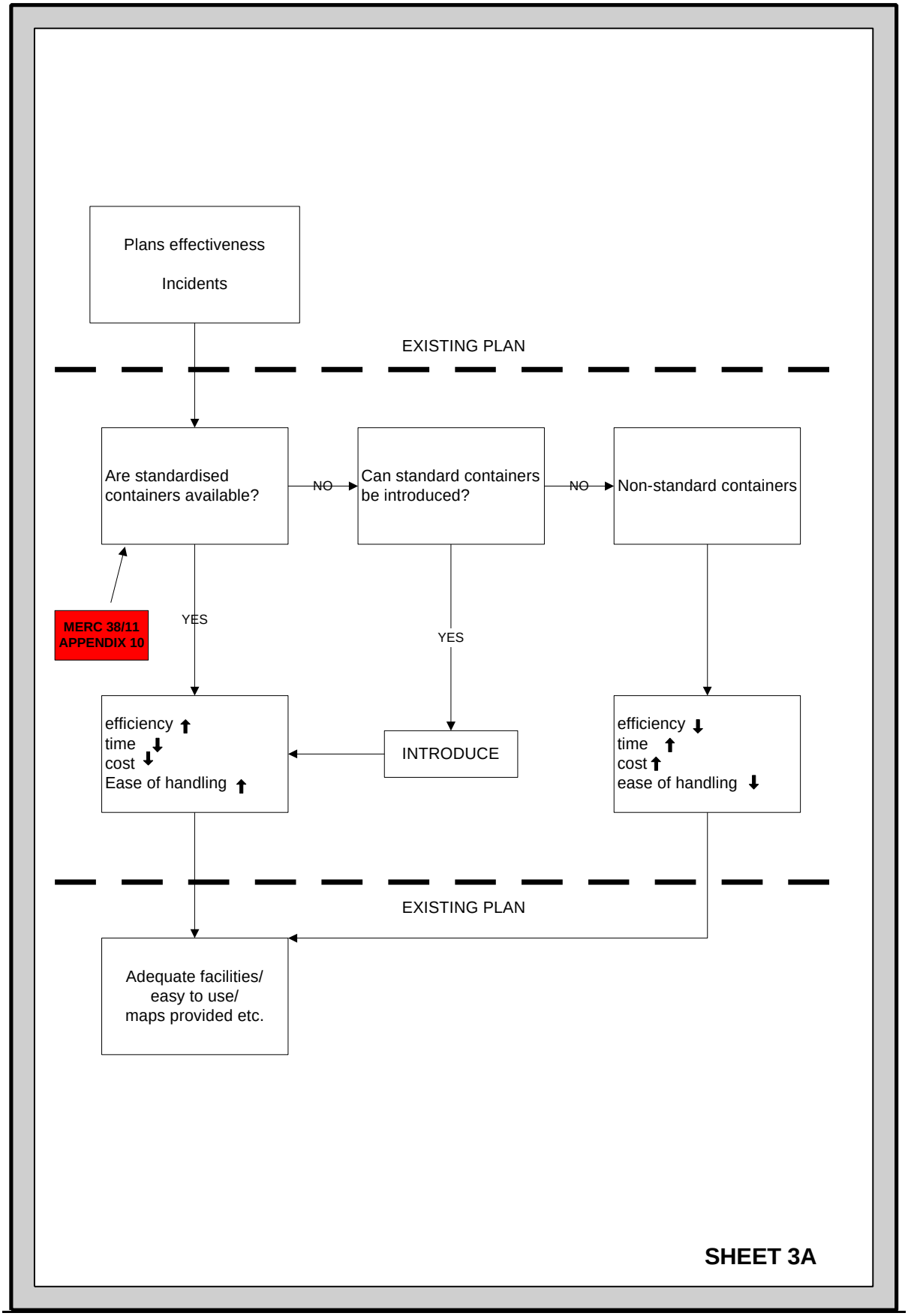
One way of improving the facilities may be to implement the wide-spread use of standardised, clearly identified receptacles. This will have the benefit of improving the efficiency of transfer and hence reducing the cost and time taken. Accidents/incidents will tend to be reduced as the transfer equipment would be designed specifically for the standard sizes. Crucially the primary containers would need to be based on existing equipment and not on containers which would have to be specially designed and manufactured. Modules have been designed and added to the model to cope with this development, Sheets 3a and 4a, where it impinges on ship and shore activities.

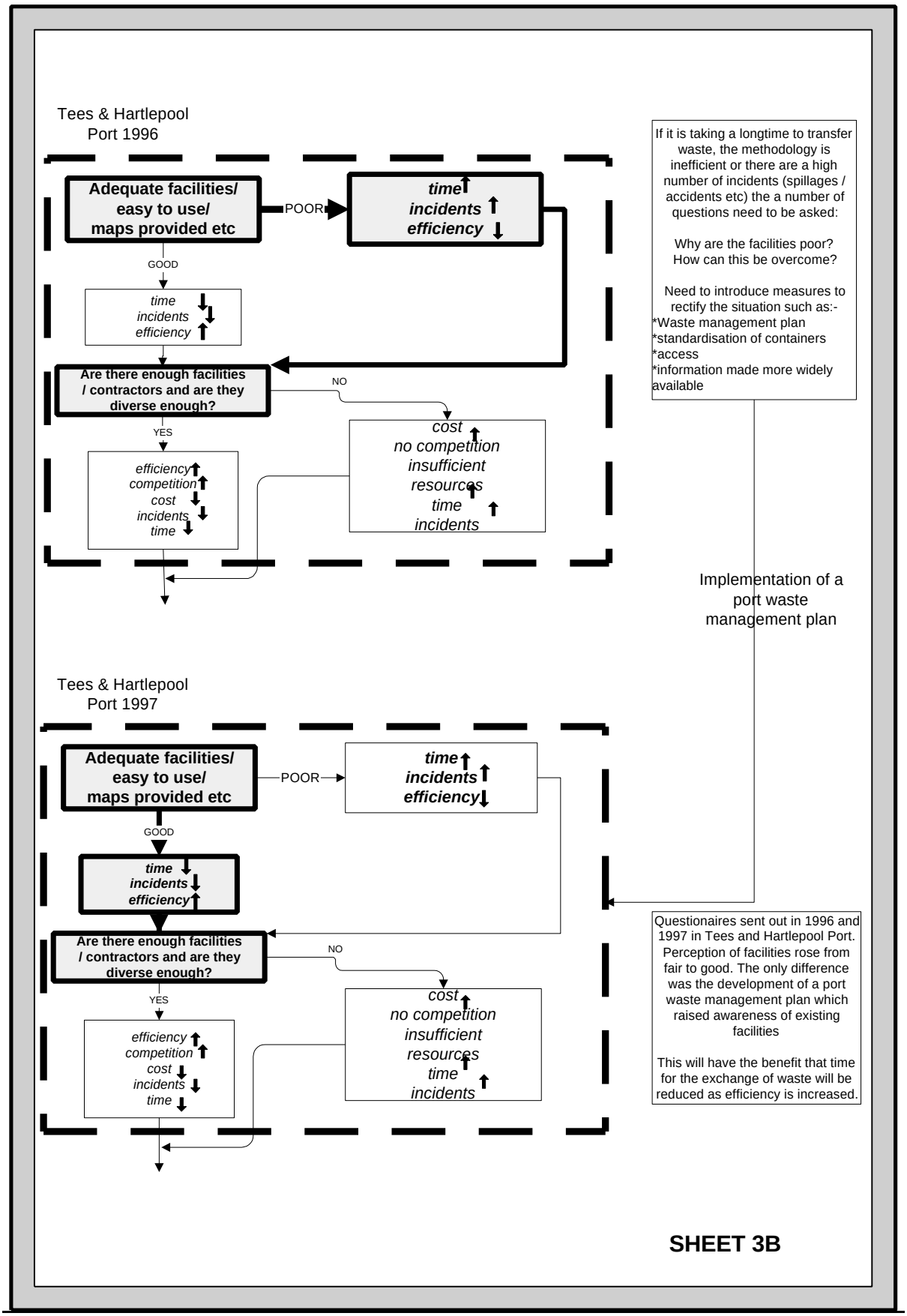
The model can be expanded almost infinitely in this way and could be developed further into a computer based tool enabling a wide range of parameters and likely outcomes to be examined. Future developments would most likely take the form of an ? expert system? which would be able to handle many more decisions and pathways. The user would then also be able to extract information more easily.

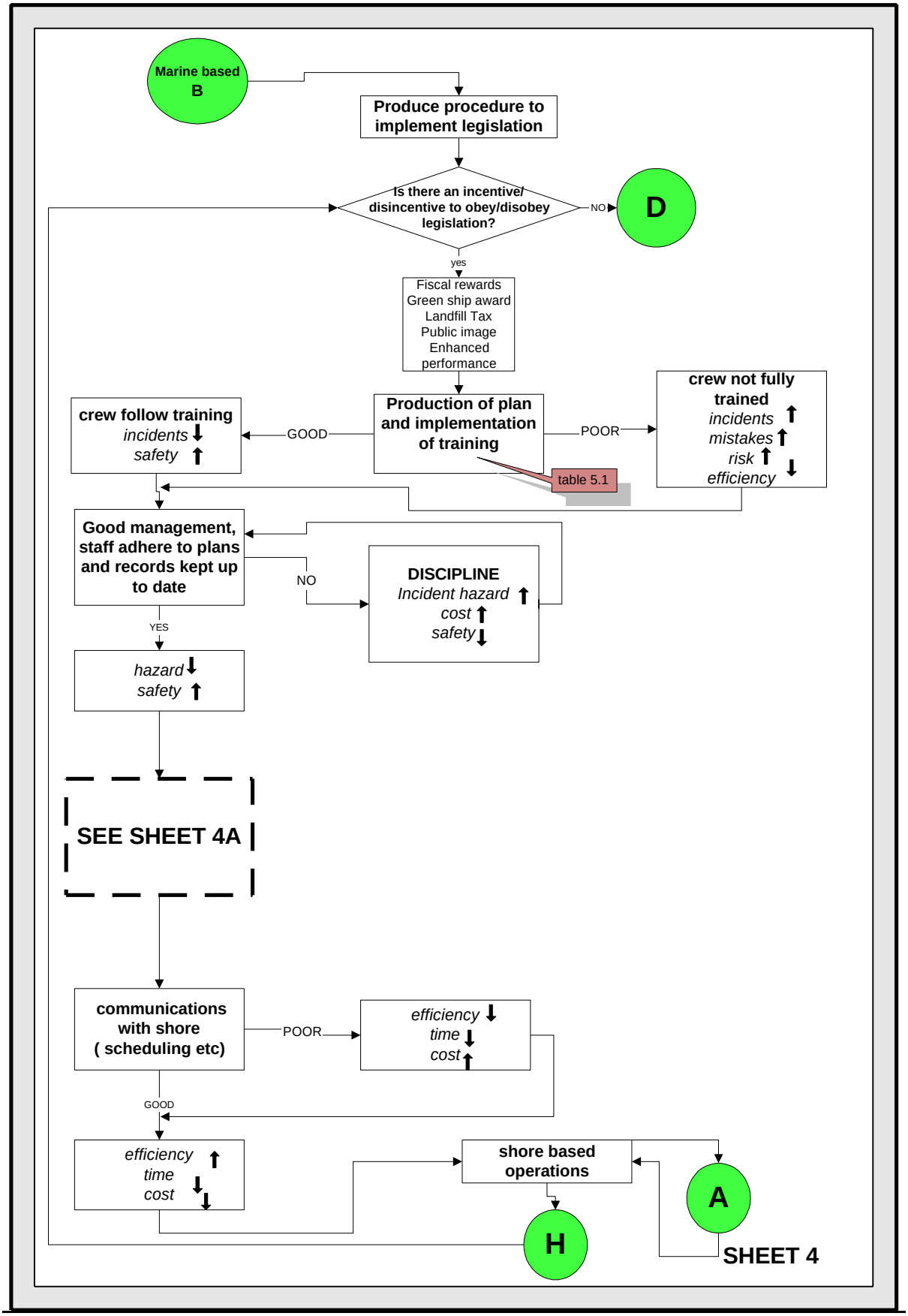

EMARC
Rule Implementation Model
OVERALL MODEL LAYOUT
START
I
Legislation
obey
disobey
A
Land based installations
B
Marine based installations
E
Contractors
H
Monitoring
F
Negative environmental impact
G
Enforcement
SHEET 1

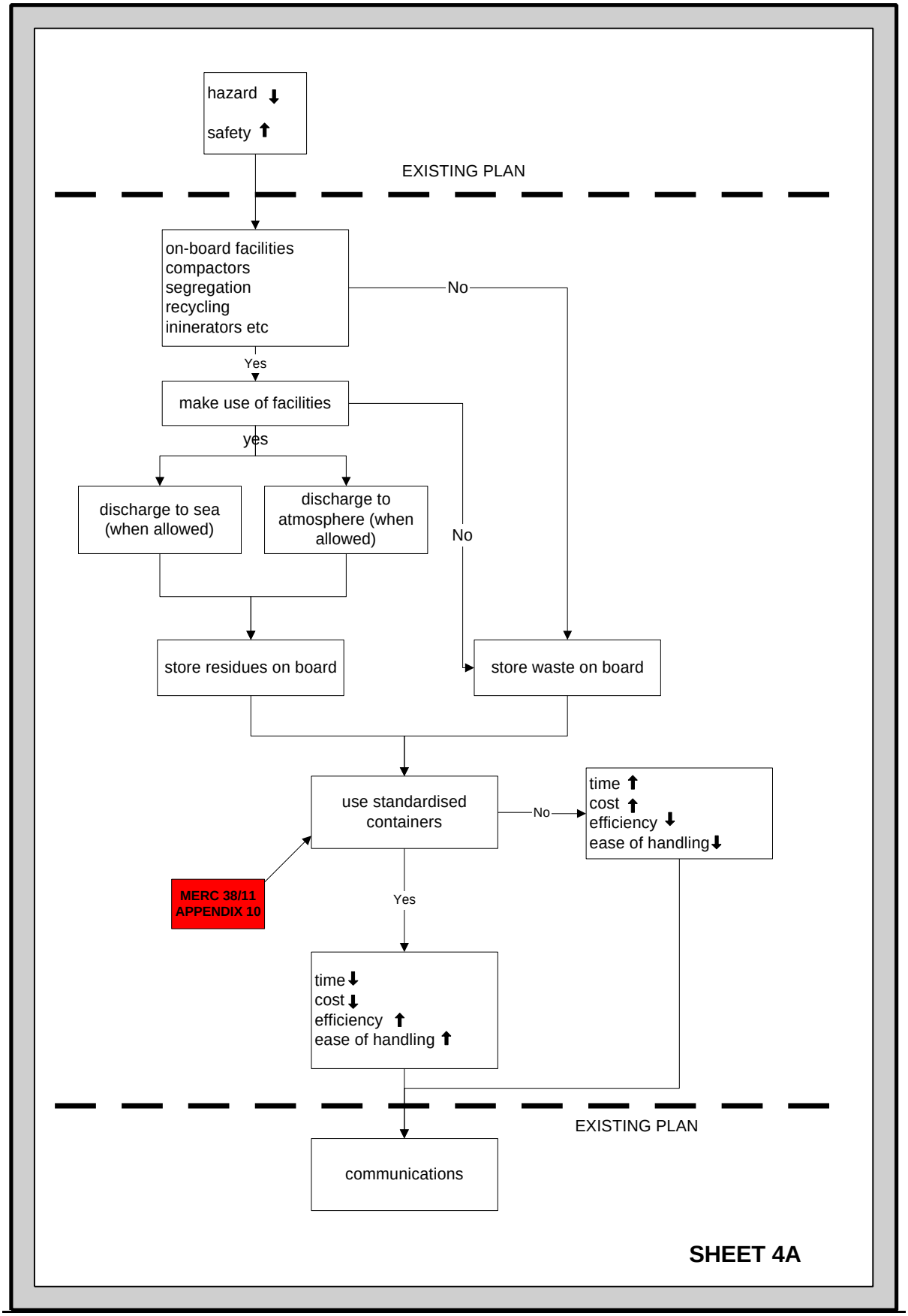

EMARC
Rule Implementation Model
I
Non government organisations Political pressure
Is there an environmental problem owing to waste?
NO
Level of Waste acceptable
YES
Do we want to address the problem?
NO
No incentives to tackle issues/ too costly to implement
Monitor Situation
YES
Incentives
Is it possible to overcome the problem?
NO
Technology not yet advanced or available
YES
How do we overcome this?
Voluntary
Persuasion
Public awareness
Policing
Monitoring
Record keeping
Best practice
Codes of conduct
D
Legislation
Define rules
Implement rules
Communicate rules/training
Are the rules practical?
NO
YES
OBEY RULES? (decision based upon incentives)
No
Disobey
Incident hazard
Yes
D
F
IMPACT ON LAND BASED AND MARINE BASED INSTALLATIONS, AND CONTRACTORS
Land based installations A
Marine based installations B
Contractors E
KEY
increase
decrease
Connector
F
Reference to data
Tables 6.1-6.8
SHEET 2

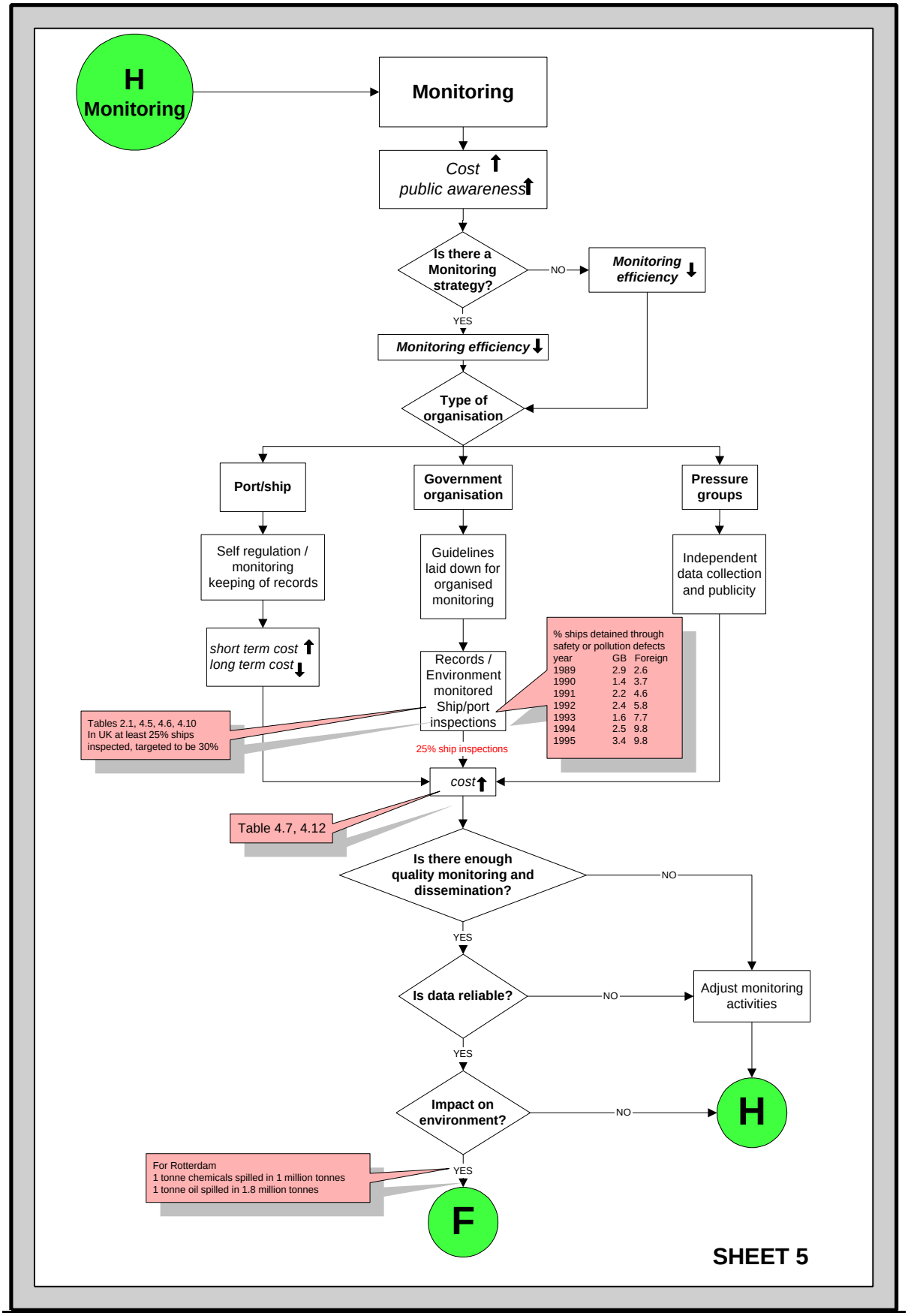

Land based installations A
Produce procedure to implement legislation
table 5.1
Is there an incentive/disincentive to obey/disobey legislation?
NO
D
yes
Fiscal rewards
Green ship award
Landfill Tax
Public image
Enhanced performance
Is procedure easy to implement
Yes
No
efficiency ⬆ incidents ⬇
efficiency ⬇ incidents ⬆
table 5.1
Training
More staff required cost ⬆
Training Poor
effectiveness of procedure implementation ⬇ incidents ⬆
Training good
Staff adhere to plans and keep records
YES
NO
DISCIPLINE plans effectiveness ⬇ incidents ⬆ cost ⬆
Plans effectiveness ⬆ Incidents ⬇
see SHEET 3A
Adequate facilities/ easy to use/ maps provided etc
POOR 70%
time ⬆ incidents ⬆ efficiency ⬇
GOOD 30% (Lloyds list)
time ⬇ incidents ⬇ efficiency ⬆
Port reception facilities, adequacy of facilities in Tees and Hartlepool as perceived by master, pre Port Waste Management Plan (source THPA)
ANNEX poor% average or better%
I 66 33
II 81 19
IV 81 19
V 63 37
Are there enough facilities / contractors and are they diverse enough?
NO
YES
cost ⬆ no competition insufficient resources ⬆ time ⬆ incidents ⬆
efficiency ⬆ competition ⬆ cost ⬇ incidents ⬇ time ⬇
See SHEET 3B for example of operation
Communication with SHIPS/COMPANY/ AGENT/TERMINAL
POOR
time ⬆ cost ⬆ efficiency ⬇
GOOD
time ⬇ cost ⬇ efficiency ⬆
H
Monitoring
SHEET 3

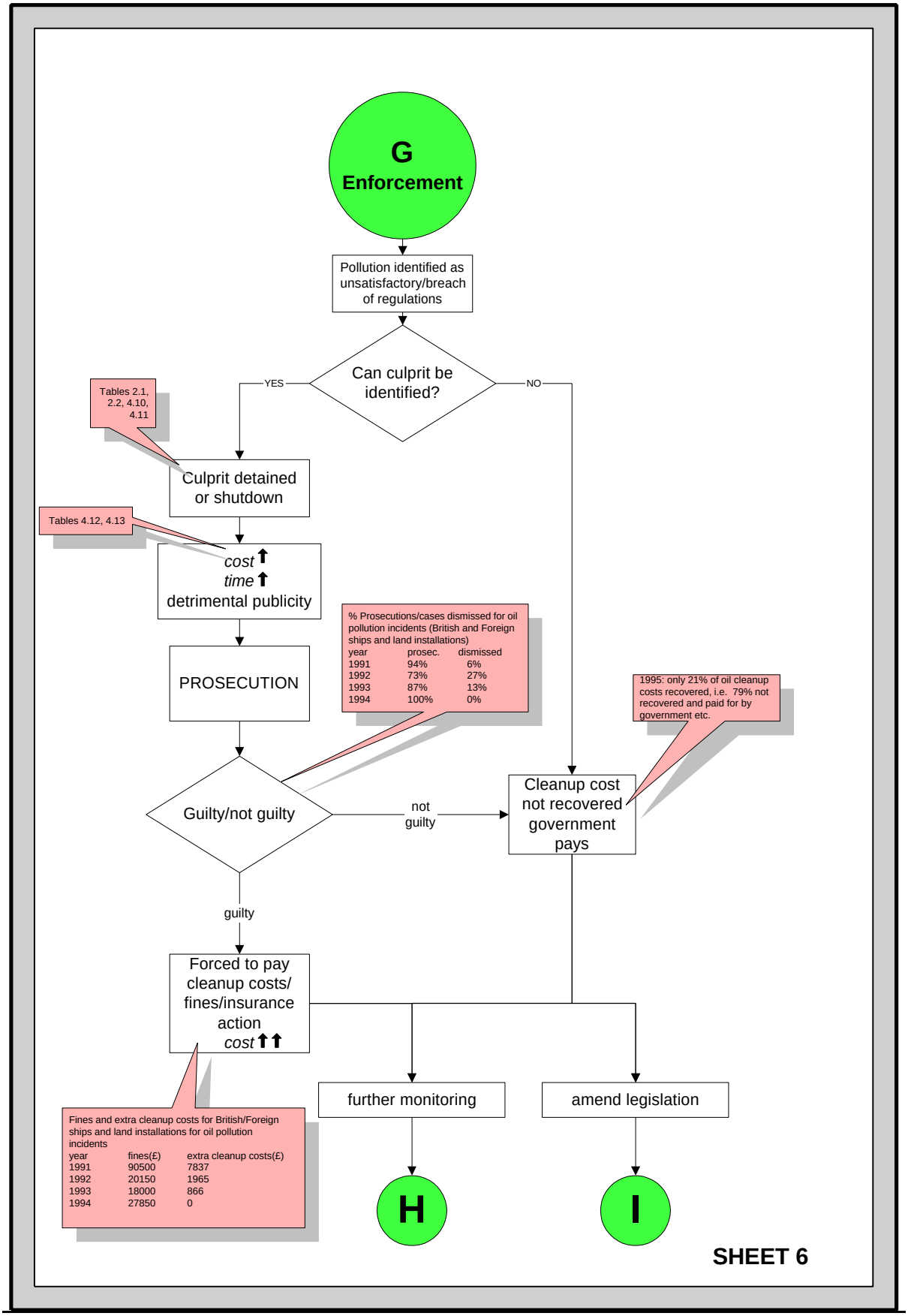

Plans effectiveness
Incidents
EXISTING PLAN
Are standardised containers available?
NO
Can standard containers be introduced?
NO
Non-standard containers
MERC 38/11 APPENDIX 10
YES
YES
efficiency
time
cost
Ease of handling
INTRODUCE
efficiency
time
cost
ease of handling
EXISTING PLAN
Adequate facilities/ easy to use/ maps provided etc.
SHEET 3A

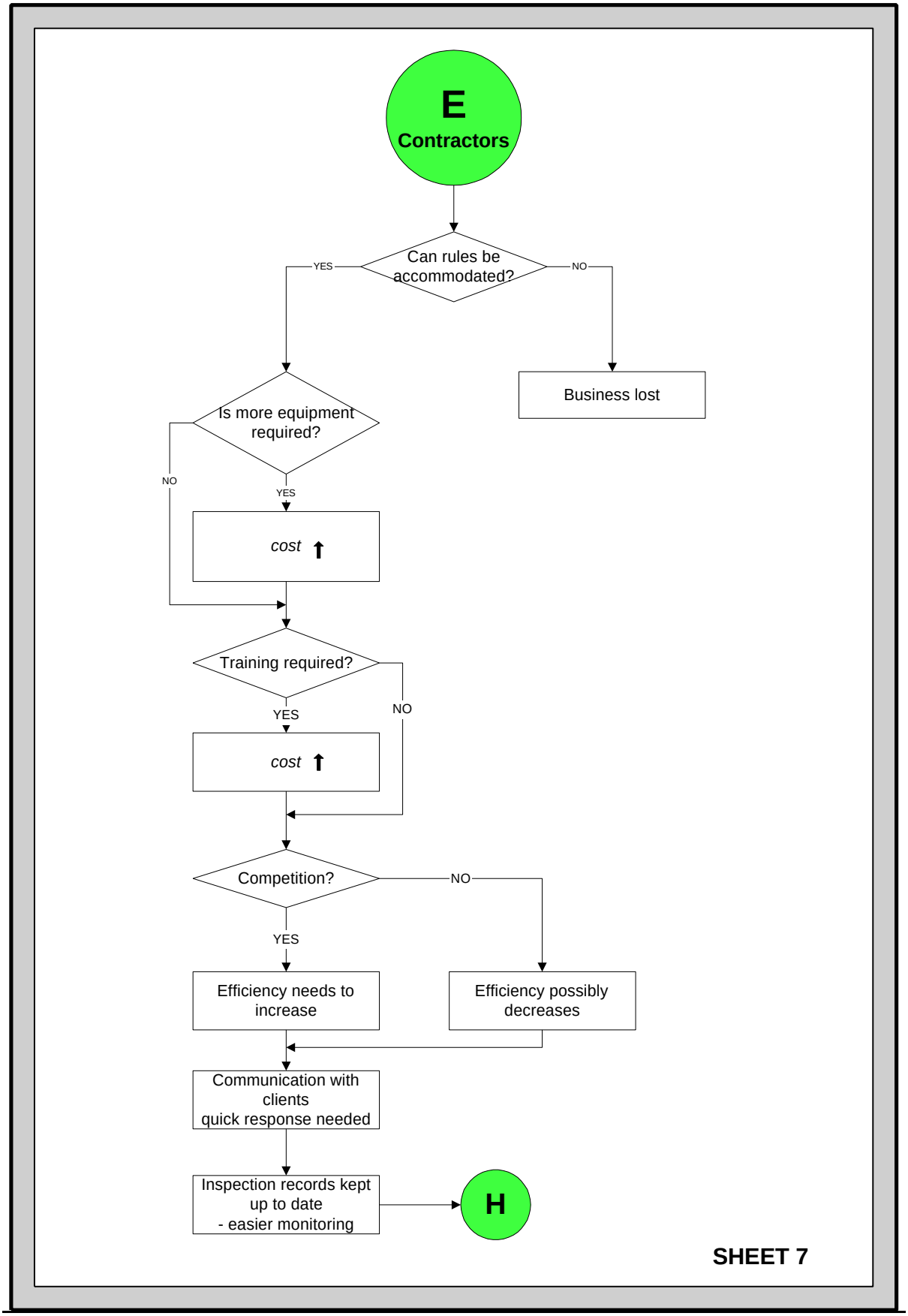

Tees & Hartlepool Port 1996
Adequate facilities/ easy to use/ maps provided etc
POOR
time ↑ incidents ↑ efficiency ↓
GOOD
time ↓ incidents ↓ efficiency ↑
Are there enough facilities / contractors and are they diverse enough?
NO
YES
cost ↑ no competition insufficient resources ↑ time ↑ incidents ↑
efficiency ↑ competition ↑ cost ↓ incidents ↓ time ↓
If it is taking a longtime to transfer waste, the methodology is inefficient or there are a high number of incidents (spillages / accidents etc) the a number of questions need to be asked:
Why are the facilities poor? How can this be overcome?
Need to introduce measures to rectify the situation such as:-
*Waste management plan
*standardisation of containers
*access
*information made more widely available
Implementation of a port waste management plan
Tees & Hartlepool Port 1997
Adequate facilities/ easy to use/ maps provided etc
POOR
time ↑ incidents ↑ efficiency ↓
GOOD
time ↓ incidents ↓ efficiency ↑
Are there enough facilities / contractors and are they diverse enough?
NO
YES
cost ↑ no competition insufficient resources ↑ time ↑ incidents ↑
efficiency ↑ competition ↑ cost ↓ incidents ↓ time ↓
Questionaires sent out in 1996 and 1997 in Tees and Hartlepool Port. Perception of facilities rose from fair to good. The only difference was the development of a port waste management plan which raised awareness of existing facilities
This will have the benefit that time for the exchange of waste will be reduced as efficiency is increased.
SHEET 3B

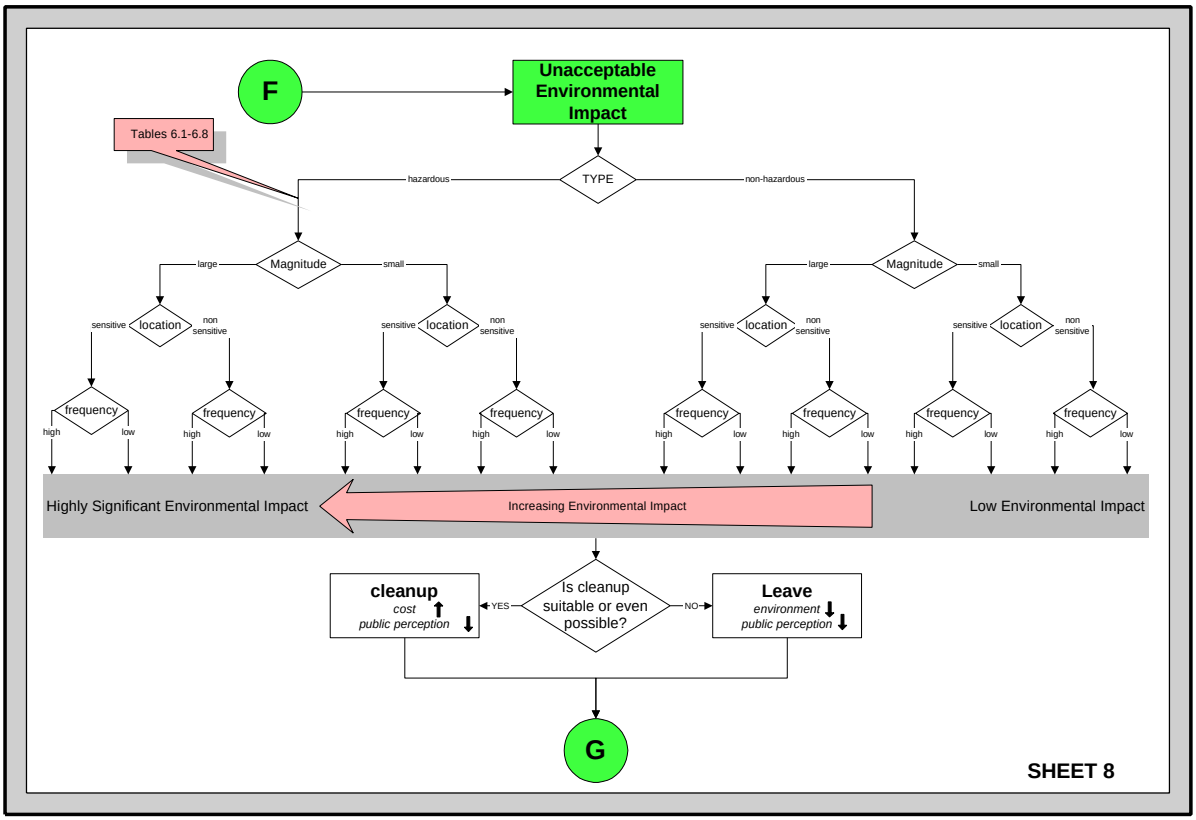

Marine based
B
Produce procedure to implement legislation
Is there an incentive/ disincentive to obey/disobey legislation?
NO
D
yes
Fiscal rewards
Green ship award
Landfill Tax
Public image
Enhanced performance
Production of plan and implementation of training
GOOD
crew follow training
incidents
safety
POOR
crew not fully trained
incidents
mistakes
risk
efficiency
table 5.1
Good management, staff adhere to plans and records kept up to date
NO
DISCIPLINE
Incident hazard
cost
safety
YES
hazard
safety
SEE SHEET 4A
communications with shore (scheduling etc)
POOR
efficiency
time
cost
GOOD
efficiency
time
cost
shore based operations
A
H
SHEET 4


hazard ⬇
safety ⬆
EXISTING PLAN
on-board facilities
compactors
segregation
recycling
ininerators etc
No
Yes
make use of facilities
yes
discharge to sea (when allowed)
discharge to atmosphere (when allowed)
No
store residues on board
store waste on board
use standardised containers
No
time ⬆
cost ⬆
efficiency ⬇
ease of handling⬇
MERC 38/11 APPENDIX 10
Yes
time⬇
cost⬇
efficiency ⬆
ease of handling ⬆
EXISTING PLAN
communications
SHEET 4A


H
Monitoring
Monitoring
Cost
public awareness
Is there a Monitoring strategy?
NO
Monitoring efficiency
YES
Monitoring efficiency
Type of organisation
Port/ship
Government organisation
Pressure groups
Self regulation / monitoring keeping of records
Guidelines laid down for organised monitoring
Independent data collection and publicity
short term cost
long term cost
Records / Environment monitored Ship/port inspections
% ships detained through safety or pollution defects
year GB Foreign
1989 2.9 2.6
1990 1.4 3.7
1991 2.2 4.6
1992 2.4 5.8
1993 1.6 7.7
1994 2.5 9.8
1995 3.4 9.8
Tables 2.1, 4.5, 4.6, 4.10
In UK at least 25% ships inspected, targeted to be 30%
25% ship inspections
cost
Table 4.7, 4.12
Is there enough quality monitoring and dissemination?
NO
YES
Is data reliable?
NO
Adjust monitoring activities
YES
Impact on environment?
NO
H
For Rotterdam
1 tonne chemicals spilled in 1 million tonnes
1 tonne oil spilled in 1.8 million tonnes
YES
F
SHEET 5


G
Enforcement
Pollution identified as unsatisfactory/breach of regulations
Can culprit be identified?
YES
NO
Tables 2.1, 2.2, 4.10, 4.11
Culprit detained or shutdown
Tables 4.12, 4.13
cost ⬆
time ⬆
detrimental publicity
PROSECUTION
% Prosecutions/cases dismissed for oil pollution incidents (British and Foreign ships and land installations)
year prosec. dismissed
1991 94% 6%
1992 73% 27%
1993 87% 13%
1994 100% 0%
1995: only 21% of oil cleanup costs recovered, i.e. 79% not recovered and paid for by government etc.
Guilty/not guilty
not guilty
Cleanup cost not recovered government pays
guilty
Forced to pay cleanup costs/ fines/insurance action
cost ⬆⬆
Fines and extra cleanup costs for British/Foreign ships and land installations for oil pollution incidents
year fines(£) extra cleanup costs(£)
1991 90500 7837
1992 20150 1965
1993 18000 866
1994 27850 0
further monitoring
amend legislation
H
I
SHEET 6


E
Contractors
Can rules be accommodated?
YES
NO
Business lost
Is more equipment required?
NO
YES
cost
Training required?
YES
NO
cost
Competition?
NO
YES
Efficiency needs to increase
Efficiency possibly decreases
Communication with clients quick response needed
Inspection records kept up to date - easier monitoring
H
SHEET 7


F
Unacceptable Environmental Impact
Tables 6.1-6.8
TYPE
hazardous
non-hazardous
Magnitude
large
small
location
sensitive
non sensitive
frequency
high
low
Highly Significant Environmental Impact
Increasing Environmental Impact
Low Environmental Impact
cleanup
cost
public perception
YES
Is cleanup suitable or even possible?
NO
Leave
environment
public perception
G
SHEET 8

12. REVIEW OF FINDINGS

The first task accomplished by the EMARC team was the collation of baseline data and information about the implementation and operation of MARPOL both on ships and in ports. This gave some information on the impact of ships' waste on the environment and the possible beneficial effects of the MARPOL Regulations. The Consortium has discovered was that there is an apparent wealth of literature available on the subject of ship air and sea pollution. This quantity of data has led to an illusion of comfort with current research effort. Environmental data over the last 18 years since the inauguration of MARPOL has undoubtedly become more widespread and accessible. Data derived from monitoring programmes of ships? oil and litter pollution is particularly abundant, however extreme caution has to be used when analysing this data considering the inherent difficulties involved with accurately determining between different sources of pollution in the marine environment.

In this respect there seems to be a constant stream of research programmes, mostly gathering data from questionnaires, aimed at establishing that either ports or ships are, or are not, playing their part in the reduction of pollution. Alternatively the research concentrates purely on the environmental effects of pollution from maritime sources.

For instance, the quantification of ship produced waste, especially oily waste, has been the subject of a number of studies worldwide. Simple, overall quantities such as ? volume per ship per voyage? has no meaning owing to the enormous range of ship size and usage. A system of waste factors has therefore evolved. The units used for these factors have not been standardised and garbage, for example, can be measured in kg/day/person or by volume, say, cubic metres, sacks or skips. Published data invariably uses scientific terminology which has no meaning when compared with a half full skip. A garbage waste factor of about 2.5kg per person per 24 hours is quoted frequently and has been used in calculations carried out as part of this project to estimate overall quantities of generated garbage.

Estimating amounts of oily waste presents a lesser problem owing to the much closer control in place on board ship and when discharging ashore although units ranging from litres/hp/day to litres/1000hp/annum. All quoted waste factors must be approached with extreme caution. They take no account of on board treatment which, for example, in the case of a modern cruise liner, will result in almost no waste being landed.

Thus the quantities of garbage or oily waste collected at any one time are frequently comparatively small and, particularly in the case of garbage, often mixed with rubbish from other sources. These sources may not even be port related. This multiplicity of operations can, unless controls are especially rigorous, lead to poor record keeping and inaccurate data. In turn this makes any assessment of the success or otherwise of the operation of MARPOL very difficult

New data on the characterisation of garbage and the quantities landed following single voyages for specific ships has been collected by the EMARC team. The figures obtained confirm the work of other researchers, but has also reinforced the difficulty of making generalisations about ship generated waste, as in many cases no waste was actually landed.

Ports are complex organisations. The simplistic view that a port authority carries out, and is responsible for, all operations within the port limits, is rarely true. In one of the ports surveyed for the EMARC project of 58 port users contacted, 29 independently arrange MARPOL facilities using a total of eight different waste contractors. It is rare for a single contractor to provide all the necessary facilities for all port users, irrespective of quantity, location or time of day.

Overall, EMARC surveys to establish the adequacy of reception facilities lead to the general conclusion that facilities in ports are very variable and that poor communication between port, port user - ships? agents - and ship is probably the main cause of perceived dissatisfaction.

The EMARC Consortium itself added to the plethora of questionnaires by sending out two of its own: one to ship owners and operators and one to ports. The response has been gratifyingly large although throughout the two year programme it has been evident that those sections of the industry that have nothing to hide responded fully and willingly. It may not be entirely fair to draw the converse conclusion.

The second main outcome achieved by the Consortium has been an inventory of current approaches to the physical management of ship generated waste both by ships and ports. It is in the development of this work that it has been discovered that the perception of the facilities themselves was so varied and that communication is such a vital element in achieving good waste control. The particular areas where EMARC members have recommended improvements in communication are:

- X shore to ship, with ports informing ships of what facilities are available, their capacity and the costs involved
- X ship to shore, with ships needing to inform ports, in adequate time, of their particular and/or special needs
- X to staff, to ensure that at the point of disposal, those staff/crew involved in disposal know and understand the arrangements

Some interesting comparisons have emerged from primary research conducted and revisited. Initial research having shown that the perception of shore based waste reception facilities at one major United Kingdom port (an EMARC partner) was no better than adequate, a conscious decision was taken by that port authority to comply with the then voluntary system of self-regulation in terms of port waste management planning. The port introduced a port waste management plan, which, to large degree, formalised the existing structure and established a mechanism or procedure whereby the method of accessing facilities was explained to a ship's master prior to arrival and, conversely, the master was asked to specify his requirements in advance. No changes to the facilities were undertaken. When the survey was reissued, an increased proportion of respondents said that the facilities were excellent, demonstrating the power of perception and the importance of communications. Recent UK legislation now makes port waste management planning mandatory as is likely to be the case with the forthcoming EU Directive.

As communications has become such a pivotal element of the EMARC findings, it merits a minor diversion into the actual handling of the waste at the ship-shore interface and the problem of ultimate disposal. The implementation of port waste management plans in the United Kingdom has shown that a clear understanding of why the work is necessary is central to achieving best practice. Therefore, the cooperation of everyone concerned with the waste management chain - ship, agent, terminal operator, harbour authority, waste contractor, local regulatory and environmental agencies, is essential if the system is to work efficiently and cost effectively.

EMARC has also considered the impact of the MARPOL Regulations on the port and ship operator. Compliance with the Regulations implies committing time, money and personnel. In the case of ports, this means physical and organisational infrastructure, and, for ship operators, investing in equipment to control and prevent pollution occurring. Compliance with the Regulations is not necessarily dependent on geography, but rather on culture. Where ports and ship operators expend effort and commitment on environmental and safety policies, MARPOL is one of several issues considered.

Those companies which are at the forefront in the implementation of environmental policies can provide benchmarks for others. There is an element of self-interest in this: public awareness in environmental matters has increased and organisations are therefore conscious of bad publicity and loss of standing. Direct compliance may be seen as enhancing their ability to attract business. Some companies will make investment ahead of legislation while, conversely, others will wait until the last minute and install just enough equipment to comply with the letter of the law.

Discussion of constraints to improvements leads to the consideration of waste generation and waste minimisation. A study of waste generation has led the Consortium to look at the legislation relevant to the ship's operational area(s); what duties and procedures apply on board ship; identification of the sources of wastes; amounts and types; costs of on-board waste management and for waste delivered to port reception facilities. This presages to waste minimisation - prevention and reduction, reuse, recycling, separation and processing of waste before storage, discharge into reception facilities and discharge to sea. Perhaps the most important of these is prevention and reduction by elimination of unnecessary products that produce waste, substitution of products that reduce the toxicity and/or amount of waste generated, introduction of ships' equipment, maintenance or operating procedures so as to eliminate or reduce waste generation and implementation of purchasing practices which encourage waste minimisation.

Reuse and recycling can be useful tools providing the constraints of purchasing, storage space and training can be overcome. The trend seems to be that more vessels are segregating waste on-board, a procedure that is not invariably followed through by shore facilities.

There follows the area of the use of on-board equipment. Processing can be defined as any mechanical process or chemical treatment (or combination) performed on ship generated waste to either reduce its volume, change its physical form or reduce its toxicity/hazard level. Techniques vary, but equipment includes pulpers, shredders, grinders, comminuters, macerators, compactors, coalescers and filter/strainers. Generally, such equipment is found on ships generating large

volumes of waste. Consideration has to be given to whether the benefits to the environment of reducing one hazard outweigh the new hazards introduced into the environment from, say, exhaust gases and suspended solids.

A finding that has emerged from research undertaken on cargo vessels in particular is that, although the on-board equipment may be available, it is not always efficient in terms of either direct cost or manpower to use it, and waste is therefore stored for disposal ashore. Were circumstances to change, that is, lack of shore facilities or facilities at excessive cost, the on-board equipment might well be adequate, but any changes in the Regulations regarding discharge overboard or emissions to air might require a revision to on-board management plans.

To sum up, work carried out specifically for the project, particularly at ports, has confirmed the wide range of operational methods in use and the different criteria used for record keeping and thus the assessment of efficiency. There is an urgent need for the standardisation of recording and reporting, both afloat and ashore if the full impact of the MARPOL rules is to be assessed accurately. Nevertheless, European shipping companies and European ports are able to demonstrate an understanding of, and conformance with the MARPOL Regulations. A significant percentage of shipping companies are using shore reception facilities, and, from a historical perspective, this appears to have reduced the quantity of waste being discharged to sea by ships.

Port operations in designated Special Areas obviously have a greater degree of responsibility to provide a full range of reception facilities, as ships are further restricted as to which wastes may be disposed of at sea. Countries in the Baltic Sea area clearly demonstrate their response to this requirement. The lack of data from the Mediterranean area may lead to incorrect conclusions being drawn.

Monitoring of emissions of atmospheric pollutants from ships is an area of research which has received much attention in recent years, owing to the proposed MARPOL Annex VI and other national and EU legislation. Generally, information regarding the environmental impacts of chemical spillages and losses overboard, and discharges of sewage waste water is sparse. Little data from pre-MARPOL environmental studies has been revealed.

Environmental information appears to be mainly available from isolated studies undertaken or commissioned by national or government-orientated groups and may therefore favour specific nations, regions or in certain cases ports. Fragmentation and variation in the focus of marine environmental research presents difficulties to any baseline data collection exercise with the aim of providing a consistent, objective synthesis.

Control systems now in place are not solely directed at MARPOL, but in most cases they will have been set up to control safety in ports and at sea, with tasks later extended to cover Port State Control activities and MARPOL checks.

The same system of evolving control applies to ship operators. The costs of complying with MARPOL are a part of operational costs and may increase capital expenditure. Some operators

may not comply because they cannot recoup the costs. However, there are front runners who actually see business opportunities in compliance and ways of avoiding operational difficulties or recurring operational discharge costs.

The presentation of definitive data to prove, one way or another, that MARPOL works is therefore not possible. However, given all these conditions, from the scant and anecdotal data available MARPOL seems to have positive effects. Spills in ports are low, quantities spilled are relatively low, the degree of penetration of special equipment on board vessels seems high and the number of prosecutions limited.

What conclusions can be drawn as the way forward regarding the critical Annexes, I, II, and V, oil, noxious liquids and garbage? In terms of Annexes I and II, on balance, on-board systems have been shown to be complementary to their shore counterparts and are adequate so long as they are used legally.

Research on garbage, Annex V, has demonstrated that the way forward lies in the keeping of a garbage record book, improved levels of communication of the facilities available and the ship's requirements for their use and, possibly, in the use of standard sized containers. Caution must be exercised as space may be at a premium in smaller vessels, and in ensuring that any garbage process book is not open to abuse.

Best practice encompasses the notion of waste minimisation where practically possible, as reduction at source will reduce the requirement for plant and equipment. Coupled with separation of the remaining waste for disposal ashore, this represents the best environmental option. Supported by continuous training and development to foster understanding of waste management systems, appropriate environmental objectives can be achieved.

13. RECOMMENDATIONS

The MARPOL Regulations are extensive and comprehensive and there is already sufficient effort being expended by IMO and others to keep the necessary technology and equipment up to date and relevant in the current environmental climate. The Regulations are having an effect although to what degree is less easy to assess. There is no doubt that if awareness of the regulations alone was used as a measure, then MARPOL would certainly be judged a success. Nevertheless, there is some evidence to show that the marine environment is improving and that the maritime community is playing its part. However, there is no room for complacency.

Information and data about waste quantities generated and landed, even from developed countries, is sparse. Environmental data is well meaning but too fragmented for firm conclusions to be drawn. National statistics from ports are required in a comprehensive and standardised form which need not be complex. The accurate reporting of annual totals for each MARPOL Annex would be a major step forward. Environmental data gathering on a long term, common, basis is essential.

Communications between the various parties in the waste management chain must be improved. This can be achieved relatively simply by ensuring that the ship reports its requirements, acknowledged by the port and the information is passed on to the waste contractor. The way in which each link operates will vary enormously in each port, but the links must be established. An authorised and proven waste management plan for every port would set the framework for such a communications system.

A move towards the standardisation of what a ship? s crew could expect to find in every port has considerable merit. Simple standard pictograms would be a start with, possibly, standardised containers for garbage further along the waste management road.

Finally, the fact that all systems are operated by people must not be overlooked. Staff training in the correct procedures backed up by the necessary management controls are essential. Adequate independent national and international monitoring is then a natural additional link in the chain to ensure that not only are the systems in place but that they are being implemented.
The most urgent work necessary to improve the implementation of MARPOL and to enable meaningful research to be carried out to measure the effectiveness of the MARPOL Regulations is set out in the following list. Note that very little ? hardware? development is necessary, the exception being the possible use of standardised containers.

The EU provides an ideal forum for the implementation of these recommendations in the context of the European region.

Research and development programmes should be set up to:

X establish criteria for the assessment of the environmental impact of the MARPOL regulations

X require all ports to prepare waste management plans

X carry out independent audits of port reception facilities

X establish ? actual? waste factors - based on waste landed by environmentally conscious ship operators

X provide common standards for reporting quantities of ships? operational waste landed under MARPOL Regulations

X promote the use of common units of quantity for ships? waste

X investigate a simple and practical standardised container system

X implement common standards for the definition of beach litter sources

X establish common standards and procedures for beach monitoring campaigns

X improve accessibility of environmental data through centralised databases

X increase research on environmental impact of chemical spillages and discharge of sewage waste

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