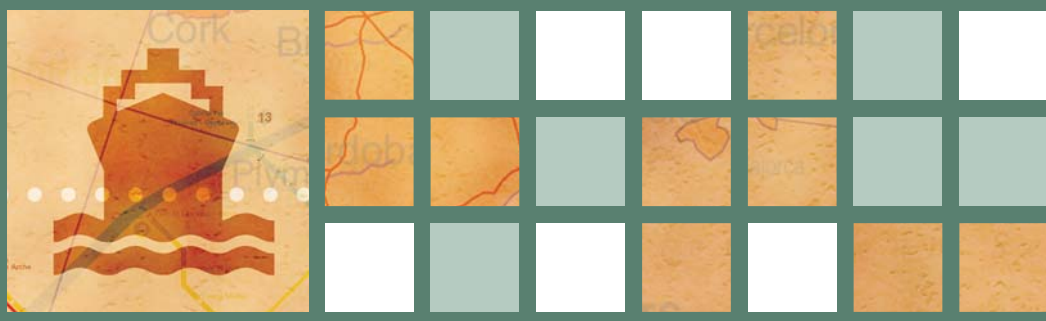
NERA
Economic Consulting

Final Report, March 2004
London



Evaluation of the Feasibility of Alternative Market-Based Mechanisms To Promote Low-Emission Shipping In European Union Sea Areas

A Report for the European Commission, Directorate-General Environment

Prepared by NERA Economic Consulting

David Harrison, Jr, PhD
Daniel Radov
James Patchett

How Markets Work℠

TABLE OF CONTENTS

ACKNOWLEDGEMENTS iv

ABOUT THE AUTHORS v

1. EXECUTIVE SUMMARY ES-1
1.1. Identification of Specific Approaches to Controlling Marine Emissions ES-1
1.2. Criteria for Assessing the Feasibility of Alternative Market-Based Approaches ES-5
1.3. Analyses of Feasibility of Market-Based Approaches for Shipping ES-6
1.4. Implications of Analyses ES-13

2. INTRODUCTION 1
2.1. Context for Policies to Address European Union Shipping Emissions 1
2.2. Objective of This Document 5
2.3. Organization of the Report 6

3. OVERVIEW OF BASIC MARKET-BASED APPROACHES CONSIDERED FOR SHIPPING 7
3.1. Overview of Emissions Trading Alternatives 8
3.2. Overview of Emissions Charging Alternatives 11

4. SPECIFIC MARKET-BASED APPROACHES FOR SHIPPING EMISSIONS 14
4.1. General Issues in Specifying a Market-Based Approach 14
4.2. Specification of Emissions Trading Approaches for Shipping Assessed in This Report 19
4.3. Specification of Emissions Charging Approaches for Shipping Assessed in This Report 32

5. CRITERIA FOR ASSESSING ALTERNATIVE MARKET-BASED INSTRUMENTS 44
5.1. Environmental Criteria 44
5.2. Efficiency Criteria 45
5.3. Distributional Criteria 46
5.4. Institutional Criteria 47

6. INCENTIVES FOR EMISSION REDUCTION OPTIONS 49
6.1. Fuel Switching 51
6.2. Installation / Operation of Abatement Technology 53
6.3. Use of Shore-Side Electricity ("Cold Ironing") 55
6.4. Increasing Vessel Efficiency 56
6.5. Reducing European Shipping Activity 58

6.6. Changing Journey Route 59

7. DETAILED QUALITATIVE ASSESSMENTS OF THE FEASIBILITY OF ALTERNATIVE MARKET-BASED INSTRUMENTS FOR SHIPPING 61
7.1. Summary of Assessments 61
7.2. Assessments Based Upon Environmental Criteria 63
7.3. Assessments Based Upon Efficiency Criteria 72
7.4. Assessments Based Upon Distributional Criteria 79
7.5. Assessments Based Upon Institutional Criteria 88

8. CONCLUSIONS AND NEXT STEPS 101
8.1. Tentative Recommendations 101
8.2. Next Steps 102

9. REFERENCES 104

ANNEX A: TECHNICAL ANNEX A-1

ANNEX B: SUMMARY OF SHIP EMISSIONS STAKEHOLDER WORKSHOP 5 SEPTEMBER 2003 B-1

TABLE OF TABLES

Table 1. Qualitative Assessments of Market-Based Approaches for Shipping **ES-7**
Table 2. Selected Examples of Existing and Proposed Trading and Charging Programmes **7**
Table 3. Potential Emissions Reduction Benefits, by Pollutant and Location (in €/Tonne) **16**
Table 4. Two Approaches to a Credit-Based Programme **20**
Table 5. Two Approaches to Benchmarking **26**
Table 6. Two Approaches to Cap-and-Trade **30**
Table 7. Three Approaches to Taxation/Charging **33**
Table 8. Two Approaches to En-Route Charging **37**
Table 9. Three Approaches to Differentiated Dues **40**
Table 10. Incentives of Economic Instruments for Various Abatement Options **51**
Table 11. Qualitative Assessments of Market-Based Approaches for Shipping **62**
Table 12. Ship Emissions in Port and at Sea, 2000 **71**

ACKNOWLEDGEMENTS

This study was requested and funded by the European Commission ("Commission") in order to provide analyses of alternative market-based approaches to promote low-emission shipping in European Union sea areas. This report is designed to provide information that would be helpful to the European Commission in developing such approaches if there were a decision to seek emission reductions from the shipping sector. The study is not intended to develop specific proposals. Indeed, although the study team was asked to develop conclusions regarding which alternatives appear most promising and provide suggestions for additional steps to develop concrete proposals for one or more of the approaches, these conclusions and suggestions are those of the study team; the Commission has made no decisions regarding which approaches are promising.

NERA Economic Consulting ("NERA") conducted the study. NERA is a firm of approximately 400 consulting economists with European offices in Brussels, London, Madrid and Rome as well as nine offices in the United States and offices in Australia, Japan and Brazil. David Harrison (NERA Senior Vice President and Director of NERA's environmental economics practice), Daniel Radov (NERA Senior Consultant), and James Patchett (NERA Analyst) are the authors of the study.

The study benefited from the assistance of individuals at the European Commission and elsewhere. Nicola Robinson of the European Commission served as project manager and Matti Vainio of the Commission served as senior advisor. Their involvements in all aspects of the study—from initial formulation, to specification of alternatives, to conceptual analyses—were invaluable. The Commission organized a workshop in September 2003 with interested parties to discuss initial considerations regarding the various alternative approaches. Individual participants at the workshop provided important insights and information. In addition, a great number of individuals and organisations provided insights, comments and supplementary information to NERA regarding one or more of the alternatives as well as comments on a draft of the report. (Interested parties are invited to comment further at env-ships@cec.eu.int.) NERA is grateful to these individuals and organisations for their assistance. Responsibility for the report and its recommendations, however, and for any errors or omissions it may contain, rests solely with NERA.

ABOUT THE AUTHORS

David Harrison, Jr, PhD, *Senior Vice President*, is co-chair of NERA's energy practice and directs NERA's environmental economics practice. At NERA, Dr Harrison has directed numerous studies related to energy and environmental issues. These studies include analyses of individual environmental and energy policies, climate change policy, and the use of emissions trading and other innovative policy approaches. He has served as a consultant in these and other areas to numerous public and private organizations. Dr Harrison has participated in the development or evaluation of most major emissions trading programmes, including most recently the European Union Emissions Trading Scheme for greenhouse gases. Before joining NERA, Dr Harrison was an Associate Professor at the John F. Kennedy School of Government at Harvard University, where he taught microeconomics, energy and environmental policy, and other subjects for more than a decade. He earlier served as Senior Staff Economist on the President's Council of Economic Advisors, where his areas of responsibility included energy and environmental regulation. Dr Harrison is the author or co-author of five books and monographs, as well as many articles in professional journals. He received a PhD in Economics from Harvard University, a MSc in Economics from the London School of Economics, and a BA in Economics from Harvard College.

Daniel Radov, *Senior Consultant*, works in NERA's energy and environment practices. His work concentrates on environmental economics, with a focus on emissions trading, climate change, and economic issues associated with environmental regulations. Mr Radov's work has spanned a wide range of industries, including electric power, automobile and engine manufacturing, forest and paper products, cement, agrochemicals, and refining. Mr Radov recently assisted the European Commission in evaluating the initial allocation of allowances in their proposed greenhouse gas emissions trading programme and is currently assisting the UK government in the development of their National Allocation Plan. Mr Radov has studied and evaluated the design, implementation, and effects on different industries of other emissions trading programmes, including existing and proposed greenhouse gas trading programmes in the US and Europe. Mr Radov holds a BA in Chemistry and Philosophy from Williams College and an M.Phil. from the University of Cambridge. Mr Radov has completed graduate coursework in environmental economics at Harvard University.

James Patchett, *Analyst,* has worked extensively with climate change programmes in both the United States and Europe. Mr Patchett has assisted in the design and evaluation of emissions trading programmes in the US and abroad. Mr Patchett has modeled electricity system effects for a variety of facilities, including nuclear, coal, and natural gas facilities. In addition, he has modeled the economic impacts of policies and regulations in numerous areas, including France, the European Union, New York, and California. Mr Patchett holds a BA in Economics from Amherst College, *summa cum laude*.

1. EXECUTIVE SUMMARY

This report provides information on the feasibility of a broad range of market-based approaches to regulate atmospheric emissions from seagoing ships in European Union ("EU") sea areas, assuming a desire to reduce emissions from this sector on the part of the EU. This study does not consider the *level* of air emissions regulation that would be appropriate for the marine sector, but rather the potential usefulness of various market-based mechanisms if there were a decision to regulate marine sector emissions. The emissions under consideration are primarily the air pollutants sulphur dioxide ("SO_2") and nitrogen oxides ("NO_X"), both of which contribute to various air quality impacts in the EU, including acidification, eutrophication, ground-level ozone (smog), and particulate matter. However the approaches considered could also apply to other emissions including carbon dioxide ("CO_2"), the main greenhouse gas contributing to global climate change.

The report does not evaluate the desirability of reducing shipping emissions, but it seems clear that such emissions will take on increased importance in the future as shipping movements grow and as emissions from land-based sources decline due to regulatory requirements. Indeed, by 2020, shipping emissions of air pollutants are projected to equal all land-based emissions in the EU. We evaluate programmes in two broad categories: (1) emissions trading programmes, in which participants trade "quantities" (typically emissions, or more specifically the right to emit); and (2) emissions charging programmes, in which participants respond to a charge or price (either on emissions or on another quantity, such as sulphur in fuel, linked to emissions).

1.1. Identification of Approaches to Controlling Marine Emissions

1.1.1. Specific Approaches Considered

Six market-based programmes (three trading and three charging) are evaluated, selected based upon their prominence in specific shipping proposals or in previous programmes for land-based sources. Because of the tradeoffs along various dimensions in specifying elements of each programme, we develop multiple approaches for each of the six programmes based upon key elements such as the sources that would participate and the administrative requirements related to certification and monitoring. Indeed, one of the contributions of this study is to provide specifications that go beyond simplistic descriptions of the basic programmes and identify the specific elements (along seven separate dimensions) that would constitute each approach. The six programmes and specific approaches we consider for each programme are the following.

1. **Credit-based trading programme.** Credit programmes provide tradable "credits" to facilities that voluntarily reduce emissions below their "business as usual" ("BAU") levels. These credits can be traded and counted toward compliance by facilities that would face high costs or other difficulties in meeting their emissions requirements. Credits are generally created through an administrative process in which the credits must be pre-certified and approved before they can be traded. In the shipping

context, a credit-based programme would allow ship owners to reduce emissions and sell the emission reduction credits either to land-based sources assumed to be subject to a cap-and-trade programme or to the government if a subsidy programme were in effect. (Such a subsidy programme has been developed in the US for the Los Angeles air basin.) Two approaches are identified that strike a different balance on the trade-off between achieving environmental objectives and obtaining cost savings.

- ***Simple credit approach.*** A simple approach would allow vessels to generate credits based upon a simple formula for determining BAU levels (e.g., 1.5% sulphur in fuel) and simple periodic monitoring of emission rates and vessel activity to verify actual emissions.

- ***Rigorous credit approach.*** A rigorous approach would require shippers to achieve emission rates below BAU levels—in order to encourage net emissions reductions—and also provide more complete estimates of BAU levels in order to avoid "anyway tonnes," i.e., reductions that would occur without the programme. Continuous monitoring equivalent to that required for land-based sources would be required for shipping sources participating in the programme.

2. **Benchmark trading.** Benchmarking programmes[1] identify a specific emissions *rate* to apply to covered activities and require that the average emission rate from these activities does not exceed the benchmark level. In contrast to the credit-based approach, benchmarking is a mandatory rather than a voluntary programme. The benchmark rate establishes a baseline and thus pre-certification is not required. Sources subject to the programme can trade credits among each other based upon set formulas for calculating credits (and debits) and thereby lower the cost of meeting the emissions rate target. In the shipping context, a benchmark trading programme would set an emission rate for ships subject to the programme and allow ship owners (or operators) to buy and sell credits based upon a formula linking emission rates to credits. Two approaches are identified, one with a more narrow scope, and one with a much broader scope; both presume that requirements on shipping emissions would be set (e.g., 1.5% sulphur in fuel).

   - ***Universal benchmarking.*** This approach would require all ships in EU waters (above a given size threshold) to participate in the benchmark programme, with no geographic differentiation and relatively simple monitoring.

   - ***Trading consortia.*** This approach would allow vessels to "opt in" to a trading consortium. In exchange for cost-saving flexibility, a lower average would be set and more complex locational formulas and monitoring would be required.

3. **Cap and trade.** Under a cap-and-trade programme, an aggregate cap on emissions is set by creating a total number of emissions "allowances," each of which provides its owner with the right to emit a unit (typically a tonne) of emissions. Allowances are

[1] Benchmarking programmes have also been referred to as "averaging" or "offsetting" programmes.

initially allocated in some way, usually to participants. Each source covered by the programme must hold allowances to cover its actual emissions, with sources free to trade allowances amongst each other. In contrast to benchmarking programmes, cap-and-trade programmes limit total emissions, and not only emission rates. In contrast to credit-based programmes—but similar to benchmarking programmes—cap-and-trade programmes do not require pre-certification of allowances; allowances are effectively "certified" when they are initially distributed. In the shipping context, a cap-and-trade programme could be set for overall shipping emissions within a given region, with individual ships allocated allowances and allowed to trade amongst each other. Two approaches are identified that differ only in their treatment of the location of shipping emissions.

- ***Trading with exchange rates.*** This approach would set simple exchange rates for emissions in different seas.

- ***Trading with geographic formulas.*** This approach would be very similar to the exchange rates approach, but it would use more detailed locational formulas to account for geographic concerns rather than simple exchange rates.

4. **Taxation/charging.** A tax/charge in this context would be intended to reduce shipping emissions, rather than to raise revenue, as is the case with most existing taxes. (Note that any of the approaches considered here could be designed to be revenue neutral through the redistribution of any revenues to the marine sector.) We consider three taxation/charging approaches that differ in whether fuel or emissions is taxed and, for the fuel taxes, whether fuel purchases or fuel consumption would be taxed. The fuel taxes would target SO_2 emissions while the emissions tax would target both SO_2 and NO_x emissions.

   - ***Tax/charge at point of sale.*** This approach would tax sulphur fuel content in excess of a given level (e.g., 1.0 percent) at the point of fuel sale in Europe. No monitoring of individual ships would be necessary although the taxing authority would need to test fuels for sulphur and assign appropriate taxes.

   - ***Fuel-use tax/charge.*** This approach would tax the sulphur in fuel used by each ship (above a given level, e.g., 1.0 percent). Continuous or frequent monitoring of ship fuel use and sulphur content would be necessary.

   - ***Emissions tax/charge.*** This approach would tax emissions from ships, with emissions weighted by sea region and distance from shore. Continuous monitoring or estimating total emissions would be involved.

5. **En-route charging.** En-route charging has been used for many years in the aviation sector to provide revenues to fund European air-traffic control services, essentially providing a payment for use of the air traffic control infrastructure. Charges are based on the distance travelled within the relevant airspace and the weight of the aircraft. Such an approach could be applied to maritime traffic to charge vessels for emissions en route. The primary difference between this programme and an

emissions tax/charge is that the en-route charge would be based upon estimated rather than monitored emissions. Two approaches are identified that vary in whether or not specific ship movements would be monitored.

- ***Trip-based charges.*** This approach would charge ships based upon generic shipping travel patterns. Periodic emissions monitoring would be used to establish emission rates.

- ***Distance-based charges.*** This approach would charge ships based upon the actual distance travelled, including variations by region and distance from shore. Periodic emissions monitoring would be required.

6. **Differentiated dues.** A system of differentiated port or fairway dues would take advantage of the fact that many ports and some countries already impose charges on vessels that use their facilities and waters. Differentiated charges in this context would involve basing port dues in part on emissions of various pollutants. Such a system of differentiated dues has been used in various Swedish ports since 1998 to encourage reductions in NO_X and SO_2 emissions, with about 20 Swedish ports using such a revenue-neutral system. Other countries have developed similar programmes that impose dues differentiated on the basis of environmental criteria. Three approaches are developed that differ in whether the dues are levied for the use of ports or fairways and, for ports, whether the programme is voluntary or mandatory.

   - ***Voluntary differentiated port dues.*** This approach would provide ports with a differentiated dues framework, with ports free to use the framework or not.

   - ***Mandatory differentiated port dues.*** This approach would require ports within the EU to adopt a differentiated dues system.

   - ***Differentiated fairway dues.*** This approach would use a differentiated fairway dues system to encourage improvements in emissions characteristics of ships using EU fairways.

1.1.2. Approaches Not Specifically Considered

One of the options for which we do not consider specific detailed alternatives is subsidisation. However, it is clear that governments or other authorities could provide subsidies in order to meet all or part of the costs associated with ship emissions reductions. Indeed, in parallel with the differentiated fairway dues scheme mentioned above, the Swedish Maritime Authority initially provided grant funding for early take-up of NO_X abatement technology.

Such subsidies could take many forms, including, for example, one-time grants for capital investment in abatement technology, or longer-term arrangements to offset the higher costs of using low-sulphur fuel. Governments or other authorities could provide these subsidies in parallel with many of the approaches listed above, e.g. as an additional incentive to accompany taxation/charging, or to buy ship emissions reductions credits

under a credit-based trading approach. This latter option is considered further in the main report, which includes a discussion of the type and extent of subsidies allowable under EU state aid rules.

1.2. Criteria for Assessing the Feasibility of Alternative Market-Based Approaches

In order to compare the feasibility of various approaches to reducing shipping emissions, each alternative is evaluated using thirteen criteria divided into four broad categories: (1) environmental criteria; (2) efficiency criteria; (3) distributional criteria; and (4) institutional criteria. The following are brief summaries of the issues addressed by these criteria.

- Environmental criteria
  - ***Overall emissions.*** How effective is the approach in reducing overall emissions?
  - ***Geographic targeting.*** How effective is the approach in targeting emission reductions where they provide the greatest environmental benefits?
- Efficiency criteria
  - ***Cost-effectiveness.*** Will the approach encourage cost-effective compliance?
  - ***Dynamic effects.*** How effective is the approach in encouraging reductions in emission-control technologies?
  - ***Tax distortions.*** How much potential does the approach have to raise revenues that could be used to reduce existing tax distortions?
- Distributional criteria
  - ***Shipowners.*** How would shipowners' potential profits be affected?
  - ***Fuel suppliers.*** How would fuel suppliers' potential profits be affected?
  - ***Port owners.*** How would port owners' costs or revenues be affected?
  - ***Consumers/labour.*** How would consumers (i.e., purchasers of shipped goods) or workers (i.e., shipping labourers) be affected?
  - ***Taxpayers.*** How would existing taxpayers be affected (e.g., through reductions in existing tax rates due to revenue raised by the approach)?

- Institutional criteria

  - ***Legal feasibility.*** Are there additional legal elements that would need to be put in place in order for the approach to be feasible? Is the approach consistent with existing European and international law?

  - ***Political feasibility.*** Are there elements of the programme's design that affect its political acceptability?

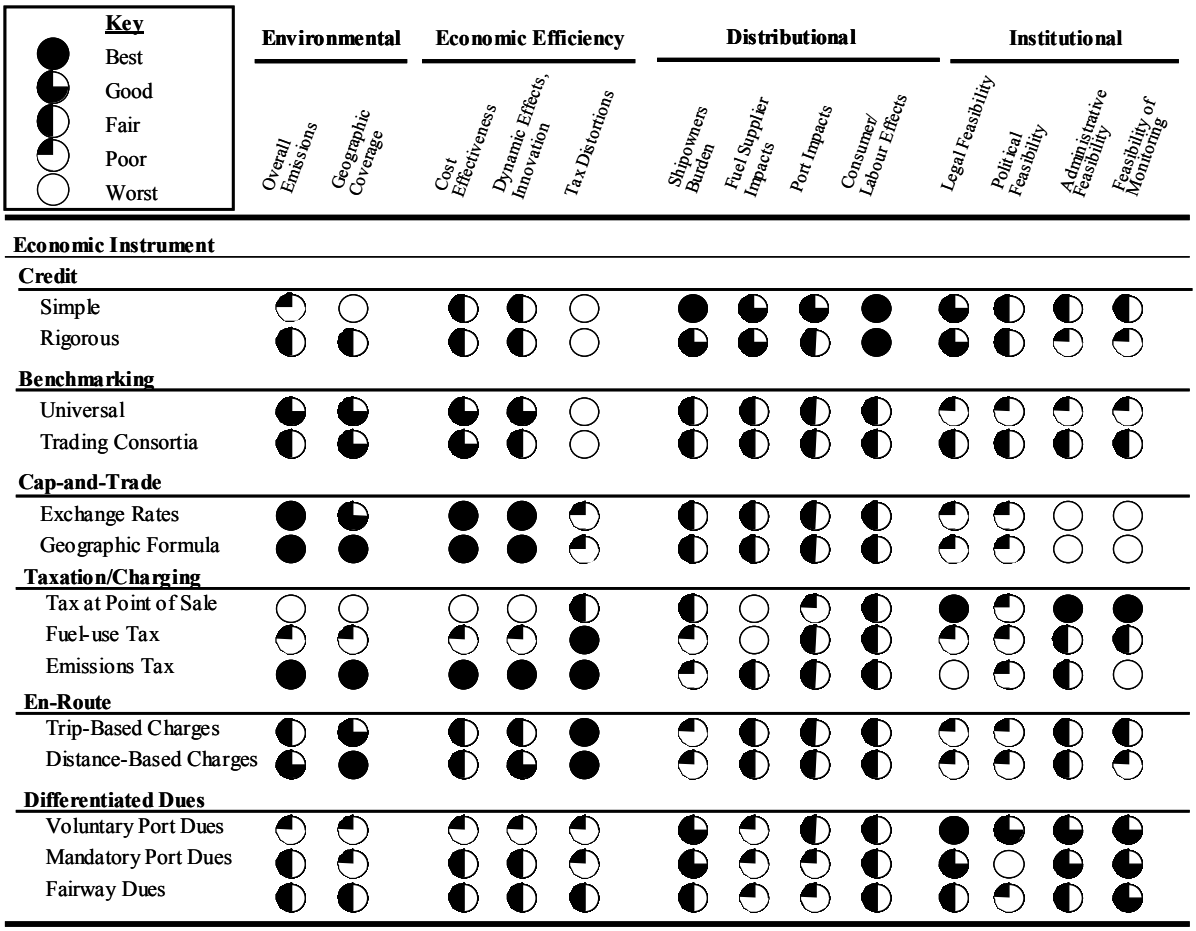
  - ***Administrative feasibility.*** Will the programme's administration be excessively burdensome?

  - ***Feasibility of monitoring regime.*** How feasible will monitoring of emissions be under the approach?

1.3. Analyses of Feasibility of Market-Based Approaches for Shipping

The report provides detailed evaluations of each of the thirteen programmes/approaches based upon each of the thirteen criteria. Below are brief summaries of the assessments of the programmes/approaches. Table 1 provides rankings as an aid to the discussion; as noted below, these rankings do not indicate weights for the various criteria and thus one cannot simply "sum" to get an overall evaluation.

Table 1. Qualitative Assessments of Market-Based Approaches for Shipping



1.3.1. Credit-Based Trading Programme

1.3.1.1. Simple Credit-Based Approach

This approach would be inexpensive to administer and would encourage voluntary reductions from shipping sources to reduce the overall costs of meeting a target. The target might either be one set for land-based sources or one set under a government subsidy programme. Clearly, the approach would be of value to shipowners, who would gain from the net revenues from trading (trading revenues minus control costs), as well as their customers and workers, which would not face higher costs or pressures to reduce wages.

If the government provided substantial subsidies (or the availability of lower-cost credits generated a more ambitious cap), the programme could generate a net environmental benefit. But the simple credit-based approach might not provide any net decreases in EU emissions if it were linked only to a land-based cap-and-trade programme. Moreover, because of its voluntary nature and relatively simple baseline certification requirements, the simple approach would be vulnerable to the possibility of "anyway tonnes." i.e., credits for "reductions" that would have been achieved without the programme. Both because of this possible criticism and the fact that no land-based trading programme currently is in place, this approach would face both legal and political obstacles.

1.3.1.2. Rigorous Credit-Based Approach

A rigorous credit-based approach would be expected to provide net decreases in EU emissions—even in the absence of government subsidies—because credits trades would require more than a 1:1 trading ratio (if it were linked to a land-based programme) and because more elaborate baseline certification requirements would reduce the likelihood of "anyway tonnes." Differentiation of shipping emission credits based upon location would further improve the environmental performance. Thus, this approach would face fewer political obstacles, although it would still require either that a land-based cap-and-trade programme be put in place or that the government provide subsidies. This precondition, however, may well be met because of the substantial interest in reducing land-based emissions in Europe and using the cost-effective cap-and-trade approach to do so.

Adding rigour and stringency would of course reduce somewhat the attractiveness of the approach to shippers (and their customers/workers), as well as increase somewhat the administrative costs of the programme. But the programme would still be voluntary, and thus any shippers that did participate would gain. Of course, land-based sources would also gain from being able to take advantage of lower-cost reductions in the shipping sector (if a land-based cap-and-trade programme were established).

1.3.2. Benchmark Trading Programme

1.3.2.1. Universal Benchmarking

A universal benchmarking programme could provide substantial emission reductions from the shipping sector and create opportunities to reduce overall compliance costs (relative to a requirement that all ships achieve the same emission rate). Administrative costs, however, would be substantial because of the large number of ships that would be involved and the difficulty of ensuring that vessels operating in excess of the average allowed benchmark (e.g., 1.5 percent sulphur fuel) are held responsible if they are found not to hold the required number of credits. The sheer breadth of the approach would be likely to create legal and political obstacles, at least in the short term, as might be implied by the Commission's decision to reject the European Parliament's proposal to allow "offsetting" at this stage under the marine fuel sulphur directive.

1.3.2.2. Benchmark Trading Consortia

Restriction of the benchmarking programme to consortia probably would make it easier to overcome some of the legal and political obstacles to benchmarking, since it would limit the number of vessels participating and allow the Commission to develop gradually the administrative, legal, and procedural mechanisms to ensure that benchmarking worked properly. Although the potential cost savings and emissions reductions would be lower than with the universal approach, the consortia approach could operate as a transition to a more comprehensive programme.

1.3.3. Cap-and-Trade Programme

1.3.3.1. Cap and Trade with Exchange Rates

The cap-and-trade programme offers the greatest potential environmental certainty as well as the greatest potential cost savings. But it is also likely to present significant administrative challenges for regulators and the shipping sector, given the novelty of the approach in the marine sector and the need for continuous emissions monitoring (or equivalent precision) to verify compliance. Moreover, the mobility of sources would present some difficulties with an initial allocation grandfathering approach—because ship owners may shift travel to vessels outside the programme—and thus some form of updating may be appropriate. Indeed, given this mobility—and the likely objections of ship owners to a cap on total emissions from the shipping sector—it may be difficult legally and politically to implement the cap-and-trade approach.

This approach of setting fixed exchange rates for emissions in different sea areas is designed to reflect major differences in the environmental effects of emissions in different locations, without requiring the inclusion of detailed locational information.

1.3.3.2. Cap and Trade with Geographic Formulas

The cap-and-trade approach with a detailed formula presents the same basic tradeoff as the fixed exchange rate approach—greater potential cost savings and environmental gains than other approaches but greater administrative costs and legal and political obstacles—but it provides the added advantages/disadvantages of greater geographic precision. The greater precision would provide greater potential environmental gains, but at the cost of greater administrative and monitoring costs.

1.3.4. Taxation/Charging Alternatives

1.3.4.1. Tax or Charge at Point of Sale

A tax on the sulphur in fuel oil purchased in the EU would probably have relatively little effect on overall EU emissions. Although the fuel tax would reduce emissions from ferries and small ships that operate in EU waters, large container ships could simply fill bunkers with fuel in non-EU countries. Indeed, the tax could encourage ships to travel further to obtain untaxed fuel, thereby increasing overall emissions. Moreover, a fuel tax would not target NO_X and would not be easily modified to provide any geographic specificity.[2] Given the likely lack of environmental effectiveness—and the probably strenuous objections of shipowners and fuel suppliers—the fuel tax is not likely to be a viable alternative.

1.3.4.2. Fuel-use Tax or Charge

Although a fuel-use tax would be ineffective in reducing NO_X emissions, it could reduce SO_2 emissions because shipowners could not avoid it by filling up with cheaper, high-sulphur oil in non-EU ports. But it would not be easily amenable to geographic targeting. In addition, the approach would not provide incentives to take some potentially low-cost options to reduce emissions, such as the installation of control technologies unless they also reduced fuel use. In addition, the administrative costs would be considerable, although the costs might be reduced by relying upon self-reported estimates of fuel consumption and sulphur content.

A fundamental political difficulty with all taxation approaches is that they generally require unanimous agreement by the European Council. It is possible that variations on these approaches that apply a combination of charges and rebates could avoid this difficulty, although an attempt to construct a legitimate "non-tax" instrument in this way could prove difficult. For example, a fuel-use tax designed to be revenue neutral (by redistributing revenues to the shipping sector) would almost certainly face fewer political obstacles.

[2] Note that a fuel tax could be developed for NO_X if it focused on fuels containing certain NO_X-reducing additives. However, such an approach would probably represent an even cruder economic instrument than a tax focusing on the sulphur content of fuel.

Nonetheless, taxation policy is notoriously difficult to reach agreement on, and this could be an insurmountable obstacle (particularly given the potential objections of shipowners and fuel suppliers).

Moreover, any tax or charge might be subject to challenge on legal grounds under the United Nations Convention on the Law of the Sea ("UNCLOS") Part 2, Section 3, which guarantees innocent right of passage for foreign-flag vessels without being subject to charges except for services received (though a legal case could be made that the use of the EU airspace for waste disposal justifies the charge).

1.3.4.3. Emissions Tax or Charge

Although an emissions tax or charge would be potentially efficient—by encouraging cost-effective emission reductions in shipping—and could be applied to NO_X as well as SO_2 emissions—this approach is also likely to face the political and legal difficulties noted above. Indeed, this version is likely to face even greater difficulties because of the additional monitoring and administrative difficulties of implementing it.

1.3.5. En-Route Charging Programme

1.3.5.1. Trip-Based Charges

A trip-based en-route charging programme would be likely to face legal and political obstacles similar to an emissions tax or charge. As with the emissions tax, however, structuring the charge to be revenue neutral could reduce the legal and political complications. En-route charging would also face the same potential challenge under UNCLOS as the other taxation/charging approaches. As noted above, a fundamental difference between the emissions tax and the trip-based en-route charge is that the trip-based charge would be based upon a simplified formula rather than monitored emissions. Thus, monitoring and administrative costs would likely be lower under the trip-based approach.

1.3.5.2. Distance-Based Charges

Generally speaking, the distance-based approach would face similar obstacles to those faced by the trip-based approach. Using a distance-based approach would, however, improve the accuracy of the charges as measures of the environmental effects of each route beyond the accuracy in the trip-based scheme. But this greater accuracy would come at the expense of greater administrative and monitoring costs. All of the legal, political and shipowner objections to the trip-based charge approach would also apply.

1.3.6. Differentiated Port/Fairway Dues Programme

1.3.6.1. Voluntary Port Dues

Differentiated port/fairway dues would build upon the experience in Sweden and elsewhere and thus could be relatively inexpensive to implement. Indeed, this voluntary approach is perhaps the instrument least prone to face legal or political obstacles. The existing experience also provides some indication of the likely effects of the programme, including its environmental effects and administrative costs, although the comprehensive review in Sweden is not yet available. Relatively crude estimates suggest that the approach has reduced SO_2 emissions by about 30 percent and NO_X emissions by about 10 percent. Of course, evaluations of the Swedish programme's success are still relatively preliminary, and the scheme is far more modest in scope than a EU-wide programme would be.

The voluntary nature of this approach—as well as the lack of transparency of actual dues paid—would be likely to limit its environmental potential. Moreover, competition among ports might also reduce the potential stringency, although this effect would be mitigated if overall revenues from port dues were the same. In addition, because the differentiation would be based upon emission rates—rather than overall emissions—control options to reduce travel would not be encouraged.

1.3.6.2. Mandatory Port Dues

Requiring a mandatory differentiated port/fairway dues system would be likely to face strong opposition from port authorities. (The European Sea Ports Organization, for example, has indicated that it would oppose a requirement for dues differentiation.) The advantage of the mandatory approach would be greater uniformity of treatment and greater potential environmental and cost-saving advantages. It may be possible to develop an intermediate version; for example, the Commission could monitor the effects of a voluntary programme in order to meet various emissions targets (although such an evaluation would not be simple). If the targets were not met with the voluntary approach, some mandatory scheme could be devised.

1.3.6.3. Fairway Dues

The differentiated fairway dues approach would require some coordinated effort by most Member States to institute fairway dues. It is not clear whether such a system would legally be considered a tax subject to unanimous agreement by all Member States, but presumably a majority of Member States would have to implement potentially significant restructuring of the method of providing marine services. Against this substantial set of disadvantages is the potential advantage that the fairway dues approach could increase the potential environmental gains from this programme.

1.4. Implications of Analyses

These analyses of market-based approaches for the shipping sector suggest some tentative recommendations for the market-based approaches that seem most promising at this point.[3] The analyses also suggest some useful next steps for developing information to assess the desirability of a specific approach.

1.4.1. Tentative Recommendations

The various market-based approaches considered here share a number of advantages relative to less flexible regulatory approaches (e.g., requirements that every ship achieve the same emission rate, install the same equipment, or use a certain type of fuel). Nevertheless, there are also trade-offs to be made when designing flexible instruments, and the approaches we consider reflect some of these trade-offs. The summary assessments above suggest one fundamental trade-off between: on the one hand, broader approaches that promise greater cost savings and environmental gains, but that would require substantial shifts in legal and political acceptability and significant administrative costs; and, on the other hand, more gradual approaches that would provide smaller cost savings and environmental gains, but that would involve less substantial administrative costs and fewer legal and political obstacles.

The detailed evaluations presented in this report and summarised in Table 1 suggest some tentative conclusions about the most promising market-based approaches to regulating emissions from the European marine sector. It is important to note that, although the table provides qualitative "scores" for each of the instruments along a number of different evaluative criteria, it should not be interpreted as assigning any particular weights to the evaluation categories. (Thus, for example, the fact that there are more criteria in some categories than others does not signify that these categories are weighted more or less in the overall evaluations.) Rather, the instruments' performance against each criterion is considered in light of the overall environmental, economic, distributional, and institutional picture.

Some of the more ambitious programmes probably would be quite difficult to implement in the near term because of uncertainties about monitoring, enforceability, legal issues, and political constraints. Given this, our overall conclusion is that it would be wise to start with more gradual approaches. Because there has been relatively little experience to date with applying market-based instruments in the marine sector, these more gradual approaches could provide valuable experience. Indeed, if these initial approaches are successful, they could be expanded to include more sources and greater overall coverage.

Although none is perfect, the three approaches listed below seem promising for at least the initial use of market-based instruments to promote low-emission shipping in EU

[3] These tentative recommendations are those of the study team and are not necessarily those of the Commission.

waters, assuming a decision to go forward with some programme. Note that even these three approaches differ in the ease with which they could be introduced and thus the likely timing; the order below provides a preliminary indication of possible timing. In addition, it would be possible to combine one or more of the three approaches.

1. ***Voluntary port dues differentiation.*** This approach could build upon the positive experience of the Swedish system of integrated port and fairway dues differentiation. Indeed, the Swedish system might function as a model for what other Member States could adopt if they choose to implement port/fairway charges to finance marine services. The Commission could encourage this development by developing emissions indices and recommended differentiation formulas for ports to use. Indeed, it might be useful to create additional incentives to encourage ports to adopt these instruments voluntarily; for example, emissions targets could be established and progress monitored toward these targets, with the possibility that if the targets were not achieved more mandatory requirements could be put in place.

2. ***Consortia benchmarking approach.*** Allowing consortia of shipowners to band together to reduce the cost of meeting more stringent limits would provide gains both to shippers and to the environment. The more stringent limits would yield environmental gains, as would the development of differential ratios based upon vessel location and stricter emissions monitoring and reporting regimes. The voluntary nature of the programme would allow vessels that are able to benefit from emissions trading to do so. This approach, however, would still face legal and political challenges—notably the changes that would be required in the International Maritime Organization ("IMO") and fuels directive—although the obstacles are likely to be smaller than for the credit-based approach. The primary difficulty would be to develop new rules and procedures for vessels that wish to be buyers on the emissions market.

3. ***Rigorous credit-based approach.*** This approach would provide experience with the market-based approach and also provide some environmental benefits as well as considerable incentives for shipowners to participate. Implementing the approach would still require legal and political actions by the Commission. Moreover, the approach would not be feasible without the development of either a cap-and-trade approach for land-based sources of SO_2 and NO_x or an explicit government subsidy programme.

1.4.2. Next Steps

All three of these approaches would build upon existing regulatory structures and provide incremental shifts rather than a wholesale transition to a market-based approach. Nevertheless, each of these three alternatives would require additional specification in order to provide the basis for a specific legislative/administrative proposal.

Key issues that would need to be investigated in order to develop specific detailed proposals for one or more of the tentative recommendations include the following.

- *Certification of credits*. For the credit-based approach, it would be important to develop procedures for certification of relevant baselines. As noted, there is a tradeoff between complexity of the certification/baseline procedures and likelihood of substantial credits being generated.

- *Legal/political requirements*. For all approaches it would be important to resolve any potential legal questions as to how the instrument would relate to the provisions of the Law of the Sea Convention and to existing Community law, and also to canvas Member States and stakeholders about their likely political acceptability.

- *Geographic differentiation*. It would be important to provide guidelines for the appropriate degree of geographic differentiation of emissions

- *Monitoring requirements*. It would be important to develop additional analyses of the precise monitoring requirements.

- *Subsidisation*. It would be useful to explore in more detail the possibility of subsidising ship emissions reductions, as a stand-alone measure and in parallel with other approaches.

- *Compliance requirements*. It would be important to specify precisely how compliance would be determined, and how violations would be treated.

2. INTRODUCTION

This document provides information on the feasibility of a broad range of market-based approaches to deal with atmospheric emissions from seagoing ships in European Union ("EU") sea areas. The European Commission ("Commission") is in the process of developing a policy mix to deal with all major emissions, including sulphur dioxide ("SO_2"), nitrogen oxides ("NO_X"), volatile organic compounds ("VOCs"), particulate matter (PM) and greenhouse gases, principally carbon dioxide ("CO_2"). This report considers the feasibility of various market-based mechanisms—comprising emissions trading schemes and various charging mechanisms—that might be part of this policy mix, focusing on SO_2 and NO_X. This study does *not* consider the *level* of environmental regulation that would be appropriate for the marine sector. This is a matter for political negotiation and should be determined in light of the benefits and costs of any proposals. Although we identify many of the specific elements of these approaches, additional specification would of course be required for a specific proposal. Indeed, the final section of the report considers the next steps in developing such details for the most promising market-based approaches.

2.1. Context for Policies to Address European Union Shipping Emissions

Any policy to deal with shipping emissions must consider the context, including the role of shipping and its importance for overall emissions in the EU, the existing and likely legal and regulatory situation, and the emerging importance of the market-based approach to air emissions.

2.1.1. Shipping and European Union Air Emissions

Both long- and short-distance shipping play important roles in facilitating intra-regional and international trade within the EU. Although in recent years the share of shipping in cargo transport has declined, ships still carry about 70 percent of all trade between the EU and the rest of the world. One recent source (Davies et al. 2000) has estimated that approximately 30,000 ships with tonnage at or above 250 gross registered tons ("GRT")—or roughly half of the world fleet—operate in European waters in a given year. A more recent study analysed over 600,000 movements by nearly 31,000 vessels in European waters over the course of four representative months in the year 2000 (ENTEC 2002). Within the EU the recent emphasis on intermodality (the inter-connectivity of various cargo transport systems) and modal shift (moving traffic away from road transport to rail and waterborne transport modes) is likely to increase the importance of shipping in coming years.

The importance of shipping to European commerce is reflected in its significant contribution to overall emissions. The recent ENTEC report estimated that in 2000, emissions from European shipping sources accounted for 2.6 million tonnes of SO_2 and 3.6 million tonnes of NO_X. Indeed, atmospheric emissions from the shipping sector are taking on increasing importance in the EU, as they are in other regions with strong environmental

programmes. The United States, for example, is considering additional policies, and individual regions within the US are developing specific programmes.[4] These various efforts all are being developed in the context of potential international regulation of emissions from new or rebuilt marine engines. Such emissions from ships are of particular concern given the Commission's finding in its 2001 White Paper that maritime transport is under-utilised and that reliance on maritime transport should be expanded (EC 2001). At the same time, the Commission has observed that by 2020, if no additional action is taken, maritime transport is likely to emit as much NO_X and SO_2 as all land-based sources combined.

2.1.2. Regulation of Shipping Emissions

2.1.2.1. International Context - UNCLOS, IMO and MARPOL

The international regulatory context is of course critical for ocean-going shipping. Although international regulation in other environmental areas is long standing, international efforts to reduce emissions from shipping are relatively new. International standards for the sulphur content of marine fuels and for NO_X emissions from new engines are contained in Annex VI to the International Convention on the Prevention of Pollution from Ships, 1973, as Modified by the Protocol of 1978 Relating Thereto, which was adopted in 1997. (This convention was developed by the International Maritime Organisation ("IMO") and is known as MARPOL.) MARPOL Annex VI has not yet entered into force, but at the time of writing only three more ratifications are required, so the conditions for its entry into force are likely to be met before long.

Annex VI sets a global 4.5 percent fuel sulphur limit, and designates two Sulphur Oxide Emission Control Areas ("SOxECAs") in the North Sea and the Baltic Sea, where the maximum sulphur content of marine fuel should be 1.5 percent or alternatively, abatement technologies yielding equivalent emission rates must be used. It also sets NO_x emission standards, which are retroactive to 2000, but these standards are not particularly stringent and virtually all ship engine manufacturers already build engines that meet these standards (Murphy et al. 2003).[5] The IMO has also established "Special Areas" and "Particularly Sensitive Sea Areas" within other Annexes to MARPOL.

Formally codified in 1982, the United Nations Convention on the Law of the Sea ("UNCLOS") is the basic legal framework that governs international shipping. For the purposes of this study, it is important to consider the jurisdiction afforded to various bodies under UNCLOS. As noted in Davies et al. (2000), states operate in three capacities: flag, port, and coastal states.

---

[4] The California Air Resources Board, for example, currently is developing proposed emission control strategies for commercial marine vessels and ports as part of the State Implementation Plan for the South Coast Air Quality Management District (Los Angeles). See Murphy et al. 2003.

[5] Note that the Annex VI standards also apply to existing engines that undergo a major conversion on or after 1 January 2003.

UNCLOS gives flag states the primary authority to impose environmental regulations (including those related to air emissions) on marine sources through their responsibility to enforce international laws. The roles of other jurisdictions—i.e., port and coastal states—"have traditionally been more limited" (Davies et al. 2000). However, the language in UNCLOS suggests that non-flag states do have some authority to regulate marine emissions.

UNCLOS guarantees port states the right to "establish particular requirements for the prevention, reduction and control of pollution of the marine environment as a condition for the entry of foreign vessels into their ports or internal waters" (Article 211, paragraph 2). In addition, UNCLOS gives port states the authority to control emissions in port through its right to "exclude vessels from its ports or place conditions upon their entry" (Davies et al. 2000).

Although coastal states have limited authority to regulate general pollution under UNCLOS, they appear to have a somewhat broader mandate with respect to air emissions. Articles 212 and 222 of UNCLOS, which govern air emissions from marine vessels, are somewhat vague with respect to the jurisdictional limits of coastal states. Indeed, when it comes to air emissions, states' jurisdiction is defined with respect to infringement upon their airspace. Article 212 allows states to "adopt laws and regulations to prevent, reduce and control pollution of the marine environment from or through the atmosphere, applicable to the air space under their sovereignty."

While UNCLOS gives some jurisdiction to port and coastal states in the control of marine air emissions, the Convention professes a clear preference for international regulations wherever possible. IMO would manage any such international regulations.[6] Though IMO is explicitly mentioned only once in UNCLOS (Article 2 of Annex VIII), UNCLOS frequently refers to the "competent international organisation" in connection with the adoption of international shipping safety and pollution standards; in most cases, this phrasing (i.e., "the competent international organisation") has been interpreted to refer exclusively to IMO. IMO is generally responsible for the oversight of international shipping activity. In particular, IMO's charter explicitly charges it with the oversight of safety and antipollution efforts in international shipping. Since its creation in 1948, IMO has established a variety of measures to enforce increased safety and reduced pollution from international shipping.

A major caveat of any jurisdictional authority relates to the right of innocent passage, which is also codified in UNCLOS. UNCLOS Part 2, Section 3 guarantees innocent right of passage for foreign-flag vessels in the territorial sea without being subject to any charges, except for services received. This restriction is clearly relevant to the control of emissions from shipping, since under a strict reading of this requirement, reducing emissions from vessels would have to be embodied in a framework of providing services to those vessels. In

[6] See IMO (2003).

addition, one aspect of the right of innocent passage, articulated in Article 21 of UNCLOS, precludes coastal states from enforcing any regulations that apply to the design, construction, manning or equipment of foreign vessels. However, in the absence of tough global engine emission standards, market-based instruments could represent a viable means of promoting the use of low-emission engine technologies in certain sea areas, without impinging upon ships' right of innocent passage.

2.1.2.2. EU Context – Strategy on Ship Emissions and Marine Fuel Sulphur Proposal

Within the EU, the Commission has established several relevant directives related to marine emissions. Of particular significance is the proposal for a directive to regulate the sulphur content of marine fuels used in the EU (COM(2002)595 Vol II - "The marine fuel sulphur proposal"). This proposes limits on the maximum sulphur content of marine fuels as follows:

- A 1.5 percent sulphur limit for all ships in the North Sea, Channel and Baltic Sea (in line with the SOx Emission Control Areas agreed at the IMO);
- A 1.5 percent sulphur limit for passenger vessels on regular service to/from any EU ports; and
- A 0.2 percent sulphur limit for ships at berth in EU ports and in all inland vessels.

The proposal is subject to political co-decision, with the European Parliament and Council of Ministers. The European Parliament voted to adopt a number of amendments to the proposal in June 2003, and on 1 August 2003 the Commission published an amended proposal (COM(2003)476) indicating those of the Parliamentary amendments that it could accept in full, in part or in principle. The Council of Ministers is considering the amended proposal with a view to achieving political agreement on a Common Position with the Parliament in the first half of 2004. The directive could then be finalised and adopted by the end of 2004, though the date of adoption and entry into force of its various provisions are still subject to negotiations.

2.1.2.3. EU Context – Subsidies and State Aid Rules

The Commission has adopted the following three sets of state aid guidelines that define the context with regard to possible state subsidies for ship emissions reductions.

1. Community guidelines on state aid for environmental protection (2001/C37/03) allow aid where it serves as an incentive to firms to achieve levels of protection that are higher than those required by Community standards, or where no Community standards exist—as is the case for NO_X emissions from seagoing ships. Investment aid can be given for plant and equipment intended to reduce or eliminate pollution, but may not exceed 30 percent gross of the eligible investment costs.

2. Community guidelines on state aid to maritime transport (1997/C205/05) allow investment aid in certain circumstances to promote the use of clean ships, such as providing incentives to upgrade Community registered ships to standards which exceed mandatory environmental standards laid down in international conventions.

3. Finally, the most recent Commission framework on state aid to shipbuilding (2003/C 317/O6) allows aid for research and development and allows aid up to 20 percent of gross expenditure for innovation, i.e. technologically new or substantially improved products and processes compared to the state of the art existing in the industry.

Thus, it appears to be legally possible for Member States to provide subsidies for emissions reductions generated through the development and use of emissions abatement technologies for ships, either for new vessels or for retrofits.

2.1.3. Market-Based Approaches to Air Emissions Policy

Once a primarily theoretical approach to environmental policy, economic instruments have gained wide acceptance over the last three decades. Indeed, virtually all environmental policy initiatives that have been developed recently in the US include a market-based component. Market-based approaches have recently gained wider acceptance in Europe as well. The EU Emissions Trading Scheme (the "EU ETS") represents perhaps the most prominent example of Europe's use of market-based approaches. Under the EU ETS, Member States are permitted to trade CO_2 emissions reduction credits among one another, as part of a EU-wide initiative to meet anticipated obligations under the Kyoto Protocol.

The Commission has recognized that market-based instruments might be used to deal with various environmental issues. Experience suggests that well-designed market-based approaches can reduce the costs and increase the likelihood of achieving environmental targets (see, e.g., Ellerman, Joskow and Harrison 2003). This experience also indicates, however, that the market-based approaches need to be carefully thought out in order to achieve these and other objectives. Moreover, it is important to include all interested parties in this process, particularly since the approach is relatively new for shipping.[7]

2.2. Objective of This Document

This report provides descriptions and evaluations of market-based approaches that might be used for shipping, building upon previous Commission studies (see Davies et al. 2000), studies and proposals put forth by various individuals and groups (see, e.g., Hirst 2002a, Hirst 2002b, Swedish Shipowners' Association 2002), and information regarding

[7] Despite the novelty of the approach, there are some examples of existing market-based approaches. As noted below, ports in Sweden, Finland, and the Netherlands have developed environmentally based port dues schemes. In addition, regulators in the Los Angeles air basin have developed a credit-based programme for marine engines to supplement RECLAIM, the cap-and-trade programme for stationary sources.

experience with existing programmes (SMA nd). Although these studies provide important background, no report provides a detailed specification of the alternatives that could be applied to shipping in Europe or a comprehensive assessment of these various alternatives.

This report has the following specific objectives:

- *Specific alternatives.* Provide a detailed specification of the market-based approaches that could be developed for shipping—including variations in basic approaches—drawing upon the literature as well as on specific proposals that have been made by various stakeholder groups.

- *Criteria.* Develop criteria for evaluating the feasibility of alternative approaches, building upon guidance provided by the Commission.

- *Assessments.* Provide assessments of the relative feasibility of the various approaches based upon these criteria.

- *Tentative recommendations.* Develop tentative recommendations regarding the relative feasibility/desirability of the alternatives in light of these criteria.

- *Key issues.* Identify a set of key issues that would need to be considered further—particularly those unique to regulating emissions from sea-going ships, such as monitoring and verification concerns—in order to develop one or more of the tentative recommendations into concrete proposals.

2.3. Organisation of the Report

The remainder of the report is organized as follows. Chapter 3 provides an overview of the six specific trading and charging alternatives considered for shipping in this report; as noted, these alternatives build upon previous experience with market-based approaches as well as upon specific proposals that have been put forth by various interested parties. Chapter 4 develops a framework for identifying the specific elements of market-based approaches, and uses this framework to identify specific elements for the six alternatives, in some cases distinguishing several variants of a given approach. Chapter 5 develops criteria for assessing the desirability and feasibility of the various alternatives. Chapter 6 presents an analysis of the extent to which each alternative provides incentives to undertake various methods of reducing shipping emissions. (Alternatives creating incentives for more methods can provide more cost-effective controls.) Chapter 7 develops detailed evaluations of the various market-based alternatives, based upon these various criteria. Chapter 8 provides concluding remarks, including tentative recommendations for the most promising alternatives and a set of future tasks for developing specific proposals.

3. OVERVIEW OF BASIC MARKET-BASED APPROACHES CONSIDERED FOR SHIPPING

Market-based approaches are typically divided into two fundamental categories:[8]

1. *Trading alternatives*, in which participants trade "quantities" (typically emissions, or the right to emit); and
2. *Charging alternatives*, in which participants respond to a charge or price (either on emissions or on another quantity, such as sulphur in fuel, linked to emissions).

This chapter provides overviews of three variants each of the trading and charging approaches, constituting the six alternatives that are considered in this report (based upon Commission guidance). The following chapter provides a framework for the design parameters that would have to be specified in order to implement any market-based instrument for the shipping sector and then describes the specific variants we consider based upon choices of these parameters.

Table 1 provides a summary of the six basic alternatives, including an indication of some existing non-shipping programmes as well as shipping programmes and proposals where relevant.

Table 2. Selected Examples of Existing and Proposed Trading and Charging Programmes

	Non-Shipping Examples	Shipping Programmes/Proposals
Trading		
Credit	• EPA Emissions Trading • Netherlands ERUPT/CERUPT	• Swedish Shipowners Proposal • RECLAIM (Marine Credits)
Benchmarking	• Averaging, banking and trading for mobile sources (ABT)	• SEAaT Proposal (mentioned)
Cap-and-Trade	• Acid Rain Trading (SO_2) • RECLAIM (SO_2, NO_X)	• SEAaT Proposal
Charging		
Fuel Tax	• Various EU Programmes in EU member states	• Norway Programmes (Sulphur)
En Route	• Eurocontrol (aviation)	
Differentiated Dues		• Swedish Maritime Program • Mariehamn Finland • Rotterdam Green Award • Port of Hamburg (discontinued)

[8] Note that alternative "taxonomies" of market-based approaches are possible. Indeed, some "trading" and "charge" mechanisms are very similar. For example, emissions trading where an auction is used to distribute allowances shares much in common with an emissions-charging policy.

3.1. Overview of Emissions Trading Alternatives

Over the past three decades, emissions trading has developed into a real-world policy option used in many policy settings. The experience with emissions trading identifies three broad types of programmes that have emerged that could also be developed for shipping:

1. Credit programmes;
2. Benchmarking programmes; and
3. Cap-and-trade programmes.

Although all of these share the feature of tradability, the three differ in important respects.[9] The following are general descriptions of each of the three variants, along with some initial observations about how each could be applied to regulate shipping emissions.[10]

3.1.1. Credit-Based Programmes

Credit-based programmes provide tradable "credits" to facilities that reduce emissions more than they otherwise would do under "business as usual".[11] These programmes then allow the credits to be counted towards compliance by other facilities that would face higher costs or other difficulties in meeting their own emissions requirements. Thus, these programmes often have the primary effect of reducing the cost of a programme to reduce emissions, rather than reducing overall emissions themselves. In general, credits are created through an administrative process in which the credits must be pre-certified and approved before they are considered valid for regulatory compliance. The critical and often contentious issue in this certification process is the establishment of the baseline—i.e., the emissions level below which emitters can receive credit. Baselines can be rate-based, in which case the number of credits earned can vary depending on activity level, or they can be "absolute," in which case the number of credits is fixed.

These programmes typically are voluntary (or "opt-in") supplements to existing regulations, either to "command-and-control" standards or to cap-and-trade programmes. A credit-based programme often serves to include sources or sectors that otherwise would remain outside the regulatory programme. This approach has been used by the Acid Rain Trading Program in the US to include power plants not initially covered by the programme. The Kyoto Protocol for greenhouse gases allows for a similar voluntary framework, by establishing various instruments that aim to encourage emissions reductions in sectors and countries not covered by the Protocol.[12] A similar approach is also used in the RECLAIM

[9] Note that the terminology of these types can differ, as noted in the text.

[10] This section draws on Harrison (2002) and Ellerman, Joskow and Harrison (2003).

[11] The credits sometimes are referred to as "reduction credits" or "emission reduction credits."

[12] These are the Clean Development Mechanism ("CDM") and Joint Implementation ("JI") programmes.

programme in the Los Angeles area, a cap-and-trade programme that covers NO_X and SO_2 emissions from a wide range of industrial and commercial activities. Indeed, as noted in Table 1, RECLAIM includes a credit programme for emissions from ships.

Thus, one way of bringing shipping emissions into an emissions trading programme would be to allow vessels to "opt in" to an existing trading programme. For example, if a cap-and-trade programme were established for land-based emitters of NO_X and SO_2 (which at least one Member State is considering under the LCPD), ships might be permitted to opt in to the programme by generating emissions reduction credits. The Swedish Shipowners Association ("SSA") has proposed one such programme (SSA, 2002, see also www.demoproject.org). Alternatively, in the absence of such a programme for land-based emitters, it would be possible for government to provide subsidies to generate demand for the emissions reduction credits.

3.1.2. Benchmarking

Benchmarking programmes define a specific emissions *rate* to apply to covered activities, and require that the average emission rate from these activities does not exceed the benchmark level.[13] Like credit programmes, benchmarking programmes provide flexibility by allowing sources that can reduce emissions cheaply to trade with sources that would require expensive measures to reduce emissions. In contrast to the voluntary nature of most credit-based programmes, benchmarking generally imposes a mandatory requirement on all sources. The other difference between benchmarking and credit approaches is in the way the baseline emissions are determined. Under credit-based programmes, baselines are typically certified at the level of the individual source, since there is often no existing requirement that can be applied to set the baseline.[14] Under benchmarking approaches, baselines typically are set at the benchmark level—which may vary by source type but usually relates to existing or proposed regulations.

One type of benchmarking approach—known as "averaging, banking and trading" ("ABT")—has been used extensively in the US for mobile source engine manufacturers as a means of achieving average emission standards for new engines.[15] These benchmarking approaches typically use information on engine and equipment characteristics (emission rates, power, lifetime, expected mileage or activity level) to serve as a proxy for the measurement of actual emissions.

---

[13] Note that many other terms have been used to describe similar programmes; other familiar terms include averaging and relative cap programmes. In the US, the most prominent examples are the "averaging, banking and trading" (or "ABT") programmes developed for new mobile sources. (See Harrison 2002).

[14] The reason for individual certification of baselines is to guard against "hot air" or "paper credits". These terms refer to credits that are awarded for emissions reductions that would have occurred anyway under business as usual, and that therefore do not represent any actual environmental benefit.

A benchmarking programme could be designed to limit shipping emissions in the EU. Such an approach applied to European shipping would probably differ from existing ABT programmes in that it would be applied to individual emitters (rather than to manufacturers) and in that it would apply to all sources, both existing and new.[16] For example, a programme might be designed to cap SO_2 emissions per tonne of fuel burned. Under such a programme, each ship would be required either to achieve the benchmark emissions rate (per unit of fuel) or to purchase rights from other shipowners whose ships had reduced emissions below the benchmark level.[17] A NO_X benchmark could also be designed, based on engine power output (in kWh). Overall, a benchmarking programme would be intended to reduce the average emissions rate from shipping sources to the benchmark rate.

3.1.3. Cap and Trade

Cap-and-trade programmes operate on principles somewhat different from either the credit or benchmarking methods described above. Under a cap-and-trade programme, an aggregate cap on emissions is set by creating a total number of emissions "allowances." Each allowance provides its holder with the right to emit a unit (typically a tonne) of emissions. The allowances are initially allocated in some way, usually among existing sources. Each source covered by the programme must hold allowances to cover its actual emissions, with sources free to buy and sell allowances among each other. In contrast to credit and benchmarking programmes, cap-and-trade programmes apply to *total* emissions, and not only emission *rates*. Also in contrast to credit programmes—but similar to benchmarking—cap-and-trade programmes do not require pre-certification of baselines. They therefore do not require pre-certification of allowances; allowances are automatically "certified" when they are distributed initially.

The cap-and-trade approach could be applied to the shipping context. Such a programme would be designed to cap overall emissions of NO_X and SO_2 from shipping sources. Vessels would receive allowances based on an initial allocation, and trading would be permitted among shipping sources. As with all cap-and-trade programmes, ships would be required to hold allowances sufficient to cover their total emissions.

[15] ABT has been applied to engines used in outboard motors, chainsaws, large off-road equipment, snowmobiles, and lawnmowers; see Harrison 2002. These US programmes generally have been applied to manufacturers rather than the enormous number of actual emitters—which dramatically simplifies programme administration.

[16] It would probably not be sensible to establish a manufacturer-based programme because large ships typically have very long lifespans, and therefore a benchmarking programme applying to new sources would take considerable time to achieve significant emissions reductions. In addition, a programme applying only to new sources could present significant complications because ships are commonly manufactured and owned by overseas companies.

[17] This type of approach has also been referred to as emissions "offsetting" in the context of shipping emissions.

3.2. Overview of Emissions Charging Alternatives

The second broad category of market-based approaches is emissions charging. With regard to shipping emissions, we identify the following three broad alternatives that could be applied to shipping emissions:

1. Taxation/Charging;
2. En-route emission charges; and
3. Environmentally differentiated port/fairway dues.

These three alternatives differ in the nature of the charge, and potentially in the nature of the charging authority. We outline the three approaches here.

3.2.1. Taxation/Charging

There are numerous examples of the use of environmentally related taxes in EU Member States (see OECD 2001). We consider two broad types of taxation alternatives relevant for the shipping context—fuel and emissions taxes.[18]

Taxes on fuels are common in EU Member States, and indeed worldwide. Although very common, fuel taxes have been used primarily as revenue-raising measures, rather than as instruments to change economic behaviour. However, since fuel combustion and fugitive emissions are the source of nearly all marine-related air emissions, reducing demand for fuel by increasing its price is one means of reducing emissions. Taxes or charges could be applied to all fuels, or only to particularly "dirty" fuels.

A simple tax or charge on the purchase of fuel "at point of sale" is one potential method for reducing emissions from shipping. Such a tax would presumably be linked to the polluting characteristics of the fuel (e.g., its sulphur content). Targeted fuel taxes recently have been proposed in a variety of contexts as a way of curtailing emissions by charging on the basis of pollutant content. Norway currently imposes a tax on the sulphur content of diesel fuel that is intended to provide incentives to reduce the sulphur content of diesel (in addition to reducing the fuel's overall use). Such a content-based tax could serve as one means of reducing shipping emissions across the European Union. Another alternative would be to tax vessels on the basis of their fuel usage in European waters.[19]

[18] This report does not consider the possibility of subsidies as instruments unto themselves, though they are considered in conjunction with some of the other programmes, including the credit-based approaches. However, it is important to note that a subsidy raises issues very similar to those raised by a tax. Indeed, a subsidy would be expected to elicit the same responses as a tax of the same magnitude.

[19] This second approach seeks to avoid the concern of shipowners being able to avoid the tax by purchasing fuels abroad. This is described in more detail below.

Another possible approach to taxation would be an emissions tax or charge. Under an emissions tax, emitters are charged for every tonne of emissions (or emissions above a certain level) at a rate specified by the regulator.

Like the other alternatives considered here, taxation would allow ships that can reduce emissions affordably to do so and thereby avoid (or reduce) their tax, while those that would face substantial costs to reduce emissions would have the option of leaving emissions constant and paying the tax.

As noted, taxes are typically designed to collect revenue. However, the primary objective of any of the programmes considered here would be explicitly environmental and would not necessarily need to collect revenue. Thus, it might be appropriate to design these approaches as revenue-neutral instruments. This could be accomplished by redistributing any receipts from the charges back to shipowners (ideally this would be done via a mechanism that did not distort shipowner incentives in other ways—e.g., the recycling ideally would not create incentives to travel further or to burn more fuel).

3.2.2. En-Route Charging

En-route charging has been used for many years in the aviation sector to ensure that aircraft owners compensate European air-traffic control services for use of the air traffic control infrastructure.[20] These charges are based on the distance travelled within the relevant airspace and the weight of the aircraft. The Commission is considering charging approaches of this sort, in order to internalise the external costs imposed by transportation services for all transport modes, as set out in its 2001 White Paper on transport policy.

Such an approach could be applied to maritime traffic to charge vessels for their emissions en-route. Authorities could collect charges from all vessels using European waters. Different approaches to estimate emissions could be used—for example, on a standardized per-trip basis, or based on actual time or distance in EU waters. An en-route charging system would resemble a direct emissions tax, although the charge would be based on emissions rates or standardized emissions, rather than measured emissions.

Note that, like the other charging approaches, these en-route charges could be designed to be revenue neutral.

3.2.3. Differentiated Port or Fairway Dues

A third variation of the emissions charging approach is a system of differentiated port or fairway charges. The charges would be structured so that they would reward vessels with lower emissions by applying lower dues obligations, whereas they would impose higher dues on vessels with higher emissions. In general, port or harbour dues are set at the discretion of individual ports and are applied to ships that rely on the ports' services.

[20] See http://www.eurocontrol.be/dgs/activities/crco/who/main.html

Fairway dues (which are levied in Finland and Sweden) are set at a national or regional level and apply to all ships using the waters where the dues apply; such fairway dues are also intended to cover the costs of services used by all ships (e.g., icebreaking, fairway maintenance, etc.). Note that the primary difference between the fairway dues approach and an en-route charging approach is that en-route charging explicitly attempts to capture the effects of different journey lengths, whereas fairway dues do not.

A differentiated dues approach would take advantage of the fact that most ports (and some Member States) already impose charges on vessels that use their facilities and waters. Differentiated charges have been applied to a number of environmental and safety characteristics of maritime vessels, including hull and engine type and emissions of various pollutants. Like other port dues, differentiated charges are typically indexed to vessel size or weight, and may be indexed to other characteristics. For example, differentiated dues based upon emissions performance have been used in Swedish fairways and in many Swedish ports since 1998 to encourage reductions in NO_x and SO_2 emissions, with about 25 ports having introduced the differentiated scheme (Swahn 2002). These new charges have replaced existing port and fairway dues in a way that is designed to be revenue-neutral, but that takes account of average vessel emissions.

Several other ports have implemented similar programmes that impose dues differentiated on the basis of environmental criteria. The Port of Rotterdam, in collaboration with the Green Award Foundation, issues a discount in port dues (around six percent of harbour dues) to ships and shipowners that meet certain environmental and safety awareness criteria. The Port of Hamburg has experimented with dues that are differentiated on the basis of various environmental criteria, including the use of low-sulphur fuel (though the programme has since been discontinued), and the port of Mariehamn in Finland has also adopted differentiated charges for NO_x and SO_2. Finally, Norway has in place a differentiated charging scheme that takes into account a wide range of environmental and safety-related considerations, although the Norwegian system only applies to vessels owned by Norwegian companies.

4. SPECIFIC MARKET-BASED APPROACHES FOR SHIPPING EMISSIONS

In order to assess the feasibility of alternative market-based approaches, it is necessary to be more specific about precisely how each instrument would be implemented. To this end, we have designed specific implementations that attempt to bring out the major distinctive features of the various approaches, and thus provide the bases for our evaluations. As noted in the final chapter, more details would have to be developed in order to implement an actual programme.

This section begins with an overview of the major elements of market-based approaches, providing a framework for specifying the precise approaches we evaluate. We then provide specifications for each of the six general approaches, identifying multiple variants of each approach to emphasize major tradeoffs.

4.1. General Issues in Specifying a Market-Based Approach

It is useful to organize the elements of a market-based programme into three major areas.[21]

1. **Threshold issues.** These include decisions regarding the basic purpose and participants in the programme.
2. **Design issues.** These include the decisions that arise as the programme is designed and turned into a specific regulatory programme.
3. **Implementation issues.** These include the decisions that come to the fore as the programme is implemented.

Although these categories are interrelated—and, indeed, must all be specified when the programme is set up—they provide a useful way of organising the many specific decisions that must be made to develop a concrete programme. Not all of the elements would apply to any given market-based approach (as noted below).

4.1.1. Threshold Issues

The basic structure of a market-based approach involves two threshold issues.

4.1.1.1. Environmental Goals of the Programme

It is important to be clear about the environmental goals to be achieved by any regulatory programme. Specifying goals for market-based approaches would include identifying the pollutants to be included and the targets for emissions or related measures.

[21] These categories are developed from Harrison (1997) and Harrison (2002).

Although both trading and charging approaches can be used to achieve the same environmental effect, the emphasis of the two approaches is different. In the case of mandatory trading programmes there is an explicit specification of the physical environmental target to be achieved. The target is expressed as the number of tonnes of emissions to be reduced, or the percentage reduction to be achieved in emissions rate. Compliance with the regulation effectively guarantees the environmental target is met.

Charging programmes, on the other hand, do not guarantee explicit environmental targets. The precise environmental results depend indirectly upon the economic incentives offered to covered sources. Charging approaches do allow the regulator to specify the *economic* benefit to be achieved by the instrument. In setting the relevant charge, a charging programme establishes (implicitly or explicitly) the *value* placed upon reductions in the specific emission type.

4.1.1.2. Entities (Countries, Ships, and Other Sources) That Are Required to Be Covered by the Programme or That Could Opt in to the Programme (or Would Otherwise Be Affected)

This includes the decision of which countries and participants would be required to be included in the programme initially and going forward. It would be necessary to determine the types of vessels that would be covered, based upon various criteria (e.g., vessel tonnage, rated engine power, and other factors). This issue would also include considerations of which entities would be able to opt in to a programme, i.e., voluntarily participate in the programme.

Considerations related to voluntary measures also apply to the differentiated dues options for ports (or even regions). Although all vessels would be subject to the differentiated dues in place for a given port, ports could have substantial discretion in deciding whether or not to participate in a differentiation approach, and of course vessels would always have the option of not taking advantage of the reduced differentiated rates.

It is also important to consider other relevant sources not in the shipping sector that might be affected by the shipping programme—for example, large land-based industrial sources could participate in trading programmes, and land-based sources, including those in the transportation sector, might be included in a general charging programme.

4.1.2. Design Issues

The design issues include the key elements of the programme as it is set up.

4.1.2.1. Geographic and Temporal Differentiation/Flexibility

This parameter refers to the possibility of using geographic or temporal considerations to differentiate charges or treatment of emissions for trading. An example of this type of differentiation in the case of command-and-control regulations would be the requirement that while in port, vessels can only burn fuels with 0.2 percent sulphur content,

while outside of port areas (at sea), vessels are allowed to burn fuels with up to 1.5 percent sulphur content.

Geographic differentiation has been discussed frequently with regard to various market-based approaches, although there are relatively few examples of geographic variability among existing programmes. Geographical differentiation could take the form of higher charges in more environmentally sensitive areas. It may also be manifested by different charges being set by different port authorities or in different marine fairways. Differentiation may also be applied by using an "exchange rate" that would weight emissions in a particularly sensitive region more than emissions in less sensitive regions. Preventing trades between certain regions, or can also implement differentiation by preventing the sale of surplus allowances into particularly sensitive areas, but allowing the purchase of allowances *from* these areas.

Table 2 shows the results of one study that has attempted to quantify the value of environmental impacts of emissions in different European Sea areas. The table shows that there are significant differences among the different regions. (Given uncertainties in determining the euro value of damages, the ratios among values are likely to be more defensible than the absolute values.) This study suggests that there could be reason to reduce NO_X emissions more, for example, in the Northern Mediterranean than in the Baltic Sea.

Table 3. Potential Emissions Reduction Benefits, by Pollutant and Location (in €/Tonne)

			Ratio Relative to Baltic	
Location	**SO_2**	**NO_x**	**SO_2**	**NO_x**
Eastern Atlantic	4,500	4,800	2.8	2.3
Baltic Sea	1,600	2,100	1.0	1.0
English Channel	5,900	5,400	3.7	2.6
Northern Mediterranean	4,700	6,200	2.9	3.0
North Sea	4,300	3,100	2.7	1.5

Note: These values include most known health effects of the pollutants in question, but exclude ecological damages, such as acidification and eutrophication.
Source: Netcen (2000).

Temporal differentiation of emissions would take the form of requiring trading in specific emission "vintages" rather than in undifferentiated emissions. Temporal flexibility typically has been provided by allowing participants to "bank" emissions—i.e., reduce emissions more than required and retain the surplus for future internal use or sale—or, less frequently, by allowing participants to borrow them from future years.[22] Restrictions on banking and borrowing can be imposed to ensure specific emissions targets in specific years, although less restrictive methods have been developed to guard against excessive emissions

[22] See Nichols 1998 and Nichols and Harrison 1994 for overviews of the relevant issues.

in a given year (see Harrison 2002). Temporal flexibility could also focus on seasonal variation in health effects. For example, existing programmes in the EU (smog) and the US (NO_X Budget Program) both differentiate between emissions in the summer and other times of the year.

4.1.2.2. Determination of "Free" Emissions Levels

For many market-based approaches, there is a level of emissions below which covered sources do not face any explicit charge or penalty. For emissions trading approaches, this level reflects the explicit or implicit allocation provided to each participating source that indicates the starting point for trades. For a cap-and-trade programme, this level corresponds to the initial allocation. For a benchmarking programme, this value corresponds to the benchmark *rate* established under the programme. Under a credit-based programme, the "free" emission baseline has a slightly different interpretation in that, in some sense, all emissions are free. Thus, for a credit-based programme, the "free" allocation would be based upon the entity's "baseline" emissions, i.e., the level below which the entity receives credit for reductions. This baseline level is typically interpreted as the amount of emissions the entity would be anticipated to emit without the credit programme.[23]

For charging programmes, it is possible to set a level of emissions that is exempt from charging. For example, a tax may be applied only to those vessels that have emissions rates above a certain level, or only to fuels with a certain level of pollutant concentration.

4.1.3. Implementation Issues

This category includes various issues that come to the fore as the programme is implemented, although they must be considered at the outset along with the other elements.

4.1.3.1. Monitoring and Reporting of Emissions

Effective emissions monitoring and enforcement is critical under all economic incentive programmes, although some tradeoffs may be made between cost and accuracy. Without effective monitoring, the policies themselves are likely to be ineffective[24] (Stavins 2000). Monitoring costs depend almost entirely on the monitoring mechanism employed. Less expensive monitoring regimes may also be expected to yield lower net environmental benefits, because of the increased possibility of evading emissions regulations.

[23] See Harrison et al. (2000) for discussions of the issues involved in setting baselines, including experience in other environmental and non-environmental programmes.

[24] Stavins (2000) discusses the importance of monitoring. In addition, a number of shipping stakeholders have recognised its importance. Hirst (2002b) makes this point with respect to emissions trading, noting that "Reasonably reliable and verifiable records of actual emissions are critical…" One of the primary aims of the DEMO project (www.demoproject.org), sponsored by SSA and SEAaT, is to demonstrate that "foolproof" monitoring systems can be made to work.

Methods must be designed to monitor and report emissions—or other relevant operating data—from each participating source in order to measure compliance. A number of different monitoring approaches are available, depending on the desired level of accuracy. One alternative for SO_2, for example, would be simply to measure the sulphur content of fuel used on-board, and then to keep track of how much fuel was used based on vessel receipts. For vessels installing abatement technology such as scrubbers, a comparable approach would be to measure periodically a vessel's emissions rate—for example, per tonne of fuel burned or per tonne-mile transported. This rate information would then be combined with information on total fuel consumption (using receipts or some other approach) or tonne-miles transported. For abatement technologies that require additional active agents such as urea or fuel additives, receipts for the purchase of these agents could also be required as further evidence of vessel emission rates.

An alternative to periodic monitoring would be to require continuous measurement and recording of vessel operating information or emissions. For example, engine fuel input and power output could be measured continuously to provide more accurate estimates of emissions of pollutants like NO_X, which vary with different engine operating characteristics. Continuous monitoring can also be applied to the exhaust gas itself to measure even more directly the actual concentration and flow of pollutants in the exhaust. This form of direct continuous measurement may be more expensive, but in some cases it may provide more accurate emissions figures than alternative methods.[25] And one potential cost benefit of continuous monitoring is that if emissions data is stored it could be provided directly to enforcing authorities, saving any need to delay vessels in port to undertake inspections.

When considering emissions from ships, one additional complication arises because of the international nature of shipping movements. Many ships are only in European waters for part of their journeys, and since bunker tanks can hold sufficient fuel to cover a vessel's movement into and out of European waters, fuel receipts would not be sufficient to estimate a vessel's emissions in European waters. For international traffic, therefore, it may be necessary to collect Global Positioning System ("GPS") data or other information regarding vessel location. Most vessels already collect this information. Location information could then be combined with data on fuel consumption, engine operation, or actual emissions measurements.

Although in theory any monitoring regime could be combined with any economic instrument, in practice the application of certain monitoring systems to certain instruments could be awkward and could distort the natural understanding of the instrument. (For example, continuous emissions monitoring applied to a fuel tax at point of sale would make

[25] Tests are currently being conducted under the DEMO project to determine the feasibility of different types of monitoring of vessel emissions and activity. These tests have been relatively preliminary in nature. Tests over a more extended period would probably be necessary to determine the durability and robustness of different monitoring approaches in the challenging marine environment.

little sense.) In the descriptions of specific instruments later in this report we have selected monitoring approaches that would naturally fit the instrument used.

4.1.3.2. Institutions Established to Implement and Facilitate the Programme

Various institutions could be developed to assist in administering the programme, including the monitoring of emissions. In the case of trading, this also includes the possibility of encouraging third parties (e.g., brokers) to participate in trading as well as the possibility of setting up an auction or other institutions to increase liquidity and establish market prices. In the case of charging schemes, there are other institutional questions related to how charges would be collected and administered, and by whom.

4.1.3.3. Determining Compliance and Enforcing the Programme

These decisions relate to the means of determining whether sources are in compliance—with either the trading or the charging programme—and of enforcing the programme if sources are out of compliance. These considerations will be critical to the environmental and economic integrity of the programme. Various means can be used to provide some flexibility while still ensuring that emissions or environmental targets are achieved. In the case of a cap-and-trade programme, for example, a "true-up" period can be developed, giving sources a month (or a quarter) to reconcile emissions and allowances.

4.2. Specification of Emissions Trading Approaches for Shipping Assessed in This Report

This section and the next define the specific parameters we use to identify specific approaches for the market-based alternatives we consider. This section considers the emissions trading alternatives and the following section considers the emissions charging alternatives. There are, of course, tradeoffs in the design of specific types of programme. Credit-based programmes, for example, can be designed with an emphasis on minimising cost or maximising the achievement of environmental targets—or even on minimising the administrative costs of developing credits. Thus, for each basic instrument, we specify multiple approaches in order to illustrate the range of possibilities.

4.2.1. Two Approaches to Credit-Based Programmes

This section specifies the parameters we assume for two credit-based approaches applied to shipping emissions, following the framework outlined above. The two options we identify —which we refer to as the "simple" and "rigorous" alternatives—highlight the tradeoff in credit-based approaches between achieving environmental objectives on the one hand and obtaining the potential cost-savings on the other hand. These two approaches serve to demonstrate two "extreme" possibilities in implementing a credit programme. While it would certainly be possible to develop a programme that was an intermediate between these two extremes, for the purposes of evaluation, it is useful to consider these two alternatives. Their major features are described in Table 4 below.

Table 4. Two Approaches to a Credit-Based Programme

Environmental Goals	• Simple Credits: Reductions in NO_X and SO_2 from ships provide credits to land-based trading scheme or are sold to government under subsidy programme. • Rigorous Credits: Reduction in overall EU NO_X and SO_2 emissions impacts via rigorous baselines and, when linked to a land-based trading scheme, exchange rates greater than 1:1.
Covered, Opt-in, and Affected Entities	• Both: Ships not required to participate; any ship above a given threshold size may opt in to credit programme. • Both: Land-based sources could gain via low-cost credits generated by shipping sector.
Geographic/ Temporal Differentiation	• Simple Credits: No geographic weighting. • Rigorous Credits: Apply "exchange rate" to weight emissions by location.
Determination of "Free" Emissions Levels	• Both: All emissions free; credits generated for emissions below baseline. • Simple Credits: Baseline equal to estimated BAU emissions. • Rigorous Credits: Baseline set below BAU emissions.
Monitoring and Reporting	• Simple Credits: Periodic monitoring of emission rates plus estimates of vessel activity. • Rigorous Credits: Continuous monitoring of engine characteristics and vessel activity.
Institutions Established	• Simple Credits: Create registry and database of included ships; set up independent "inspection stations" to perform periodic monitoring. • Rigorous Credits: Create registry and database of included ships; establish agency (or bureau) to certify emissions reductions.
Compliance & Enforcement	• Both: Verify compliance and enforce against entities that violate the programme.

4.2.1.1. Environmental Benefit to Be Achieved

Both credit approaches described here would be designed to allow shipowners to sell emissions reduction credits generated from the voluntarily reduction of emissions. These credits would be sold either to an assumed cap-and-trade programme for NO_X and SO_2 emissions from relevant land-based sources (to *offset* emissions) or to the government in exchange for subsidies (to *reduce* emissions). (Note that no cap-and-trade programme for land-based sources exists, although several Member States currently are considering whether to introduce limited trading arrangements under the Large Combustion Plants Directive (2001/80), in the form of national plans. A subsidy programme would not, of course, necessitate an existing cap-and-trade programme.)

The first alternative described here—the "simple" credit approach—is specified to focus on cost savings rather than added environmental benefit. If the programme were linked to a land-based cap-and-trade programme, it would have the primary effect of reducing the costs of a land-based programme and would not be expected to reduce *overall*

EU emissions of NO_X or SO_2. However, any credits purchased by the government via a subsidy programme would represent overall reductions in EU emissions.

The second alternative described here—the "rigorous" credit approach—is specified to achieve *both* cost savings and some environmental gains. This alternative would require a more rigorous baseline (described below) from which to calculate emission reduction credits. If the programme were linked to a land-based programme, this more rigorous baseline would lead to environmental improvements, as well as further reductions in emissions levels across the EU. On the other hand, if the programme were funded by government subsidies, the rigour of the baseline would have only fiscal, rather than environmental, implications.

In addition, if the rigorous approach were linked to a land-based programme, the scheme would set an exchange rate on emissions from ships that could require greater than a one-for-one reduction in marine emissions to offset land-based emissions. Such exchange rates would likely depend on estimates of the damage caused by a tonne of emissions from ships relative to a tonne of emissions on land.[26] By requiring greater reductions from shipping sources to offset a given quantity of emissions from a land-base source, the rigorous option would make a one tonne reduction in shipping emissions less valuable than a one tonne reduction from a land-based source. Since the exchange rate would be based on overall environmental impact, it would ensure that the inclusion of marine sources into a land-based programme did not lead to any worsening of the environmental impact of emissions. Similarly, if the rigorous approach were funded by government subsidies, emissions reductions could be weighted differently depending on location, subsidising emissions reductions at different rates in different locations.

4.2.1.2. Entities Included

To function properly, any emissions trading scheme requires both buyers and sellers. Buyers must be offered something that they have a use for, and sellers must have access to buyers so that what they sell has some value. If the credits that sellers might volunteer to generate have no value because there are no buyers, potential sellers would have no incentive to make emissions reductions.

As noted, one likely source of credit value would be as part of a pre-existing market for emissions allowances.[27] Participants in the existing market would then be willing to pay for the credits earned by opt-in participants. Such an approach would be similar to a recent proposal outlined by the Swedish Shipowners' Association (2002). Under this scheme,

[26] The offset programme for new sources in non-attainment areas of the US has a similar feature, with offset ratios ranging from 1:1.1 to 1:1.5 depending upon the degree of non-attainment.

[27] One alternative source of demand for emissions reduction credits could be other shipping sources. In this case, however, there would have to be some existing regulatory requirements in place on at least some shipping emissions. As a consequence, the programme would be more mandatory than voluntary, and would be better described under the benchmarking or cap-and-trade approaches discussed below.

marine sources that were able to reduce their emissions below a predetermined baseline would be able to do so to generate emissions reduction credits. Those marine sources that could achieve emissions reductions relatively inexpensively could voluntarily do so and then sell the resulting credits to land-based sources. As noted, this would require the existence of a land-based cap-and-trade programme for European industrial facilities or electricity generators, so that there would be demand for the emissions reduction credits from ships.

As noted, an alternate way of attaching value to credits would be for the government to offer a direct payment or subsidy for each unit of emission reduced. Under such a programme, the government, rather than the market, would set the price for emissions reduction credits.

4.2.1.3. Geographic and Temporal Differentiation

One important issue for the credit programme considered here is that of the geographical "weight" of emissions reductions. Since marine emissions reductions would be used to offset land-based emissions, it may be important to take into account the different levels of impact caused by shipping sources as compared to land-based sources.

As noted above, we consider two credit-based alternatives. Under the simple alternative, we assume that all reductions from marine sources, regardless of location, would be valued as they would from land-based sources. That is, a reduction of one tonne of NO_X emissions from shipping anywhere in EU waters would have the same value as a reduction of one tonne of emissions from a land-based source.

Under the rigorous alternative, in contrast, emissions reductions would have different weights depending on their location. By applying such an "exchange rate" to marine emissions, it might be that, for example, two tonnes of emissions reductions from a vessel at sea was equivalent to a single tonne of emissions reductions in port (or one tonne of emissions from land, if used to offset emissions from a land-based source). Moreover, emissions in different seas areas could be covered by different exchange ratios. Such exchange rates might be developed using information from environmental exposure or health effects studies. If the information from the Netcen report were used—as presented in Table 3, it would imply, for example an exchange rate of 3.0 to 1.0 between NO_X emissions in the Northern Mediterranean and Baltic Sea.

4.2.1.4. Free Emissions – Baseline Emission Levels

Under a credit scheme, in a sense all emissions are "allowable" and without penalty, because participation in the programme is voluntary. However, below a certain baseline—which is determined separately for each vessel in question—emissions reductions would be rewarded. The determination of this baseline emissions level—an issue unique in its importance to credit programmes—can be the most complex and contentious aspect of developing a credit programme.

Credit-based programmes require that some administrative decision be made on the number of credits each entity can sell. Since the programme is voluntary—with companies able to participate or not depending upon their particular circumstances—there may be cases in which firms get "anyway credits," i.e., credits for reductions that would have been made without the programme.[28] Such credits can compromise emission reduction objectives. The programme could reduce the likelihood of "anyway credits" by more detailed procedures to ensure that the credits were "additional," although experience indicates that these additional administrative requirements can substantially reduce the likelihood that entities will participate and thus that promised cost savings would be achieved.[29]

For some land-based programmes, regulators have set baselines according to *absolute* emissions baselines for emitters. For example, a particular factory might have baseline emissions of 1,000 tonnes of NO_X annually, and if total emissions are below that level for the year, the emitter receives credits, which can be sold in the emissions trading market.

In the case of shipping, however, it would be more sensible to set *relative* baselines for individual emitters—that is, to set a baseline emissions *rate* for each ship. If an absolute baseline were provided, an individual ship could "reduce" its emissions—and thus generate more credits—by shifting European traffic to other ships, generating credits but no real emissions reductions.[30] With a relative baseline, the ship would have to travel to obtain credits. Ships would thus receive credits equal to the difference between their actual emissions rate and their baseline emissions rate, multiplied by some measure of their activity.

A credit-based approach could be applied to either SO_2 or NO_X emissions. For SO_2, this baseline emissions rate would probably be established relative to fuel usage for each ship. Assuming the EU adopts the Commission's proposal to enforce a 1.5 percent sulphur content rule for marine heavy fuel oil, as well as a 0.2 percent sulphur limit for fuel burned while in port, these levels could serve as the baseline rates—i.e., the rates below which ships would receive credits. Average SO_2 emissions below this rate would be credited and could be sold in other emissions markets.

A similar benchmark rate would need to be developed for NO_X. However, because NO_X emissions are not as closely related to any single parameter (in the way that SO_2 emissions are related to fuel sulphur content), the benchmark would probably need to

[28] There is evidence of "anyway tonne" for the opt-in programme for the Acid Rain trading programme in the United States. See Ellerman et al 2000.

[29] See Harrison 2002 for a summary of the relevant experience.

[30] The distinction between land-based and marine sources here is a matter of degree. A credit programme for land-based sources also could result in "leakage" if activity reductions at the credit-generating facility were compensated for by increases elsewhere. (Indeed, as noted in Ellerman et al. 2000, there is evidence of such leakage in the credit-based programme developed for the acid rain trading programme.) This issue has been raised in the context of the CDM mechanism and, indeed, in the context of the overall Kyoto Protocol programme, which would not cap global emissions but only emissions in developed countries that sign the Protocol.

involve more parameters than the sulphur benchmark, including engine power rating and other operating characteristics. One starting point for developing a NO_X benchmark would be to rely on the IMO NO_X curve, which sets NO_X emissions rates limits (in g/kWh) for newly built or significantly retrofitted ships engines. The IMO curve emissions rate limits vary based on rated engine speed, setting a limit of 12g/kWh for medium-speed engines. (Average emission rates have been estimated in ENTEC 2002 at around 18g/kWh for slow-speed engines, and 13.5 g/kWh for medium-speed engines.) Of course, the EU might wish to develop a more rigorous curve to serve as the benchmark, as it is widely acknowledged that the existing IMO curve is not particularly strict.

For the purposes of this analysis, we consider two broad approaches that might be taken in setting the baseline emissions levels below which credits may be earned. For the simple credit alternative, the baseline would be set equal to a "Business as Usual" ("BAU") level that represents the emissions rate from the participating vessel in the absence of the credit programme. Thus, any and all emissions reductions by a vessel could receive credit.

Under the rigorous credit approach, we apply a mandatory initial reduction in emission rates to any vessel opting into the trading scheme. This would be accomplished by first estimating the BAU emissions level or rate, and then imposing a reduction on that rate. Thus, for example, a vessel projected to emit SO_2 at a rate consistent with a fuel having sulphur content of 1.5 percent could have its baseline set 20 percent below that value, i.e., at a level equivalent to burning 1.2 percent sulphur fuel. The installation of abatement equipment or the use of even lower sulphur fuel would still generate credits, relative to this new baseline set *below* BAU.

4.2.1.5. Monitoring and Reporting

We consider two possible monitoring regimes for the credit-based approaches, periodic and continuous monitoring methods. For the simple credit programme, we assume periodic monitoring, which would involve the measurement and certification of an emissions rate that would be assumed to apply on average over the course of the vessel's operation. For SO_2 emissions, this could be based on certified fuel sulphur content, or on certified characteristics of abatement equipment. For NO_X, it would be possible to establish average emission rates for a vessel by measuring emissions over representative journeys. These certified emissions rate data for either pollutant could be combined with information on fuel use to estimate overall emissions—and avoided emissions—relative to baseline levels.

The rigorous credit approach would be designed to use continuous monitoring of engine characteristics, rather than periodic certification of average emission rates. This would provide greater accuracy, but would not necessarily affect the other aspects of the programme. Continuous *emissions* monitoring (i.e., installation of on-board devices that measure emissions at all times) on its own probably would not be sensible for a credit-based

programme unless it were combined with monitoring of other vessel activity levels, so we do not consider it here.[31]

For vessels operating outside of European waters, the monitoring regime would also need to include some way of recording when to begin crediting the vessel with avoided emissions. This would have to be done by relying on GPS data recorded on the vessel and reported in a universally agreed manner.

4.2.1.6. Institutions

In order to implement a credit-based programme, an agency would need to be established to administer the programme. For both credit approaches, this agency would need to keep a registry of participating vessels, track emissions rate baselines, and coordinate certification of emissions levels. Because both of the programmes described here presumably would be coordinated with a land-based emissions trading programme, trading markets would already be in operation and thus would not need to be established.

For the simple credit approach, inspection stations would need to be established to perform periodic emissions rate testing. The administrative agency would need to retain a schedule for updating certifications for participating vessels (e.g., annual updates), which could be incorporated into the current regime for vessel certification.

For the rigorous credit approach, institutions would need to be established to ensure the appropriate fitting of monitoring technology and to maintain a database of monitoring data, including reported vessel fuel use, tonne-miles travelled, engine characteristics, emissions, and credits earned.

4.2.1.7. Compliance and Enforcement

The institutions noted above would need to perform random inspections to check emissions rates. These inspections would be intended to confirm—where relevant—the continued operation of installed abatement technologies and the sulphur content of fuel. Such inspections have been used successfully in the context of the Swedish Maritime Administration's differentiated dues programmes (SMA, *not dated*).

4.2.2. Two Approaches to Benchmarking

This section identifies the elements we assume for a benchmarking approach for shipping emissions, following the framework outlined above. As with the credit-based approach, we identify two possible implementations—labelled "universal benchmarking" and "trading consortia." These implementations differ primarily in their breadth, with the

[31] This is related to the decision to use a baseline rate, rather than an absolute emissions baseline. If emissions alone were monitored, but not output levels using some output measure, then vessels that stopped operating in European waters could receive credits, even if their operations were replaced by other vessels not participating in the credit-programme.

former including all vessels over a certain size, and the latter including only those ships that choose to participate in benchmarking as a means to comply with what may be thought of as a broader command-and-control alternative. Both of these are summarised in Table 5 below.

Table 5. Two Approaches to Benchmarking

Environmental Goals	• Universal Benchmarking: Reduce average emissions rates from shipping. • Trading Consortia: Reduce average emissions rates from shipping, requiring further reductions from those that participate in trading.
Covered, Opt-in, and Affected Entities	• Universal Benchmarking: Vessels over a certain size required to participate • Trading Consortia: Vessels "opt in" to trading scheme group
Geographic/ Temporal Differentiation	• Universal Benchmarking: No geographic differentiation. • Trading Consortia: Differentiate benchmark based on consortium location. • Both: Banking would be permitted.
Determination of "Free" Emissions Levels	• Universal Benchmarking: Benchmarked "average" emissions rate. • Trading Consortia: Ships opting for trading face a lower benchmark than "command-and-control" compliers.
Monitoring and Reporting	• Universal Benchmarking: Periodic monitoring of emission rates combined with fuel use or engine activity monitoring. • Trading Consortia: Two-tiered system: trading vessels adhere to stricter monitoring and reporting; other vessels have more limited requirements.
Institutions Established	• Both: Create registry and database of included ships; establish agency to oversee monitoring and ensure compliance. • Universal Benchmarking: Allow brokers to facilitate trades. • Trading Consortia: Establish agency to certify consortia.
Compliance & Enforcement	• Both: Verify compliance and enforce against entities that violate the programme.

4.2.2.1. Environmental Benefit to Be Achieved

Both of the benchmarking approaches described here have the broad objective of reducing overall EU emissions and emissions from the shipping sector by reducing the average emissions *rate* of vessels operating in EU waters. Universal benchmarking is designed to allow all vessels to trade, with the objective of meeting a predetermined average emissions rate. The trading consortia alternative, on the other hand, would require all ships to meet at least a predetermined "command-and-control" rate, but would allow ships the option of developing independent trading consortia, which collectively are required to meet a *lower* average rate.

4.2.2.2. Entities Covered

Under the universal benchmarking approach, all marine vessels over a certain size would be required to participate in and collectively meet the benchmark emissions rate.

Under the "trading consortia" approach shipowners could develop smaller trading consortia that would *collectively* conform to their emissions requirements, with some vessels over-complying to offset higher emissions from other vessels. In essence, this approach would enforce a more traditional command-and-control–style requirement (like a limit on sulphur in fuel) on all vessels that did not participate in trading, but would allow vessels that wished to trade to develop small groups that would do so.

An approach similar to this one has been proposed by the Shipping Emissions Abatement and Trading group ("SEAaT), a consortium of petroleum companies and ship owners. Under this proposal, which SEAaT refers to as "offsetting," shipowners would be able to install scrubbers or other technologies to reduce SO_2 emissions as an alternative to complying with the forthcoming marine fuel sulphur requirements (SEAaT 2003, see also www.seaat.org). The emissions reductions resulting from the installation of such equipment would generate credits for the ships using them. These emissions reductions could then be sold to other participants in the trading consortium, who would be allowed to have emissions that were higher than the command-and-control requirement (in this case the 1.5 percent sulphur limit). Thus some of the ships participating in the trading consortium would be allowed to have average emissions above the limit that would otherwise apply to them, because they would be able to purchase allowances from the low-emitting ships.

4.2.2.3. Geographic or Temporal Differentiation

Although it would be possible to differentiate emissions geographically for either of the benchmarking programmes described here, we have assumed, for the purposes of evaluation, that the universal benchmarking approach would not include an element of geographic differentiation. Thus, as it is specified here, the universal benchmarking approach would entail a single market for allowances, with all allowances having the same value. Of course, it is important to note that there might still be different benchmark rates for different regions. For example, the benchmark rate for emissions in port might correspond to a 0.2 percent sulphur requirement, while the benchmark rate for emissions at sea might correspond to a 1.5 percent sulphur requirement.

Under the trading consortia approach, we have assumed that the regulating authority would certify individual consortia for trading only within a particular geographic region; trading between consortia would not be permitted. (Of course, trading among consortia could be permitted if it appeared administratively feasible and environmentally sound, as it would deliver additional cost savings.) For example, a single consortium might be certified only for operation within the North Sea. Through the certification process for each trading consortium, the regulator would have the opportunity to assess the significance

of geographic concerns for each pollutant and region, and allow those concerns to dictate the geographic breadth of each trading consortium.

4.2.2.4. "Free" Emissions Level

In the case of benchmarking, the "free" emissions level is equivalent to the benchmark emissions rate—i.e., the emissions rate at which vessels would not be required to purchase—or be able to sell—allowances.

As described above for the credit-based approaches, one straightforward method for applying benchmarking to SO_2 emissions would be to require *average* emissions from shipping sources to be equivalent to what would be emitted under the requirement to use 1.5-percent sulphur fuel. The 1.5-percent figure—and the emissions associated with it—would effectively become the level at which emissions were given "freely". This benchmark rate would be applied instead of requiring that all fuel used have sulphur content actually equal to 1.5 percent.[32] A similar rate would need to be developed for NO_X, perhaps relying on the IMO curve described above.

For the universal benchmarking approach considered here, we assume that all ships would be subject to meeting the same average benchmark emissions rate. As noted, these ships could participate in trading such that some ships might emit *above* the benchmark rate and others might emit *below* the rate, but the *average* rate would meet the target benchmark.

For the trading consortia approach, we assume a slightly more complicated benchmarking regime. As noted, for this approach, we assume that *all* ships are subject to "command-and-control" sulphur and NO_X emissions rate limits. However, we assume that ships opting to participate in a trading consortium would be required collectively to achieve a *lower* average emissions rate than would be required under the command-and-control alternative. For example, consortia formed under the voluntary benchmarking programme might be required to achieve average emissions rates equivalent to what would be emitted if a 1.2 percent sulphur requirement applied to them, while vessels opting to comply without trading could simply use 1.5 percent sulphur fuel to be in compliance.

Temporal flexibility would also be provided for both alternatives via banking. That is, emitters would have the opportunity to reduce emissions in early years of the programme and "bank" them for use in future years. As noted above, this can allow emitters to reduce emissions in gradual steps if more stringent regulations (or higher emissions) are anticipated in future years.

[32] This is one of the options discussed in proposals developed by SEAaT. They also discuss the possibility of a cap-and-trade approach (Hirst 2002a and Hirst 2002b).

4.2.2.5. Monitoring and Reporting

For the universal benchmarking approach, all vessels would be subject to periodic monitoring of emissions characteristics, focusing on NO_X and SO_2 emissions rates. For NO_X, this periodic monitoring would need to be coupled with an on-board device installed to measure engine activity in EU waters. Periodic monitoring of SO_2 emissions rates would need to be supplemented by measurement of the ship's fuel usage in EU waters, which could be achieved either through an on-board device or periodic inspections of fuel level and purchase receipts. For both NO_X and SO_2, ships would need to install on-board GPS devices to track location and entry into EU waters (though many ships have already done so).

For the trading consortia approach, we assume a two-tiered monitoring system. For those vessels choosing to comply with command-and-control limits individually rather than opting into trading consortia, only periodic testing of emissions rates (and, for SO2, fuel sulphur content) would be required. However, ships opting in to trading would have the more rigorous monitoring requirements described above for universal benchmarking (i.e., location data combined with the installation of other on-board devices to track engine activity and fuel usage).[33]

4.2.2.6. Institutions Established

For both of the programmes described here, an administrative agency would need to be developed to maintain a registry of included vessels. The same agency—or a similar one—would have to be established for the purpose of overseeing emissions monitoring and ensuring compliance.

In the case of universal benchmarking, the agency would be responsible for overseeing periodic inspections of emissions rates and the installation of on-board technologies to measure fuel usage and engine activity. Administrators would then need to monitor trading and ensure that it occurs within the parameters established.

For the trading consortia, the agency would have the authority to certify or deny applications for consortia. Individual shipping groups would be expected to develop proposals for trading consortia and submit them to the regulator. The proposals would then need to be assessed against on a variety of criteria, including credibility and geographic concerns.

[33] A related but slightly different tiered approach would be to associate more stringent monitoring regimes with a more favourable benchmark rate (or allocation under cap-and-trade, below). In a sense, this would give vessels the added flexibility of being able to trade off monitoring costs for abatement costs, and vice versa.

4.2.2.7. Compliance and Enforcement

As noted above, for both approaches, agencies would need to be established to oversee compliance and enforcement. The task would be much broader in the case of universal benchmarking, as it would include all vessels over a certain size. For the trading consortia approach, the regulator would need to oversee compliance and enforcement only for those ships voluntarily participating in trading. (Note, however, that authorities would also need to enforce the command-and-control regulations for ships not participating in trading.)

4.2.3. Two Approaches to Cap and Trade

This section identifies the elements we assume for a cap-and-trade programme to reduce shipping emissions. We again identify two possible implementations—labelled "trading with exchange rates" and "trading with geographic formula." These approaches would differ only in their means of accounting for geographic differences between regions. The first approach would deal with geography in a crude framework, setting exchange rates for trading among different regions. The second would establish a detailed formula that would rely on detailed GPS information regarding ship location to establish the value of the credit. The details of these approaches are outlined in Table 6.

Table 6. Two Approaches to Cap and Trade

Environmental Objective	• Trading with Exchange Rates: Reduce emissions of NO_x and SO_2 to overall cap set for shipping sources, using crude exchange rates to account for geographic concerns. • Trading with Geographic Formula: Reduce emissions of NO_x and SO_2 to overall cap set for shipping sources, using a detailed location formula to account for geographic concerns.
Covered, Opt-in, and Affected Entities	• Both: All marine vessels over a certain size.
Geographic/ Temporal Flexibility	• Trading with Exchange Rates: Trading between different geographical regions governed by exchange rates/no trade rules. • Trading with Geographic Formula: Formula to differentiate emissions at different locations using GPS data and continuous monitoring or estimation of emissions. • Both: Banking permitted.
"Free" Emissions Levels	• Both: Allocation updated on basis of previous year's emissions or tonne-miles travelled ("updating").
Monitoring and Reporting	• Both: Continuous monitoring of emissions.
Institutions Established	• Both: Registry and database of included ships; agency to monitor emissions reductions; marketplace (brokers) for trading of allowances.
Compliance & Enforcement	• Both: Validate emissions reductions and enforce continuous operation of monitoring equipment.

4.2.3.1. *Environmental Objectives*

The environmental objective of any cap-and-trade programme is quite explicit—a cap is set for overall emissions, and covered entities are collectively required to meet that cap. In this case, this would mean setting an overall cap for emissions of NO_X and SO_2 from vessels operating in EU waters. As noted above, the only distinction between the two approaches considered here is in the complexity of their accounting for geography. Thus, the environmental objective of the geographic formula approach entails slightly more emphasis on geographic concerns than the programme using exchange rates.

4.2.3.2. *Covered Entities*

For either cap-and-trade approach, all vessels over a certain size would be required to participate in the trading programme. It would be possible to allow other, smaller vessels to "opt in" to the programme, although this is not considered in detail here. Note, however, that vessels opting in would be subject to requirements similar to those described in the credit-based approach section.

4.2.3.3. *Geographic and Temporal Differentiation*

As noted, the distinction between the two approaches described here is in the complexity of their inclusion of geographic differentiation. While both approaches would be designed to include an element of geographic differentiation, the geographic formula approach would be designed to account for geographic concerns in a more sophisticated framework.

The exchange rate approach would apply rough exchange rates to emissions reductions in different regions. In the simplest implementation, allowances generated in port might have twice the value of allowances generated at sea—an exchange rate of 2:1. In this example, an increase of one tonne of SO_2 emissions in port would be offset by a reduction of two tonnes of SO_2 emissions at sea. Here, we assume that this approach sets exchange rates between several broad regions, such as those above in Table 3.

The more complex scheme—the geographic formula approach—would entail using detailed data from an on-board GPS system to calculate the value of each allowance relative to other allowances being sold in the market. Rather than varying the value of emissions in different geographic regions, this approach would assign a unique value to each unit of emissions. Emissions units would of course need to be standardised for trading purposes. For example, SO_2 emissions might be reported in terms of port-tonne equivalents of SO_2.

4.2.3.4. *"Free" Emissions Levels*

One of the major additional features of a cap-and trade programme is the initial allocation of allowances, which sets the level of "free" emissions permitted to individual vessels. There are a wide range of initial allocation alternatives that may be used, including distributing allowances for free and auctioning them (which would amount to an emissions

tax). The various alternatives are reviewed elsewhere (see, e.g., Harrison and Radov 2002), so we do not discuss the alternatives in detail here. It is worth noting, however, that the fluid nature of the international shipping industry could make "grandfathering" approaches less appropriate than methods based on updated activity information.

4.2.3.5. Monitoring and Reporting

Both of the cap-and-trade approaches described here would require continuous monitoring of NO_X emissions, because of the importance of ensuring a fixed emissions cap. It might be possible, however, to measure SO_2 with sufficient accuracy using a combination of periodic testing and fuel-use monitoring. Thus, all covered vessels would be required to install on-board emissions monitoring devices for NO_X and would need to have fuel monitored for SO_2. In addition, on all vessels, these devices would be linked to location monitoring, which would be used to determine the effective emissions by the vessel for the purposes of the trading scheme. In the case of the exchange rate approach, "effective emissions" would involve relatively simple exchange rates, while GPS information would certainly be needed for the geographic formula approach.

4.2.3.6. Institutions Established

As with benchmarking, institutions for a cap-and-trade programme would have to be established for two broad purposes. First, an agency would need to be established to administer the programme. As with the other trading programmes described here, this agency would be responsible for maintaining a registry of ships included in the programme as well as information on ship characteristics. This agency would also be responsible for overseeing the monitoring of ship emissions and ensuring that the overall cap is met.

An agency would also be needed to facilitate trading among ships. At least initially, this agency would probably need to assist in encouraging brokers to participate in the trading programme.

4.2.3.7. Compliance and Enforcement

The administrative agency described above would also be responsible for ensuring that the overall cap is met. This responsibility would include the need to perform periodic inspections of ships to guarantee that their monitoring equipment is functioning and has not been tampered with. In addition, this could entail the need to levy penalties against shipowners who, at the end of the year, do not hold sufficient allowances to cover all annual emissions.

4.3. Specification of Emissions Charging Approaches for Shipping Assessed in This Report

This section provides specification of the three major emissions charging programmes that are assessed in this report.

4.3.1. Three Approaches to Taxation/Charging

We consider three possible taxation/charging approaches, each of which is described in more detail below and summarised in Table 7 below. The first two taxation/charging approaches—the fuel tax at point of sale and the fuel-usage tax—focus on taxing fuel, with one targeting fuel purchases in the EU and the other targeting fuel consumption in the EU. Both would be effective primarily in targeting SO_2 emissions, which are highly related to fuel type and usage. The third approach—the emissions tax—would tax total emissions of NO_X and SO_2 from ships operating in EU waters.

Table 7. Three Approaches to Taxation/Charging

Environmental Objective	• Tax at point of sale: Target SO_2 by reducing high-sulphur fuel *purchases* in Europe. • Fuel-Use Tax: Target SO_2 by reducing high-sulphur fuel *usage* in Europe. • Emissions Tax: Reduce overall emissions of NO_X and SO_2 from shipping sources.
Covered, Opt-in, and Affected Entities	• Tax at point of sale: All marine vessels, though functionally only ships with intra-EU routes. • Fuel-Use Tax: All marine vessels over a certain size. • Emissions Tax: All marine vessels over a certain size.
Geographic/ Temporal Flexibility	• Fuel-Use/Tax at Point of Sale: No geographic differentiation. • Emissions Tax: Emissions weighted based on region and distance from shore.
"Free" Emissions Levels	• Fuel-Use/ Tax at Point of Sale: Tax applied to fuel sulphur content in excess of given level (e.g., above 1.0 percent by weight). • Emission Tax: Tax rebate for emissions below a certain rate
Monitoring and Reporting	• Tax at point of sale: No monitoring necessary. • Fuel-Use Tax: Continuous (or frequent periodic) monitoring of fuel use. • Emissions Tax: Continuous monitoring or estimation of funnel emissions.
Institutions Established	• Tax at point of sale: Tax collection entity; agency to test fuels and assign appropriate taxes. • Fuel-Use Tax: Tax collection entity; registry and database of included ships; agency to monitor fuel usage and type; certification of fuel receipts or testing of bunker fuel characteristics. • Emissions Tax: Tax collection entity; registry and database of included ships; agency to monitor emissions and determine charges.
Compliance & Enforcement	• Tax at point of sale: None. • Fuel-Use Tax: Ensure that fuel use estimates are accurate. • Emissions Tax: Validate emissions estimates.

4.3.1.1. *Environmental Objectives*

The two fuel taxes described here would be designed primarily to reduce emissions of SO_2. The tax at point of sale would target fuel purchases made in Europe, while the tax on fuel usage would directly target fuel *actually burned* in EU waters. Both taxes would have the ultimately objective of encouraging the use of low-sulphur fuels in EU waters.

The emissions tax would have a much broader scope and be intended to reduce total emissions of both SO_2 and NO_X from shipping sources operating in EU waters.

4.3.1.2. *Covered Entities*

Any fuel tax would of course affect both fuel producers and purchasers. The fuel tax at point of sale would affect all vessels that purchase bunker oils in EU territory. Although the tax would seek to cover all vessels that operate in EU waters, large vessels that regularly operate outside of the EU would probably be able to avoid the tax by purchasing fuel outside of Europe, as discussed in more detail later in this report.

The fuel-usage tax would be designed in a similar way to the point of sale tax, except that it would prevent ships from avoiding the tax by purchasing fuel outside of the EU. Thus, the tax would be designed to apply to all users of fuel oil in EU waters. Indeed, it would be designed to estimate total fuel consumed in EU waters and tax shipowners based on the sulphur content of that fuel.

Finally, the emissions tax would be designed to cover all marine vessels over a certain size operating in EU waters. Presumably, this would cover a vessel population similar to what would be covered under the cap-and-trade programme described above.

4.3.1.3. *Geographic and Temporal Differentiation*

As specified here, neither of the fuel taxes would be designed to differentiate geographically. The emissions tax, however, would be designed to use an approach similar to that described above for trading with exchange rates. That is, emissions in different broad geographic regions would be taxed differently. For example, consistent with the Netcen (2002) report discussed above, SO_2 emissions in the Eastern Atlantic might be taxed at a rate approximately three times greater than emissions in the Baltic Sea.

Temporal differentiation would have no significance for this or any of the charging options.

4.3.1.4. *"Free" Emissions Levels*

Under the fuel tax at point of sale approach, a tax would be levelled on bunker fuel with sulphur content above a certain percentage. For example, the tax might be set at €1 per tonne for every 0.1 percent sulphur above 1.0 percent. Thus, fuel with sulphur content of 1.5 percent would be taxed at €5 per tonne of fuel, and fuel with a sulphur content of 2.0 percent would be taxed at €10 per tonne of fuel. If the tax were designed in this way, "free"

emissions would be equivalent to the sulphur that would be emitted if the ship burned only 1.0 percent sulphur fuel.

Free emissions would be analogous with the fuel-use tax. For example, if the tax rate were again €1 per tonne for every 0.1 percent sulphur above 1.0 percent, a ship that burned 10,000 tonnes of 1.5 percent sulphur fuel annually in the EU would pay a fuel tax of €50,000. Thus, the free emissions level—that is, the emissions for which the vessel is not charged—would be equivalent to the sulphur that would have been emitted if the ship had burned only 1.0 percent sulphur fuel.

For the emissions tax, the free emissions level would need to be determined independently for each ship and would be received in the form of a tax rebate. The level of free emissions would be determined in a manner analogous to an allocation under a cap-and-trade programme. Then, the rebate would be equivalent to the ship's "allocation"—or free emissions level (determined, for example, using one of the methods described in Harrison and Radov 2002)—multiplied by the tax rate.

As noted above, such an approach to revenue recycling could be combined with any of the three approaches above to return revenues to the shipping industry, creating a revenue neutral instrument.

4.3.1.5. Monitoring and Reporting

The fuel tax at point of sale would not require any monitoring of shipping, though it would require testing the sulphur content of fuel sold by suppliers in the EU. The fuel use tax would require continuous monitoring of fuel use. That is, ships would be required to install an on-board technology to monitor fuel use. This information would be combined with information on fuel type, which could be obtained from receipts—or other proof of fuel purchase—that indicated the sulphur content of their fuel.

As it is specified here, the emissions tax would require continuous emissions monitoring, analogous to that described above for cap and trade. As for cap and trade, this would involve the installation of on-board monitoring devices for all covered ships.

4.3.1.6. Institutions Established

For all of taxes or charges described here, a tax collection agency would have to be established. In the case of the point of sale tax, an agency would also be needed to test fuels being sold in the EU for their sulphur content and assign the corresponding taxes.

For both the fuel-use tax and the emissions tax, an administrative agency—presumably the tax collection agency—would need to maintain a registry and database of included ships. As part of this task, the agency would be responsible for ensuring that all covered ships were being taxed appropriately. In addition, this agency would need to keep track of data regarding fuel use and emissions, collected from each ship's on-board monitoring devices. As noted, it would also be responsible for collecting the taxes on a periodic (e.g., annual) basis, as well as assuring that all monitoring devices are correctly

installed (i.e., they have not been tampered with). For the fuel-usage tax, the agency would also be responsible for certifying data (e.g., receipts, etc.) on fuel characteristics.

4.3.1.7. Compliance and Enforcement

For the tax at point of sale, there would be essentially no need for enforcement, although the collection agency would need to ensure that the taxes were being levied correctly. As noted above, for both the fuel-use and the emissions tax, the oversight agency would need to ensure that shipowners were not tampering with monitoring devices, and that estimates of fuel type and total emissions were accurate.

4.3.2. Two Approaches to En-Route Charging

As described earlier, the standardized charge for an en-route system could be calculated based on trip distance in European waters combined with information on operating characteristics (e.g., vessel size, weight, emissions rate, etc.). The vessel characteristics, combined with journey distance, would serve in effect as a proxy for emissions by that vessel for each segment of its journey. Here we consider two specific implementations of an en-route charging system—"trip-based" charges and "distance-based" charges. These two approaches differ primarily in the way the distance travelled in EU waters is calculated—whether it is calculated using generic route information or specific information about a particular ship's journey. Table 8 below describes these two approaches.

Table 8. Two Approaches to En-Route Charging

Environmental Objective	• Trip-Based Charges: Improve emissions characteristics of ships operating in European waters by developing charges based on generic ship travel patterns. • Distance-Based Charges: Improve emissions characteristics of ships operating in European waters by developing charges based on precise ship movements.
Covered, Opt-in, and Affected Entities	• Both: All marine vessels over a certain size operating in European waters.
Geographic/ Temporal Flexibility	• Trip-Based Charges: Charges vary by predetermined route, accounting for regional geographic concerns. • Distance-Based Charges: Geographic differentiation by specific location, based on region and distance from shore.
"Free" Emissions Levels	• Both: Charges contain implicit emissions rate for which emissions are free.
Monitoring and Reporting	• Trip-Based Charges: Periodic emissions monitoring and ability to track generic shipping routes followed. • Distance-Based Charges: Periodic emissions monitoring and GPS to keep track of specific shipping routes followed.
Institutions Established	• Both: Charge setting authority; charge collection entity; entity to certify fuels and vessel emission rates; entity to assign appropriate charges.
Compliance & Enforcement	• Both: Agency to validate emissions estimates and ensure continuous operation of abatement technologies.

4.3.2.1. Environmental Objectives

The two approaches to en-route charging considered here have the same general environmental objectives. Both would seek to encourage improvement in ships' emissions characteristics by imposing stricter charges on ships with higher emissions rates and longer journeys. Specifically, the charges would be intended to target emissions of NO_X and SO_2. As noted, the primary distinction between these two would be in their precision; thus, the distance-based charges, which would be more precise in charging ships for their specific location, would have slightly broader environmental goals.

4.3.2.2. Covered Entities

As with many of the other programmes described here, these charging approaches would be designed to charge all ships over a certain size for their use of EU waters. Thus, the charges would be applied to any ship over the specified size that used EU waters at any point during the course of the year.

4.3.2.3. Geographic and Temporal Differentiation

As noted, the simple, trip-based approach to en-route charging would be to charge ships on the basis of each port-to-port trip taken (in the case of transit traffic or single-port

journeys, the charge could be based on a standard distance from the area of entry into EU waters). Under such an implementation, the characteristics of common routes—*e.g.*, length of trip, average distance from shore—would first have to be determined. Authorities would then use these factors, combined with vessel characteristics (*e.g.*, gross tonnage, certified emissions rate or fuel type information), to determine the appropriate charge for each journey.

The distance-based approach to en-route charging would charge ships on the basis of *actual* distance travelled rather than *estimated* trip parameters. This approach would rely on GPS or alternative means of pinpointing a vessel's location in order to estimate distance from shore and distance travelled in EU waters. As in the trip-based charging approach, authorities would combine this information with characteristics of the individual vessel to estimate total emissions. The charge to shipowners would then be assessed on the basis of estimated emissions.

Thus, both of these en-route approaches would involve an element of geographic differentiation. The trip-based approach would assign a specific charge for commonly travelled routes, though it would of course vary depending on each vessel's characteristics. We assume that one component of this charge would account for geographic concerns. That is, the charge would be greater for routes travelled in geographically sensitive areas (e.g., the English Channel) and less for routes travelled in less sensitive areas.

The distance-based charge would go a step beyond this and account specifically for the movements that ships make on a particular journey. Charges would then be calculated based on each ship's actual location over the course of a journey (using the GPS data), relying on an approach similar to that described above for the cap-and-trade approach that uses a geographic formula. Thus, ships might have the opportunity to reduce the charges they pay by adjusting their routes to travel through less sensitive areas.

4.3.2.4. "Free" Emissions Levels

We assume that the en-route charges described here would be set to charge vessels that have emissions above a certain rate. That is, ships would be certified for a given emissions rate and then charged based on that rate. Implicit in this charge would be an emissions rate for which emissions are free. For example, the charge might be structured such that, for ships with mid-sized engines, the NO_X charge is only assessed for ships with an emissions rate above 10g/kWh. In this case, the "free" emissions level would be all emissions up to what would be emitted if the ship had a rate of 10 g/kWh.

Like the taxation/charging approaches described in the previous section, en-route charges could also be designed as revenue neutral if revenues were returned to shipowners.

4.3.2.5. Monitoring and Reporting

The primary monitoring tool for both of these en-route approaches would be periodic testing of emissions characteristics. Ships would be required to submit to periodic

(e.g., annual) inspections, which would estimate NO_X and SO_2 emissions rates. These emissions rates would then serve as the basis for determining the en-route charges assessed, in combination with other operating characteristics.

In order to assess the charges appropriately, it would also be necessary to monitor ship travel. In the case of the trip-based approach, this would involve tracking generic ship movements in EU waters (e.g., travel from Lisbon to Rotterdam). The distance-based approach would require more precise knowledge of ship location and thus would necessitate the installation of on-board GPS devices (for those ships not already so equipped) to track the location of ships as they travel through EU waters.

4.3.2.6. Institutions Established

As with all of the programmes described here, an administrative agency would need to be established to oversee either of these en-route approaches. In this case, the agency would have responsibility for the charges, both setting (accounting for geographic concerns, etc.) and collecting them. In addition, since the charges would need to be based on detailed information about each ship, including emissions and other vessel characteristics, the agency would need to track this information in a database that included all potentially affected ships.

4.3.2.7. Compliance and Enforcement

As for many of the other programmes described here, either en-route charging programme would require some enforcement to ensure accurate compliance. This would include the responsibility of ensuring that all ships travelling in EU waters are appropriately charged. In addition, surprise inspections would probably be necessary to ensure that ships are operating any abatement technologies for which they are receiving credit. For example, if a ship is certified for an emissions rate based on its usage of Selective Catalytic Reduction ("SCR")[34], the surprise inspections would be intended to ensure that the ship was actually operating SCR at all times in EU waters.

4.3.3. Three Approaches to Differentiated Dues

There are several possible means of implementing an environmentally differentiated dues system for marine vessels. We consider here three possible implementations of differentiated dues. Two of these—the "voluntary differentiated port dues" and "mandatory differentiated port dues"—focus on differentiating existing port dues on the basis of environmental criteria. The third approach—labelled "differentiated fairway dues"—would seek to establish a new EU-wide system of dues to charge ships for using European fairways.[35] Each of these approaches is summarised in Table 9 below.

[34] SCR is an abatement technology designed to reduce NO_X emissions.

[35] Finland, Sweden and Norway have existing fairway dues programmes.

Table 9. Three Approaches to Differentiated Dues

Environmental Objective	• Voluntary Differentiated Port Dues: Provide ports with an environmentally differentiated dues framework to encourage improvements in environmental characteristics of ships visiting EU ports. • Mandatory Differentiated Port Dues: Use port dues as direct mechanism through which to encourage improvements in environmental characteristics of ships visiting EU ports. • Differentiated Fairway Dues: Use fairway dues to encourage improvements in environmental characteristics of ships using EU fairways.
Covered, Opt-in, and Affected Entities	• Voluntary Dues: All ships over a certain size entering selected EU ports. • Mandatory Dues: All ships over a certain size entering *any* EU port. • Fairway Dues: All ships over a certain size using EU fairways.
Geographic/ Temporal Flexibility	• Voluntary Dues: Inherent geographic differentiation because not all ports would take up voluntary dues. • Mandatory Dues: No geographic differentiation. • Fairway dues: Increase dues for particularly sensitive fairways.
"Free" Emissions Levels	• Voluntary/Mandatory Port Dues: Set at emissions level where dues are identical to rates prior to differentiation. • Fairway Dues: Only free where Member States have pre-existing fairway dues scheme.
Monitoring and Reporting	• All: Periodic monitoring of emissions characteristics.
Institutions Established	• Voluntary Dues: Provide institution, or develop EU guidelines, to assist ports in establishing differentiated dues. • Mandatory Dues: Create agency to ensure differentiated dues charging at all ports. • Fairway Dues: Establish new fairway dues agency in most Member States.
Compliance & Enforcement	• Voluntary Dues: No enforcement necessary. • Mandatory Dues: Establish agencies to ensure port compliance and validate certified emissions rates. • Fairway Dues: Establish agency to validate certified emissions rates.

4.3.3.1. Environmental Objectives

All of these differentiated dues programmes would have very similar environmental objectives. All three would seek to encourage reductions in NO_X and SO_2 emissions rates from ships. Several existing programmes, including the scheme in Mariehamn Finland and the Green Award, consider a range of environmental criteria, including SO_2 and NO_X emissions rates, waste disposal, hull type, and emissions of particulate matter, among others. We assume that the differentiated dues programmes would focus on SO_2 and NO_X.

For example, the Commission could develop a standard system for emissions indexing that would award index points to different levels of emissions or for the installation of different types of abatement equipment or efficiency measures.[36] Alternatively, the dues could be tied to a specific charging structure. The Swedish differentiated dues approaches, for example, define a formula for the charge to be applied to a sliding scale of NO_X emission rates.[37]

For the voluntary approach, the EU might recommend standard discounts from existing dues (and standard increases) that would be applied to vessels scoring at different levels on the index. For example, the Commission might recommend that vessels achieving the highest index rating, or vessels fitted with emissions control equipment, or vessels that otherwise achieve emissions below some proportion of the average level, would receive a 20 percent discount on their dues, relative to other vessels. Under the voluntary approach, ports would also have the opportunity to design their own system of differentiated charges, using the EU-wide index and discounts (or increments) in the manner that they felt best suited them. Of course, ports might also choose not to implement any differentiation of dues.

Under the mandatory dues scheme, the Commission could impose a single structure of environmentally differentiated port or fairway dues across all ports or waters in the EU. Under such a system, ports would be required to differentiate dues on the basis of the criteria laid out by the Commission. The EU system would presumably pre-empt the individual characteristics of different port dues schemes, although some individual variation by ports might also be allowed (for example, some fraction of the available discount could be tied to characteristics left to the discretion of individual ports). The mandatory system could also rely on the EU-wide indexing system described above, imposing a specific discount structure.

For the fairway dues approach, the Commission would need to develop a new structure for levying the charges in most Member States, since most States do not have existing fairway programmes. Nonetheless, the overall objectives and structure of the programme would be roughly similar to the port dues approaches. Of course, the differentiated fairway dues approach would target shipping *routes* (i.e., fairways) rather than destinations (i.e., ports). We assume that the fairway dues would be structured around an indexing programme similar to the one described above. Thus, vessels would receive environmental indices, and the charge would be differentiated according to that index.

4.3.3.2. Covered Entities

All of these programmes would be designed to apply differentiated charges to all ships over a certain size. In the case of the port dues approaches, ships would be affected on

[36] IMO has had discussions about developing such indices for CO_2 emissions and other environmental factors.

[37] This charge has a maximum at 12 g NO_X/kWh, and it has been suggested that a new maximum charge may be applied to the rate of 10 g NO_X/kWh.

the basis of their *stopping in* ports, while the fairway dues approach would affect ships *passing through* European fairways.

The port dues approaches would affect two principal populations—shipping vessels and port authorities. The mandatory and voluntary approaches could potentially affect identical populations, if all ports were to adopt the voluntary dues. However, it is of course likely that some ports would choose not to differentiate dues. Thus, the voluntary dues scheme would probably affect fewer port authorities and fewer ships.

The differentiated fairway dues would not affect port authorities directly. They would, however, affect the maritime authorities in states with existing fairway dues programmes and, of course, shipowners.

4.3.3.3. Geographic and Temporal Differentiation

As noted above, under the voluntary dues programme, not all ports would choose to differentiate dues. In addition, those ports that did differentiate would not necessarily all differentiate in the same way. Thus, the voluntary programme would inherently involve a great deal of variation across ports. However, the variation would be unlikely to be tied explicitly to any specific environmental goals. Of course, it might be expected that ports in environmentally sensitive areas would be most likely to implement the differentiated dues programmes. Nonetheless, any geographic differentiation would be unlikely to be tailored to any comprehensive environmental objectives.

Under a mandatory dues system, it would of course be possible to differentiate dues more systematically. However, due to the potentially significant effects on competition among ports and the political ramifications, we assume here that a mandatory programme would not include geographic differentiation.

Thus, the fairway dues programme offers perhaps the best opportunity among the dues approaches to develop a systematic geographic differentiation scheme that is tailored to an environmental objective (i.e., discouraging emissions in particular locations). Indeed, we assume here that the fairway dues would be developed uniquely for each broad geographic region and differentiated according to information on environmental effects. The approach here would be similar to that described above for the trading with "exchange rates."

4.3.3.4. "Free" Emissions Levels

We assume that the port dues approaches would be revenue neutral, similar to the existing Swedish programme. Thus, the "free" emissions level would need to be set such that revenue is not significantly affected. In order to achieve revenue neutrality, it would of course be expected that cleaner ships would pay less than they would have previously, while dirtier ships would pay more than they would have previously. In this case, those ships that are paying the same dues as they were prior to the differentiation are emitting at the "free" emissions level.

For those Member States that have existing fairway dues schemes, the dues there would presumably be designed to be revenue neutral as well. For those states, the "free" emissions levels would be analogous to those under the port dues approaches described above. In other states, the "free" emissions level would probably be close to zero as all covered vessels would be required to pay a fairway due of some magnitude.

4.3.3.5. Monitoring and Reporting

As discussed above, all of these differentiated dues programmes would be designed to rely on a EU-wide indexing programme. The index would be determined via periodic inspections and certification of vessel characteristics. Thus, monitoring here would be analogous to monitoring under the en-route programmes described above, though it would involve monitoring of the additional environmental parameters necessary for developing the index.

4.3.3.6. Institutions Established

An administrative agency would probably need to be established to oversee any of these three approaches. Under all of these approaches, the agency would need to oversee the development of the environmental index for each ship, which would include monitoring and inspection, as well as maintaining a database of each ship's rating. Under the voluntary programme, this would represent the majority of the agency's responsibilities.

For the mandatory port dues programme, the agency would have the additional responsibility of ensuring that ports are levying the appropriate charges, though there would be no need to collect charges. Under the fairway dues programme, however, the agency would need to levy and collect the charges (or facilitate collection in Member States), because there is no existing structure for fairway dues collection in most Member States.

4.3.3.7. Compliance and Enforcement

The oversight agency would also be responsible for ensuring that shipping entities are complying with the programme. As with other approaches involving periodic monitoring, the monitoring would probably need to be supplemented with additional enforcement inspections to check fuel type and other compliance issues. It might be necessary for third-party certifiers to validate the index more often when incentives not to operate equipment exist.

5. CRITERIA FOR ASSESSING ALTERNATIVE MARKET-BASED INSTRUMENTS

We divide the criteria for assessing the alternative instruments into four broad categories. The first category relates to environmental criteria, notably the ability to reduce shipping emissions but also the ability to target emissions reductions where they provide the greatest environmental benefit. The second category includes efficiency criteria related to encouraging cost-effective emissions controls as well as minimizing administrative and other costs. The third category addresses distributional criteria, including impacts on key stakeholders in shipping activities (shipowners, fuel suppliers, and ports) as well as other broad groups affected by the instruments. The fourth group includes political and legal considerations. The following are brief descriptions of these various criteria.

5.1. Environmental Criteria

5.1.1. Overall Emissions Targets

The various instruments have different potential to reduce overall EU emissions and different degrees of certainty in achieving specific targets. As noted above, emissions trading programmes generally provide greater certainty that targets are met than emissions charging approaches, because they can set targets directly rather than indirectly by specifying taxes or charges.

5.1.2. Targeting of Emissions in Specific Geographical Areas

Another important concern is the extent to which the instrument can be used to improve environmental quality in particularly sensitive regions. Since emissions can have different effects depending upon their composition and location, this criterion relates to whether the mechanism can accommodate such differences. Generally speaking, the benefit from reducing SO_2 and NO_X emissions is likely to decline as the distance from shore increases. Table 2 (above) also suggests that within European sea areas, emissions are likely to have different effects depending on where they are located.[38] Moreover, although SO_2 and NO_X are regional pollutants, they can also have local impacts—thus for example, a single source emitting 20 tonnes of NO_X around Lisbon is not necessarily environmentally equivalent to two separate sources emitting 10 tonnes each around Lisbon and Lubeck.

The issue of geographical differentiation often has been raised in the context of emissions trading programmes. Concern over the differential effects of pollutants emitted in different locations was raised during the development and early implementation years of the US Acid Rain Program, as well as in the RECLAIM programme. The basic concern was

[38] CO_2, by contrast, has effects that are almost exclusively global—one characteristic of CO_2 that makes it well suited for emissions trading.

that so-called "hot-spots" could develop in which pollutant concentrations and environmental damages were higher than in other regions. In the Acid Rain programme, some states attempted to address this concern by placing restrictions on out-of-state trading. In the end, however, concerns that trading would exacerbate regional differences proved misplaced, because as it turned out, emissions reductions were actually greatest in the areas of greatest concern (Ellerman et al. 2000).[39] The RECLAIM programme ultimately settled on a two-zone system of geographic differentiation to protect the high-pollution inland region. Sources in this region were not permitted to purchase emissions from sources outside the region.

In the shipping case, of course, it would not be sufficient simply to treat emissions from one vessel differently from emissions from another vessel. Because ships' positions are not fixed, the ability to differentiate geographically is closely linked to the issue of location monitoring. As a consequence the particular specification for monitoring plays an important role in determining how well each instrument satisfies this criterion.

5.2. Efficiency Criteria

5.2.1. Attainment of Least Cost Abatement Measures

A key objective of market-based mechanisms is to reduce the cost of meeting environmental target. A cost-effective mechanism is one that achieves a given emissions target at the lowest possible cost. Economic theory predicts that under certain conditions such as perfect information and zero transaction costs, charging and trading alternatives can both meet an emissions target in a cost-effective manner. However, not all of the instruments considered create incentives for all measures that would reduce emissions, and therefore they will differ in their overall costs. Moreover, in the real world, where access to information is costly, the costs of achieving environmental targets under different mechanisms can vary significantly.

Because of the critical importance of instrument cost-effectiveness, and of the incentives created by different instruments, we devote the next chapter to a detailed examination of instrument incentives. The chapter examines the extent to which each instrument encourages shipowners to avail themselves of all potential measures that would reduce ship emissions.

5.2.2. Incentives for Innovation

This criterion relates to the effects the market-based approach might have on innovation and other dynamic cost savings. Higher emissions costs imposed by a mechanism will create incentives to develop more cost-effective emission reduction

[39] Of course, this was an empirical question, and its resolution in the case of the Acid Rain Programme might not apply to shipping.

technologies. Mechanisms will differ in the degree to which incentives to innovate are created and the types of innovation that they spur.

5.2.3. Effects on Tax Distortions

This criterion relates to the potential gains to the economy of using revenue collected to reduce tax distortions. Taxes such as income and sales taxes are considered distortionary because they create a sub-optimal allocation of goods and services. This creates a drag on the economy as a whole and introduces net welfare losses. Pollution taxes, however, if implemented correctly, tend to reduce economic inefficiency because they apply a price to environmental damage that otherwise would not be priced appropriately. In fact, their general *purpose* is to shift the economy to a more efficient level of pollution output, introducing net gains to welfare. Revenues generated from emission taxes may be used to reduce the level of distortionary taxes, thereby reducing the inefficiencies created by them. This is sometimes referred to as the "revenue-recycling" effect.

5.3. Distributional Criteria

It is important to recognise that while a market-based mechanism may achieve efficient levels of pollution and bring net gains to society as a whole, the costs may fall disproportionately on one group. Implementation of such a mechanism may be difficult since political resistance is often strongest when one group or industry bears a large portion of the costs. When costs are more evenly distributed, there is less of an incentive to organise lobbying efforts to apply political pressure in opposition to a regulation. Moreover, disproportionate costs to a particular industry may lead to significant job losses in that industry, in which case the cost of the regulation may weigh heavily on specific individuals. Listed below are the main groups considered under the distributional criteria:

5.3.1. Shipowners

Shipowners would face higher costs of doing business in Europe either in the form of higher fees, costs of installing new equipment, or costs of using different fuels. Some may be able to pass costs on to customers or suppliers while others may not. The ability to pass costs on to customers depends on a number of factors such as the price elasticity of supply and demand. The price elasticity of demand is defined as the percentage change in quantity demanded given a one percent change in price. Consider, for example, shipowners whose customers are highly sensitive to a price increase (i.e. the price elasticity of demand is high). Standard economic theory predicts that under these conditions, these shipowners will bear a significant portion of the costs of the regulation. Considerations about economic factors such as price elasticities that affect the allocation of the costs of a given mechanism will be important in determining a successful instrument.

5.3.2. Fuel Suppliers

The extent to which fuel suppliers bear the burden of costs will depend on the incentives created by the mechanism. For example, as described below a fuel tax levied at point of sale could lead to a substantial shift of fuel purchases outside EU territory. This could have a devastating impact on EU fuel suppliers with little environmental benefits.

5.3.3. Port Owners

Impacts on port owners could manifest themselves in a number of ways. Emissions reductions valued differently in different regions could cause individual port owners to gain or lose significant port dues depending how location-specific emissions reductions are valued. In addition, a large share of the costs could fall on port owners if a programme required them to manage a significant portion of the monitoring and administrative duties. Finally, a mechanism that creates incentives for firms to shift out of the shipping sector in the EU could hurt business not only for port owners, but for ship owners and fuel suppliers as well.

5.3.4. Consumers and Employees

Instruments that increase costs to the shipping industry are also likely to result in some portion of these costs being passed on to consumers. In effect, an increase in the cost of shipping increases the prices that consumers (and other businesses) pay for shipped goods (though it should be noted that at present, the proportion of prices which correspond to transport costs is not high – in fact as low as 2% for many consumer goods). High costs may also cause shipowners and ports to reduce employment in the shipping sector, which would go against the goal of encouraging a modal shift to sea.

5.4. Institutional Criteria

Apart from the efficiency and distributional criteria, there are of course institutional considerations as well. These criteria relate to the political, legal, and practical concerns that are critical in the implementation of a programme.

5.4.1. Legal Feasibility

This criterion considers the authority of the Commission and Member States to legislate and enforce each instrument with both the Law of the Sea, including the right of innocent passage and other relevant international law, and existing EU legislation, including the directive on the sulphur content of marine vessels and the Large Combustion Plant Directive (LCPD).

5.4.2. Political Feasibility

This criterion concerns the political acceptability of each instrument, which is closely linked to legal concerns. For example, one important consideration for gaining political

acceptance of any instrument may be that it can be implemented in a way that "phases in" the new requirements for marine vessels. Approaches that allow for experimentation, gradual expansion of coverage, and gradual tightening of limits or increases in charges are likely to fare better than more radical measures. This criterion also relates to the political likelihood of being able to achieve any legislative backing necessary to put each instrument into force.

Note that this criterion does not consider the political acceptability of any programme's environmental ambition, only of the instrument itself. The environmental objectives of the programme a matter for political negotiation and are not addressed in this study.

5.4.3. Administrative Feasibility

Some promising market-based approaches have been derailed by high administrative costs. This criterion reflects the feasibility of developing and administering the programme. A major component of administrative feasibility is, of course, the cost of administering the programme, including the transaction costs of engaging in trades or determining charges. These considerations will be particularly important in the current context due the large number of ships that could fall under the scope of the programme. Mechanisms that require extensive administrative efforts for each emitter, such as establishing a baseline level of emissions for each ship, may be prohibitively costly and therefore not feasible.

5.4.4. Feasibility of Monitoring Regime

Determining compliance with new emissions requirements entails some form of monitoring of "actual" emissions or vessel activity. Indeed, the previous chapter identified monitoring regimes that would be associated with each of the specific approaches considered in this study. This criterion considers the feasibility of implementing these monitoring regimes, which can vary significantly in scope under the various instruments. For example, taxing actual emissions from mobile sources would probably require more resources devoted to monitoring than a tax levied on fuel or its sulphur content.

6. INCENTIVES FOR EMISSION REDUCTION OPTIONS

As noted above, one of the primary attractions of market-based alternatives is that they allow for flexibility in the actions undertaken to reduce emissions. Unlike many "command and control' alternatives—whether technology standards or emissions limits—market-based approaches give individual operators incentives to reduce emissions in the manner best suited to each operators' emission source. To understand how the market-based instruments considered here would function, it is therefore important to consider how each instrument would affect the incentives for various methods of reducing emissions.

This chapter discusses how each of the instruments considered here would affect the incentives for a range of actions to reduce emissions from shipping sources. In theory, most instruments could potentially be modified to create incentives for almost any abatement option. In some circumstances, however, the modifications necessary to incorporate incentives for certain abatement options could be administratively cumbersome and inefficient—generating more costs than benefits. Thus, it is important to be clear about which instruments *naturally* generate certain incentives and which would require substantial modifications in order to do so.

To shed light on these issues, this section considers how well the instruments considered would be able to create incentives for various abatement measures. We consider both measures that would naturally create incentives, and those that would require more contrived or cumbersome instrument designs. We consider the incentives created to implement the following emissions reduction measures:

- *Fuel switching*. By switching to fuels that produce lower emissions (e.g., lower sulphur fuels, or perhaps fuels with certain additives), shipowners can reduce emissions per tonne of fuel burned.

- *Installation and operation of engine or funnel technologies (SCR/HAM/scrubbers)*. A variety of technologies have been developed that can be used to reduce emissions from ship engines—either by modifying the engine itself, or by installing equipment to reduce the emissions content of the exhaust.

- *Use of shore-side electricity ("cold ironing")*. By making use of electricity generated on-shore, vessels can reduce or eliminate the need to keep their engines idling while in port. This is likely to reduce net emissions, assuming that shore-side electricity generation is subject to higher emissions standards than ship engines.

- *Increasing operating or technical efficiency*. Reducing a vessel's overall fuel consumption by improving fuel and energy efficiency will lead to a reduction in overall emissions levels. In general, efficiency can be improved by modifying engine characteristics, increasing engine maintenance, reducing electricity consumption, improving ship

design, the use of antifouling paint, or adjusting the vessel's speed to travel using less fuel per unit of distance travelled.

- *Decreasing output.* If an economic instrument made operating costs higher, ships might choose to reduce output—i.e., make fewer trips or travel shorter distances.

- *Changing route*. Different routes may be desirable if certain shipping lanes contribute more to the damage resulting from shipping emissions than other lanes, or if certain ports are located in particularly sensitive areas.

The table below summarises the effects of the schemes considered here on the incentives for these various abatement options, as described below. Instruments that naturally create incentives for certain abatement options are represented by a check mark, while those that would require modifications from the specific implementations considered here are represented by a question mark.

It is also important to note that any of the approaches outlined here could be supplemented with subsidies designed to provide incentives for the installation of specific control technologies. For example, as in Swedish programme, a subsidy could be provided to shipowners who install SCR to reduce NO_X emissions. Thus, any of the programmes could be made to generate incentives for a particular technology, although such subsidies could also be viewed as going against the desire to allow market mechanisms to determine individual abatement choices.[40]

[40] As noted above, such subsidies have characteristics and effects similar to those of taxation programmes and thus are not considered separately here.

Table 10. Incentives of Economic Instruments for Various Abatement Options

Key: ✓ Designed to create incentives for the abatement option. ? Would require significant modifications to incorporate incentives for the abatement option.	Abatement Options					
Economic Instrument	Switch Fuels	SCR/scrubber/ HAM	Cold Ironing	Adjust Operating Efficiency	Reduce Operations	Adjust Route
Credit						
Simple	✓	✓	?	?		?
Rigorous	✓	✓	?	?		✓
Benchmarking						
Universal	✓	✓	?	?	✓	✓
Trading Consortia	✓	✓	?	?	✓	✓
Cap-and-Trade						
Exchange Rates	✓	✓	✓	✓	✓	✓
Geographic Formula	✓	✓	✓	✓	✓	✓
Taxation/Charging						
Tax at Pump	✓	?	✓		✓	
Fuel-use Tax/Charge	✓	?	✓		✓	?
Emissions Tax/Charge	✓	✓	✓	✓	✓	✓
En-Route						
Trip-Based Charges	✓	✓		?	✓	✓
Distance-Based Charges	✓	✓		?	✓	✓
Differentiated Dues						
Voluntary Port Dues	✓	✓	✓	?	✓	✓
Mandatory Port Dues	✓	✓	✓	?	✓	✓
Fairway Dues	✓	✓	✓	?	✓	✓

6.1. Fuel Switching

The most obvious and direct way of creating an incentive for shipowners to switch fuels would be through a direct charge on different types of fuels. However, because fuel type (e.g., sulphur content) directly affects ships' emissions *rates*, virtually any programme that monitored and charged[41] for emissions—either through continuous emissions monitoring or periodic monitoring coupled with some method of tracking fuel consumption—would create an incentive for shipowners to switch fuels. Thus, all of the

[41] In this section, we use the term "charge" to apply to both trading and charging programmes in the sense that both programmes would effectively "charge" ships—either explicitly through a tax or due or implicitly through a trading programme in which the market levies the "charge".

programmes outlined here would create incentives for fuel switching. The mechanisms through which these incentives would be achieved are described in the following sections.

6.1.1. Credit-Based Programmes

As noted above, a credit-based programme would be designed to monitor emissions rates periodically and keep track of ship position and overall fuel use or engine activity. Using fuels certified with lower emissions would allow shipowners to earn emissions credits, which would give them a direct incentive to switch fuels. Because the credit-based approaches described here would monitor emission rates only periodically, incentives to use new types of fuels or new additives would require that they be certified and accepted as reducing emissions and emission rates.

6.1.2. Benchmarking

Both of the benchmarking approaches described here would create an incentive for fuel switching because switching fuels can reduce a ship's emissions rate, which would free up allowances for sale in the market. For example, switching to 1.0 percent sulphur fuel would provide a surplus of 0.5 percent sulphur per unit of fuel consumed (if the benchmark rate were 1.5 percent), which could be sold in the market. Similar incentives would be generated for fuels containing additives with potential to reduce emissions—here again, if new additives were developed, the emissions characteristics of fuels containing them would have to be independently certified.

6.1.3. Cap and Trade

The requirement to use a form of continuous emissions monitoring under a cap-and-trade scheme would create the necessary incentives for fuel switching. This would be true for both cap-and-trade approaches described here.

6.1.4. Taxation/Charging

Any of the tax programmes described here would provide incentives for shipowners to switch fuels. As noted above, a differentiated fuel tax—levied either at point of sale or on fuel usage—would create a direct incentive for shipowners to switch fuels, because the tax would explicitly make certain fuels more expensive than others. It is important to note, however, that a fuel tax at point of sale would not create this incentive for all emitters, but only for those that cannot realistically refuel outside of EU waters. (This is discussed in more detail in a subsequent section.)

As noted above, a tax on total emissions would be coupled with continuous emissions monitoring. Thus, an emissions tax would create an incentive to switch fuels because shipowners would face higher costs when using higher-emitting fuels in European waters (because of their higher emissions).

6.1.5. En-Route Charging

En-route charging approaches would require vessels to pay based on the distance travelled or for specific trips completed, taking into account the vessel's weight and environmental characteristics such as fuel type or emissions rate. Vessels using fuel with higher average emissions would be charged more, and therefore vessels would have incentives to switch to lower-emitting fuels.

6.1.6. Differentiated Dues

Under any of the differentiated dues programmes described here, dues levels would be explicitly tied to calculated emission rates from each ship. Because emissions rates (particularly for SO_2) are related directly to fuel types, shipowners would be charged more for using higher-emitting fuels, thus creating an incentive for shipowners to switch fuels. For fuels seeking to reduce their emissions using additives, these would have to be explicitly recognized in the differentiated dues scheme, or the indexing or certification programme that the differentiation was linked to.

6.2. Installation or Operation of Abatement Technology

A variety of abatement technologies have been developed to reduce the amount of NO_X and SO_2 that engines emit. Some of these technologies (e.g., selective catalytic reduction, or SCR) are used widely on many engine types, while others (e.g., humid air motor, or HAM) are designed specifically for use on ship engines. These technologies reduce the emissions rate by altering the chemical reaction that takes place in the ship's engine and transforming the pollutants that are typically emitted into other substances that are not as harmful to the environment.

Like fuel type, abatement technologies affect ships' emissions *rates*. Thus, an economic instrument would need to charge shipowners on the basis of either total emissions or emissions rate in order to create an incentive for the installation of abatement technologies.

6.2.1. Credit-Based Programmes

Because shipowners would receive credit for reductions in their emissions rates under a credit-based programme, such a programme would naturally create incentives for shipowners to install abatement technologies. As in the fuel switching case, shipowners would only receive credit for the abatement technologies to the extent that they were certified as reducing emissions.

6.2.2. Benchmarking

As with credit-based programmes, under benchmarking programmes, the incentives to install abatement technologies arise from the prospect of being certified as emitting below the benchmark rate, or of actually emitting below this rate. Thus, both the benchmarking approaches described here would create incentives for installing abatement technologies.

6.2.3. Cap and Trade

Continuous emissions monitoring under a cap-and-trade programme would mean that shipowners could use abatement technologies to reduce emissions and free up allowances. Thus, like the other trading schemes, both cap-and-trade programmes would create incentives for the installation of abatement technologies.

6.2.4. Taxation/Charging

Neither of the fuel taxes suggested would naturally generate incentives for shipowners to install abatement technologies, because shipowners would not receive credit for accompanying reductions. However, taxation programmes could be modified to give vessels that had installed certified emissions abatement technology an exemption from fuel taxes. In this case, ships would have to undergo a potentially cumbersome certification process not commonly associated with fuel tax programmes, and the level of the exemption or tax rebate would have to be set for different technology types.

A tax on total emissions would, on the other hand, provide incentives for the installation of abatement technologies, since shipowners who had installed an abatement technology would have lower overall emissions thus pay less in taxes.

6.2.5. En-Route Charging

Because charges under an en-route scheme would be based on each ship's certified emissions rate, ships with abatement technologies installed would pay lower charges. Thus, an en-route programme would provide the necessary incentive for the installation of these technologies.

6.2.6. Differentiated Dues

All of the differentiated dues approaches described here would naturally be tailored to charge shipowners on the basis of their certified emissions rate. Thus, abatement technologies would result in shipowners paying lower dues, creating an incentive for the installation of such technologies. Incentives for operating the equipment would be maintained provided there was inspection and periodic monitoring of the use of the equipment. Note that if the differentiation were tied to other aspects—for example, fuel characteristics, as in the Swedish system for SO_2—then the dues scheme would have to be modified to provide incentives to install abatement technology.

6.3. Use of Shore-Side Electricity ("Cold Ironing")

The use of shore-side electricity would reduce a ship's total emissions and its fuel consumption. Thus, any instrument that charged ships on the basis of total emissions (rather than emissions *rates*) or increased the cost of fuel would create incentives for ships to employ cold ironing.

6.3.1. Credit-Based Programmes

Although neither of the credit programmes described here is explicitly specified to include incentives for cold ironing, a credit-based approach could be used to give incentives to use shore-side electricity by explicitly estimating baseline emissions in port (see, e.g. ENTEC 2002 for indicative estimates of in-port emissions levels and lengths of port stays). A vessel could then receive credit for the use of shore-side power, based on estimated reductions in emissions for every hour spent in port relative to a baseline scenario in which the vessel generated its own power. It probably would be necessary here to take into account any requirements applying to in-port emissions, such as requirements to burn only 0.2 percent sulphur fuel while in port.[42]

6.3.2. Benchmarking

Because benchmarking schemes charge ships on the basis of their emissions rates rather than their total emissions, such approaches would not naturally provide an incentive for shipowners to employ cold ironing. However, because benchmarking would increase the cost of fuel, there would be an incentive to reduce fuel consumption, which could be achieved through cold ironing.

As with credit-based approaches, for benchmarking to provide more explicit incentives to use shore-side electricity, there would need to be an explicit formula specifying the benchmark emissions and avoided emissions while at berth. It is likely that this benchmark would be separate from, and in addition to, any benchmarks applied while the vessel's engines were on—it would not be possible to credit emissions reductions based on emissions per unit of fuel consumed, for example, since no fuel would be consumed while the engines were off.

6.3.3. Cap and Trade

Because a cap-and-trade approach would effectively charge ships on the basis of their total emissions, either cap-and-trade programme described here would naturally create

[42] In determining the baseline, it would of course be important to take account of any special requirements that apply to vessels in port, for example, the proposed requirement that vessels burn only 0.2 percent sulphur fuel while at berth.

incentives for the use of cold ironing. Ships that elected to use shore-side electricity would free up emissions credits to cover other emissions or sell on the market.

6.3.4. Taxation/Charging

Taxation of fuel—either at point of sale or on the basis of usage—would provide additional incentives to reduce fuel consumption, and therefore could create incentives to make use of shore-side electricity.

Like a cap-and-trade programme, a tax on total emissions would naturally provide an incentive for the use of cold ironing because shipowners would be taxed for all emissions; thus, any reductions (such as those that could be provided by cold ironing) would generate gains for the ship.

6.3.5. En-Route Charging

Like benchmarking, en-route charging would base charges on ships' emissions rates rather than total emissions. Thus, en-route charging probably would not create incentives for the use of shore-side electricity, except to the extent that it created incentives for a reduction in fuel use. Incentives for cold ironing could be integrated directly into an en-route charging programme if an explicit discount in dues were included for ships making use of shore-side electricity.

6.3.6. Differentiated Dues

The differentiated port dues schemes described here could naturally create incentives for the use of shore-side electricity, via an explicit specification of the discount (or index points) given to ships making use of these facilities.

The situation is less clear for differentiated fairway dues schemes, since these may be applied to vessels that would not have an opportunity to use shore-side electricity because they did not visit ports. However, as for en-route charging, an explicit discount could be provided to ships for the use of cold ironing.

6.4. Increasing Vessel Efficiency

Like cold ironing, increasing the efficiency of a ship's engine reduces both fuel consumption and total emissions.[43] Any instrument that charged ships on the basis of *total* emissions or increased the cost of fuel would provide added incentives to increase the technical and operating efficiency of a ship (or adjust the vessel's speed, which reduces the

[43] A recent study for IMO (MARINEK 2000) has estimated that changes in operating procedures, including weather routing, ballast optimisation, and reduced speeds could reduce overall fuel consumption by up to 40 percent, which would dramatically reduce emissions of both SO_2 and NO_X.

vessel's fuel consumption per kilometre travelled). Such incentives would also encourage ships to invest in other efficiency-improving measures, such as more frequent maintenance, reducing electricity consumption, improving ship design, and the use of antifouling paint.

6.4.1. Credit-Based Approaches

As they are specified here, neither of the credit programmes would provide an incentive for increasing vessel efficiency. However, a credit-based programme could be designed to provide incentives for increasing technical or operating efficiency if it were possible to establish credible baselines for efficiency or operating procedures in the absence of the credit programme. Establishing such baselines could prove difficult, however. One option would be to establish a baseline rate of fuel use per tonne-mile travelled for different vessels, and then to monitor fuel consumption, distance travelled via GPS, and tonnes transported, to compare the vessel's performance against its baseline.

6.4.2. Benchmarking

As noted above, benchmarking would increase the cost of fuel and thus produce added incentives for fuel-saving measures, including efficiency improvements. However, because efficiency improvements would not affect ships' emissions rates (as defined here), benchmarking would not provide incentives for efficiency increases beyond those provided by the increase in fuel costs. It might be possible to develop a benchmarking approach that explicitly incorporated incentives for changes in operating efficiency; of course, such an approach would require the development of a separate benchmarking system or an explicit discount for operating efficiency improvements.

6.4.3. Cap and Trade

As with the other abatement measures, the combination of fixed allowances and continuous monitoring would cause cap-and-trade schemes to generate incentives for the reduced fuel consumption that efficiency improvements provide.

6.4.4. Taxation/Charging

As noted above for cold ironing, taxes on fuel would provide incentives to reduce fuel consumption, and therefore would also create incentives for efficiency improvements. An emissions tax would also create incentives for efficiency improvements because the charges would be based on total emissions, which are directly related to fuel consumption.

6.4.5. En-Route Charges

Because en-route charging applies standard factors to specific trips or distances travelled, it would not naturally create incentives for efficiency improvements. Thus, as they are specified here, the en-route charging options do not include incentives for fuel efficiency improvements. However, if different formulas were used for vessels with different fuel

efficiencies, or if fuel efficiency were an element of the charge, then it would be possible to generate added incentives for improvements in operating efficiency. Of course, adding such features to the programme could add significant additional costs.

6.4.6. Differentiated Dues

None of the differentiated dues programmes described here would create incentives for fuel efficiency measures. However, differentiated dues systems could provide incentives for specific efficiency measures by awarding index points or granting explicit reductions for such measures, or if fuel efficiency more generally were incorporated as an element of the charge or indexing scheme.

6.5. Reducing European Shipping Activity

If the approach used to control emissions made each kilometre travelled more expensive, a shipowner might choose to make fewer journeys or travel shorter distances in EU waters, reducing the overall "output" of the shipping sector.

6.5.1. Credit-Based Programme

A credit-based programme would not create an incentive to reduce the vessel's output, as credits are awarded on the basis of emissions *rates*, not overall emissions levels. Since the emissions rate stays constant, regardless of how many trips the vessel makes, a credit-based programme would not create an incentive for shipowners to alter their travels.

6.5.2. Benchmarking

Because benchmarking would make every kilometre of travel more expensive, it would create an incentive for shipowners to adjust travel. This is true for either of the benchmarking approaches considered here.

6.5.3. Cap and Trade

Because cap and trade caps total emissions, ships would be able to reduce emissions by reducing output, thereby freeing up allowances for sale in the market. Thus, such a programme would create natural incentives for reducing output.

6.5.4. Taxation/Charging

Due to the increased cost associated with each kilometre of travel, a shipowner would have an incentive to reduce output in the presence of either fuel tax. In the case of an emissions tax, a shipowner would have an incentive to reduce output because overall emissions would be reduced concurrently, making the shipowner's tax burden less.

6.5.5. En-Route Charging

Since en-route charging would increase the cost of each journey, there would naturally be an incentive for the vessel owner to reduce output.

6.5.6. Differentiated Dues

Differentiated dues would also increase the costs of each journey, therefore creating an incentive to decrease the vessel owner's level of output.

6.6. Changing Journey Route

By altering their routes, ships could potentially reduce the environmental effects of their emissions by emitting less in sensitive areas. For example, a ship might opt for a slightly less direct route to its destination, keeping it farther away from land for a larger portion of its journey, and causing less of its emissions to reach land. Alternatively, ships could reduce the environmental effects of their emissions by avoiding travel to ports in particularly sensitive areas.

In order for an economic instrument to create incentives for such route shifts, the instrument would need to incorporate geographic variation explicitly in the way it is constructed. That is, the instrument would need to charge more for emissions in more sensitive areas.

6.6.1. Credit-Based Programmes

Of the two credit-based programmes described here, only the rigorous approach, which would give emissions reductions in different locations different weights, would provide an incentive for shifting routes. The simple credit programme could incorporate a similar element of geographic differentiation, though it would of course require additional monitoring that might not seem reasonable for a less precise programme.

6.6.2. Benchmarking

Of the two benchmarking programmes specified in this report, only the trading consortia approach is explicitly designed to incorporate a geographical element. Thus, it would affect the incentives for a ship's route, while the universal benchmarking approach would not. The universal benchmarking approach could be geographically differentiated as well, though it would of course require additional monitoring of ship location.

6.6.3. Cap and Trade

Both of the cap-and-trade programmes described here naturally would include an element of geographic differentiation. That is, emissions reductions generated in port, for example, would be worth more than credits generated well out at sea. Thus, a cap-and-trade programme would provide an incentive for shipowners to adjust their routes.

6.6.4. Taxation/Charging

For the fuel tax schemes, it would be difficult to include an element of geographic differentiation and thus affect the incentives for altering routes. Under the point of sale tax, different fuel taxes could be levied in different locations, but this would probably not affect ships' routes substantially. An element of geographic differentiation could more easily be incorporated into a fuel-use tax; however, it would go well beyond the scope of a typical fuel-taxing programme and could substantially increase the cost of administering the programme.

An emissions tax, as it is specified here, would create incentives for adjusting route because it taxes emissions in different locations differently.

6.6.5. En-Route Charging

En-route charging programmes would naturally be designed to incorporate geographic differentiation and thus affect the incentives for choice of route and ports of delivery. Both the distance-based charge and the trip-based charge would create the right incentives, although it is unclear if either would have an advantage. The distance-based approach could better reduce overall emissions, but there is also the possibility in some circumstances that it could provide incentives for vessels to shorten actual distances travelled, to the detriment of environmentally sensitive regions.

6.6.6. Differentiated Dues

Of the differentiated dues options considered here, both the voluntary port dues and the fairway dues approaches would generate incentives for route changes, because the charges would be differentiated geographically. However, while the fairway dues would be differentiated to address environmental and health concerns, the voluntary dues programme would probably be differentiated randomly. Thus, although voluntary dues might create incentives for route changes, the route changes might not reduce the environmental effects of emissions.

Due to political concerns, it would be difficult to design the mandatory port dues scheme in a way that differentiated between different ports. Thus, at it is specified here, the mandatory dues programme would not affect the incentives for journey route, though theoretically this would be possible.

7. DETAILED QUALITATIVE ASSESSMENTS OF THE FEASIBILITY OF ALTERNATIVE MARKET-BASED INSTRUMENTS FOR SHIPPING

The likely performance of any of the specific market-based approaches to promote low-emission shipping in the EU will depend upon a host of factors. The objective of this study is to provide relatively broad assessments of likely feasibility, with an eye toward developing conclusions on which of the various approaches seem most promising for development of more detailed proposals.

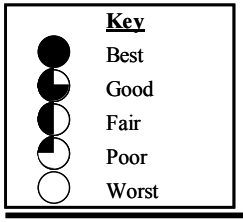
7.1. Summary of Assessments

Table 11 summarises our qualitative assessments related to the six market-based instruments outlined above. The table includes circles that provide a five-level ranking from best (solid black) to worst (solid white) along the various criteria.

It is important to recognise that the evaluations contained in the table are necessarily shorthand abbreviations for the more detailed evaluations contained in the descriptions below. In particular, it would of course be inappropriate simply to "sum across" for each of the potential instruments to pick the highest "score" on the table. Even if it were possible to score the alternatives in such a mechanical way, it would first be necessary to apply appropriate weights to each of the criteria. Some of the criteria are likely to be judged more important in an overall evaluation than others.

Before evaluating the individual instruments with respect to each of the criteria identified, it is useful to note once again the relationships between the criteria. For example, an instrument's cost-effectiveness can have an important indirect relationship to its environmental effectiveness, because with less expensive alternatives it is easier to reach political agreement on more ambitious environmental targets.

Table 11. Qualitative Assessments of Market-Based Approaches for Shipping



	Environmental		Economic Efficiency			Distributional				Institutional			
	Overall Emissions	Geographic Coverage	Cost Effectiveness	Dynamic Effects, Innovation	Tax Distortions	Shipowners Burden	Fuel Supplier Impacts	Port Impacts	Consumer/ Labour Effects	Legal Feasibility	Political Feasibility	Administrative Feasibility	Feasibility of Monitoring
Economic Instrument													
Credit													
Simple													
Rigorous													
Benchmarking													
Universal													
Trading Consortia													
Cap-and-Trade													
Exchange Rates													
Geographic Formula													
Taxation/Charging													
Tax at Point of Sale													
Fuel-use Tax													
Emissions Tax													
En-Route													
Trip-Based Charges													
Distance-Based Charges													
Differentiated Dues													
Voluntary Port Dues													
Mandatory Port Dues													
Fairway Dues													

The following are discussions of the reasoning and comparisons that lie behind these evaluations.

7.2. Assessments Based Upon Environmental Criteria

This section considers the extent to which the policy instruments are able to deliver overall environmental benefit for the emission of NO_X and SO_2. It also considers the ability of the instrument to be tailored to different geographical regions that may be more or less sensitive to emissions. For the purpose of these evaluations, we assume that the instruments work to their potential and that enforcement measures are effective. Difficulties associated with enforcement or implementation more generally are addressed in later evaluation sections.

7.2.1. Overall Emissions

When considering the effect of various trading programmes on overall EU emissions, it is of course important to take emissions from *all* sectors into account. A reduction in shipping emissions does not necessarily mean a reduction in overall EU emissions. For example, shipping emissions could be reduced, only to be offset by increased emissions from land-based sources or other sources in the transport sector. Increasing costs for the shipping sector but not for other forms of transport could encourage a modal shift away from shipping, and could result in emissions "leakage." Of course, most other transport sectors already have their emissions regulated, in one form or another, by existing EC directives. The Commission has expressed a desire to achieve a modal shift toward cleaner forms of transport in its 2001 White Paper (EC 2001). Other things being equal, additional costs levied on the shipping sector will make shipping more expensive (and therefore less attractive) to transport consumers. The only way to avoid modal shifts away from environmentally friendly transport modes is to enact legislation that causes *all transport sectors* to internalise fully their environmental costs.

The environmental effects of trading schemes follow almost directly from the level of free emissions set for covered sources. The environmental effect of a charging scheme depends crucially on the level of the charge—the greater the charge, the greater the emissions reduction will be. However, in contrast to a cap-and-trade regime, or indeed other trading alternatives, it can be quite difficult to predict what the environmental effect of a charging approach will be. The uncertainty arises because the costs of emissions reductions are not known with certainty. Thus, a major disadvantage of charging schemes—relative to any of the trading approaches—is that it will be difficult to know what level of charge will achieve the desired environmental goals.

On the other hand, charging alternatives are arguably better suited when the benefit per tonne of emissions reduction can be assessed with some certainty. In such a case, the charge per tonne could be set to a level that approximates the benefits of emissions reductions. Although the precise level of emissions reductions would still not be known in advance, the emissions level achieved by the charging alternatives could be assumed to

provide an appropriate balancing of costs and benefits. In practice, of course, it is difficult to determine the likely benefits from emissions reductions, particularly since the benefits can vary dramatically depending on their location (and thus on the likely exposure).

7.2.1.1. Overall Emissions Under Credit-Based Approaches

Like benchmarking, an opt-in credit programme would not guarantee a specific level of emissions from the shipping sector. Instead, selected ships would reduce their emissions so that they could benefit from emissions trading, but others could ignore the emissions market. All credit-based systems are subject to concerns that an appropriate baseline emissions level be set to avoid granting credits for "anyway tonnes," i.e., emission reductions that would occur without the credit programme.

Under a simple credit approach such as Option 1, emissions reductions in the marine sector would come either from a government subsidy programme or in lieu of emissions reductions from other land-based sources. Emissions from shipping sources would fall, because vessels that could reduce their emissions for less than the market price for allowances could earn credits and then sell them to the government or to land-based sources. As noted above, the total amount by which ship emissions were reduced would be uncertain. Moreover, the *net* additional environmental benefit of Credit Option 1 could be quite small if tied to a land-based system (rather than to a government subsidy programme). If the credit-based programme were tied to a land-based cap-and-trade programme, the overall emissions levels in the EU would not be substantially lower than they would have been under a cap-and-trade regime that covered only stationary sources.[44]

Under a more rigorous credit approach, because of the way in which the baseline is set to be below BAU emissions, overall emissions would likely be reduced even if the programme were tied to a land-based programme. In this case, the participation of shipping in the emissions trading scheme would contribute to reducing the overall volume of emissions in the region. (It would be useful to check that shipping emissions had approximately the same environmental consequences as land-based emissions.)

7.2.1.2. Overall Emissions Under Benchmarking

A benchmarking programme, on the other hand, would not establish an absolute emissions cap, and thus would not guarantee a specified emissions level or environmental benefit. Because the emission limits imposed by benchmarking programmes are relative limits, they do not restrict overall emissions levels—though of course they are expected to reduce them. For example, a fuel-based benchmark (under which ships are permitted to emit a certain amount of pollutant per unit of fuel consumed) would give ships incentives to reduce emissions *per unit of fuel consumed*, rather than to reduce total emissions.

[44] In fact, if the location of emissions is important, then the environmental *impact* of the emissions could worsen if higher emissions were allowed from land-based sources.

7.2.1.3. Overall Emissions Under Cap and Trade

Because a cap-and-trade programme would set an overall emissions cap for the marine sector, it is the only method that would guarantee a certain emissions level and fixed environmental benefit for the sector.[45]

7.2.1.4. Overall Emissions Under Taxation/Charging

A tax or charge on the sulphur content of fuel levied at the point of sale—or any pump-based tax—would probably have little impact on overall emissions. Because large container ships could simply fill their bunkers with fuel in non-EU countries, large ships would have little incentive to use lower sulphur fuels. Though such a tax would reduce emissions from ferries and smaller ships trading primarily within EU waters, the overall impact on emissions would probably be fairly limited. Indeed, such a tax could lead to an increase in emissions if ships ended up carrying fuel farther, thus increasing ships' average tonnage and the kWh necessary to move the ship. In addition, because NO_X emissions are much less closely linked to the type of fuel burned, it would be nearly impossible to control NO_X emissions using a fuel-based tax.

A tax or charge on fuel use would be equally ineffective in reducing NO_X emissions. However, a fuel use tax could be effective in controlling SO_2 emissions, because shipowners could not avoid it by filling up with cheaper, high sulphur fuels in non-EU ports. Indeed, the effect of a bunker-based tax would be similar to placing a limit on the sulphur content of fuel. Regulators would essentially use the tax to determine the sulphur content of fuel used by shipowners. Shipowners would simply select the fuel that minimized their total cost, taking the tax into account. If the tax made low sulphur fuels cost less than high sulphur fuels, then shipowners would choose to burn low sulphur fuels.[46]

A tax or charge on total measured *emissions* could be very effective at controlling overall emissions of either SO_2 or NO_X. Indeed, an emissions tax set at €30 per tonne would have an environmental impact equivalent to a cap-and-trade programme in which the allowance price were €30 per tonne. Of course, under a cap-and-trade programme, the price would be set by the market rather than by authorities. If uncertainty about the relationship between price and emissions is put to the side, then in theory, the environmental impact could be equivalent to a cap-and-trade programme.

7.2.1.5. Overall Emissions Under En-Route Charges

Like a fairway dues approach, en-route charging systems could be designed to allow coastal States to apply charges to ships that pass through their territorial waters while

[45] In addition, the incentive properties of cap-and-trade programmes discussed in Chapter 6 could facilitate agreement on more stringent environmental targets, providing still greater environmental benefit.

[46] Shipowners would also take into account any effects that varying sulphur contents had on operating costs.

emitting gases that cause environmental damage. En-route charges would provide slightly more accurate estimates of vessel emissions than a fairway dues approach, and therefore might be expected to reduce emissions somewhat more effectively. Of the two approaches considered here, the approach based on actual distance travelled would provide better environmental benefit, because it would be closer to actual emissions, rather than estimates based on standard or generic trip distances.

7.2.1.6. Overall Emissions Under Differentiated Dues

Among the charging schemes, those involving differentiated dues are perhaps in the widest use across Europe. Most existing port dues schemes are voluntary—that is, individual ports decide whether or not to differentiate dues and to what extent. As noted in Chapter 2, a voluntary port dues scheme is only one of the possible implementations of differentiated dues that could be used in the broader EU context. Indeed, the three potential implementations described in Chapter 2 would generate very different incentives to reduce emissions.

It is instructive to consider the experience of the Swedish differentiated dues scheme here. The scheme has been in place for over five years, and is currently under review. Its ultimate aim is to reduce emissions of SO_2 and NO_X of ships calling at Swedish ports by 75 percent from their 1996 levels. According to estimates published by the Swedish Maritime Administration, the scheme is estimated to have reduced SO_2 emissions by 50,000 tonnes and NO_X emissions by 27,000 tonnes (SMA 2001). These estimates are likely to overstate the actual environmental benefit of the programme, however, because they make relatively crude assumptions about what the level of emissions would have been without the scheme.[47] Another estimate published by an SMA official suggests that when more accurate estimates of BAU emissions are used, the environmental benefit for SO_2 would be closer to 8,000 tonnes. Based on these more accurate measures, he estimates that the programme has reduced emissions of SO_2 by just under 30 percent and NO_X emissions by around 10 percent (Swahn 2002, citing Mariterm 1999).

Scandinavian vessels were more likely to take advantage of the lower rates offered by the scheme (Lemieszewski 2003). This may be due to the fact that they were likely to spend more time in Swedish waters, but may also be due to their greater sensitivity to Swedish public opinion. One of the driving forces motivating adoption of cleaner operating technologies appears to have been public relations and corporate image for customers, because the direct financial benefit for ships was not sufficient to cover the overall costs of achieving the lower emission rates. As a consequence, Polish and German vessels were less likely to take advantage of the lower dues.

[47] For example, the estimates do not attempt to account for the fact that many vessels participating in the programme were already operating under low sulphur fuel, or that many vessels benefiting from the "low NO_X" charges already had NO_X emissions below the levels rewarded by the differentiation scheme.

Thus, in addition to the uncertainties about level of environmental effectiveness of the scheme, experimentation and additional experience are also required to understand how vessel owners will respond to the differentiated incentives. In Sweden the current review is intended both to examine how well the scheme has achieved its environmental goals, as well as whether it continues to provide authorities with sufficient funds to cover their activities. Although the scheme is intended to be revenue neutral, if overall receipts were lower than expected in the first years of the scheme, then in fact vessels would have received a net benefit from the introduction of differentiation. Though clearly this change in costs would not be sustainable.

7.2.1.6.1. Voluntary Port Dues Differentiation

A lack of cost transparency would clearly present a significant obstacle to developing a voluntary port dues system. Even ports that indicated that they were differentiating dues might well not reflect this differentiation in the final dues collected from shipowners. Uncertainty about the extent of adoption of differentiated charges and uncertainty about the effect of the charges on vessel behaviour, combined with the option for ports not to differentiate dues at all makes voluntary dues differentiation among the instruments least likely to yield environmental benefit.

One potential obstacle to the environmental effectiveness of the differentiated port dues options arises as a result of competition between ports, as well as the subsidies that many ports receive from local and member state governments. In essence, because ports are in competition with each other, it is not uncommon for them to offer unpublicised discounts to vessels in the hope of attracting them. Discounts are often granted to attract important customers, with charges up to 50 percent below official levels. Moreover, the increasingly competitive market means that actual agreed prices may be regarded as confidential business information (Kågeson, 1999). This lack of transparency in port dues means that vessels do not always pay the stated charges. Shortfalls may be covered from general government revenues. There is, therefore, some question as to whether differentiated port dues would be applied as officially stated, and therefore question regarding their ability to deliver the environmental benefit that would be realised if they were implemented perfectly. This may be less of a concern for fairway dues, because Member States could impose charges uniformly.

7.2.1.6.2. Mandatory Port Dues Differentiation

A mandatory differentiation system would not necessarily mitigate the complications that bargaining introduces. Indeed, even under a mandatory system, it would be difficult to determine whether—and to what extent—ports were actually implementing the differentiated dues. In addition, the general opacity of the pricing structure possibly would not generate significant incentives for individual shipowners to reduce emissions—the increased charges for higher emissions might not be as high as if an alternative instrument were used. At the very least, bargaining and price opacity would probably make

the differentiation less effective than might otherwise be expected. If the complications associated with bargaining could be overcome, then a mandatory differentiation system could theoretically achieve a significant level of emissions reduction. Yet, for such a programme to be truly effective, it could require a large-scale restructuring of the way ports negotiate dues.[48]

Barring a significant restructuring of port dues pricing structures, then, neither voluntary nor mandatory dues differentiation would have clear effects on overall emissions. The mandatory approach would be more likely to reduce emissions, but the overall effects are uncertain. Such schemes probably would only be effective if dues levels were able to become more transparent, which could be difficult given the increasingly competitive nature of port operations.

One final disadvantage of port dues approaches, both voluntary and mandatory, is that they would be unable to cover emissions from ships that did not stop in EU ports—*i.e.*, those ships that were merely passing through EU waters.

7.2.1.6.3. Fairway Dues

A fairway dues scheme would be better able to avoid the difficulties associated with port competition, because it would be administered at the Member State level. Charges could be set transparently and would not be subject to negotiation with vessels. Another potential advantage of fairway dues relative to port dues is that they would be better suited to covering emissions over a wider area.

7.2.2. Geographic Targeting

Table 2 indicates that geography can play an important role in determining the environmental impact of shipping emissions of SO_2 and NO_X. Emissions reductions generated in different regions might be valued differently under a trading programme. In the evaluations below, we consider the extent to which various instruments would be amenable to taking account of geographic variation in valuing emissions.

[48] Some of the complications associated with lack of transparency might be avoided by levying an environmentally differentiated *tax* directly on ports—with the expectation that these additional costs would eventually be passed on to shipowners in the form of environmentally differentiated dues. If such a tax effectively forced ports to internalise the environmental costs of shipping, it would be reasonable to expect ports to reflect these environmental costs in their dues structures. In order to ensure the success of such a scheme, it would be important to prevent ports from defraying the new costs of these environmental taxes by recourse to local or other government authorities—or any outside sources.

7.2.2.1. Geographic Targeting Under Credit-Based Approaches

Geographic considerations may be particularly important in the context of a trading programme that is integrated with a land-based emissions market. For example, if an opt-in programme were set up and all emissions were weighted equally, then shipping opt-ins could actually *worsen* environmental quality overall because of the difference between the impacts of emissions on land and at sea. The second credit-based approach, which would incorporate a geographically determined exchange rate, is designed to guard against this possibility. Credits earned at sea and in port would be weighted differently and differentiation could also be applied to different sea areas.

7.2.2.2. Geographic Targeting Under Benchmarking

Benchmarking approaches could also deliver geographically targeted improvements. The easiest way to achieve this would be to apply different benchmarks for emissions in different sea areas, with the most sensitive areas given the lowest benchmark. Unless trades were forbidden between different areas, however, trading could equalize the average emission levels in the differentiated regions. To prevent this "levelling," it probably would also be necessary to prohibit trading between the different sea areas. This approach would limit the potential for regional "hot spots" to develop by permitting ships to trade only with those vessels earning surplus allowances in the same region that they were operating in. Of course, such an approach would create greater complexity and cost, since it would require much more detailed monitoring of vessel location, and would require indexing emissions allowances to specific geographical regions.

A second approach would be to weight emissions in sensitive regions more heavily than those in less sensitive regions. An "exchange rate" approach like this would have the advantage of making emissions in sensitive regions more costly than those in other regions. Although it would still leave open the possibility of emissions "levelling" between the different regions, this would be less likely than under the first approach.

7.2.2.3. Geographic Targeting Under Cap and Trade

Cap and trade programmes would be able to achieve geographical targets by adopting restrictions similar to those in the benchmarking case. Under a cap and trade programme, because vessels are able to travel freely, it might be necessary to establish *separate* trading programmes with different caps for each region to ensure that specific environmental targets were met.

Alternatively, it would also be possible to apply a discount or exchange rate to allowances applied to emissions in sensitive regions—so that, for example, two emissions allowances could be required to cover a tonne of emissions in the most sensitive regions, thereby doubling the effective cost of emissions in the sensitive area.

7.2.2.4. Geographic Targeting Under Taxation/Charging

Neither a pump-based fuel tax nor a tax on fuel use would lend itself to differentiation on the basis of geography. Because the taxes would be based purely on the sulphur content of fuels, it would be difficult to include an element of geographic differentiation in either of these programmes.[49] Trying to introduce differentiation would result in a tax much closer to the emissions tax.

Emissions taxes could achieve specific geographical targets relatively easily, assuming that GPS and continuous monitoring or estimation of emissions was used. Under an emissions tax, administrators would have access to data about each vessel's specific location during the course of a trip. Using a simple algorithm, this data could be combined with information about the distance travelled and the ship's characteristics to estimate the cost of emissions from the ship's journey. Different charges could be applied to emissions in different geographical areas.

7.2.2.5. Geographic Targeting Under En-Route Charges

Because en-route charging differentiates the charges assessed for trips between different points, they would naturally accommodate geographical differentiation of environmental targets. When passing through environmentally sensitive regions, ships could be assessed a higher charge per tonne of emissions than when passing through other regions. En-route charging schemes would not necessarily distinguish between emissions close to shore and those far from shore for any given trip. To the extent that "near-shore" and "at-sea" emissions differed from vessel to vessel for a given trip (say, Rotterdam to Calais), en-route charging would not be the instrument best suited to such geographical fine "resolution".

7.2.2.6. Geographic Targeting Under Differentiated Dues

One potential disadvantage of port-level differentiation is that ports are unlikely to have jurisdiction over areas beyond their immediate waters. Thus there could be a concern that emissions might be reduced in port, but not outside the port. Although emissions in port are likely to have the greatest environmental impact per tonne, the bulk of emissions occur outside port (Table 11). It is therefore important to be able to target both in-port and at-sea emissions.

[49] Note that it would be possible to differentiate geographically under a tax on fuel-use, but this would be more easily accommodated via a tax on emissions.

Table 12. Ship Emissions in Port and at Sea, 2000

		NO_x		SO_2	
Vessel	**Location of Emissions**	kt	Percent	kt	Percent
Ferries	*At Sea*	406	11.5%	301	12.0%
	In Port and Manoeuvring	6	0.2%	6	0.2%
All Others	*At Sea*	2971	84.0%	2052	82.6%
	In Port and Manoeuvring	152	4.3%	156	6.2%
Total		**3535**	**100.0%**	**2515**	**100.0%**

Note: Excludes emissions from fishing vessels, which account for less than 3,0% of total emissions.
Source: Entec (2002).

In general, differentiated dues schemes would apply to emission rates. Under relatively simple dues differentiation approaches, shipowners would not necessarily face different charges for emissions in port or near to shore, and emissions at sea. Thus as with en-route charges, simple dues differentiation would have difficulty achieving geographically targeted reductions at this level. However, more complicated dues approaches would be able to achieve lower emissions reductions in port. For example, by including a dues reduction for ships that are able to take advantage of shore-side electricity, dues differentiation would be able to reduce emissions at port more than at sea. Furthermore, a dues scheme could include provisions to measure both "at-sea" and "at-berth" emissions rates—with the scoring for "at-sea" emissions rates allowing higher vessel emissions. This would allow dues differentiation to give additional incentives for lower emissions in port.

One way of implementing such an approach would be to differentiate between auxiliary engines and main engines. Under the Swedish programme, for example, the uptake of abatement technology such as SCR was greatest for main engines, because the high capital cost deterred many vessels from installing abatement technology on auxiliaries. However, because auxiliary engines are the ones most heavily used when vessels are in port, the environmental benefit of the abatement technology was not as high as it might have been. Thus it may be useful to authorities to set different charges or to apply different index weightings to vessels, so that auxiliary engine emission rates are treated differently from main engine emission rates.

Port dues are in theory well suited to geographical differentiation of environmental targets because dues can be set at each port individually. However, there are significant differences between the impacts of voluntary and mandatory schemes, and in practice it is not clear how well port dues would be able to achieve geographically differentiated targets. Voluntary approaches would allow ports in particularly sensitive areas to apply dues differentiation more stringently, but of course would not require that they do so. Thus the verdict for a voluntary port dues scheme is uncertain.

For mandatory dues differentiation, the evaluation is also somewhat ambiguous. Although in this case, all ports would be required to differentiate their dues in a particular way, the application of the same differentiation to ports in different regions would make it

difficult to differentiate geographically. And forcing some ports to adopt particularly severe differentiations of dues could be very difficult.

Differentiated fairway approaches may be better able to achieve regional geographical differentiation than port-based dues approaches. Member states could set dues for their waters and these could be differentiated without as much concern about distorting competition between ports, because Member States would be better able to coordinate their actions and charges than ports can.

7.3. Assessments Based Upon Efficiency Criteria

One of the primary advantages of market-based instruments is that they provide flexibility, which allows covered entities to comply in a way that reduces the overall costs of the regulations. These criteria include the overall cost effectiveness of the instruments, as well as criteria related to costs (both administrative and monitoring). In addition, we consider the incentives that the various instruments create for innovation, which can have an effect on the long-term cost effectiveness of the programme. Finally, we consider any effects the instruments have on taxes.

7.3.1. Cost Effectiveness of Abatement Incentives

Chapter 6 describes the ways that each of the instruments we consider could be used to provide incentives for a range of emissions abatement measures. Ideally, an instrument should be able to provide incentives for all of these measures, and to do so in a way that provides equal incentives to reduce a tonne of emissions regardless of the measure adopted. An instrument that worked perfectly would create incentives so that measures leading to the least costly means of achieving the environmental target were adopted. Here we summarise what the discussions in Chapter 6 mean in relation to each instrument's ability to create incentives for the least cost abatement measures. All of the instruments considered would provide better incentives than a simple command-and-control regulation, although the ultimate measure of cost-effectiveness requires consideration of administrative and monitoring costs as well as abatement measures.

7.3.1.1. Cost Effectiveness Under Credit-Based Approaches

Credit-based approaches can be reasonably cost effective, although it is important to keep in mind that they only yield emissions reductions from vessels opting into the scheme. Indeed, because the "Simple Credit" alternative would not provide any *additional* emissions reductions (but only reduces the cost of achieving existing land-based emissions targets), there is a sense in which it cannot be said to achieve cost-effective emissions reductions.

Credit-based programmes will also have difficulty providing incentives to reduce fuel consumption or shipping output as a way of reducing emissions, so they are not as efficient as a cap-and trade approach or direct taxation of emissions.[50]

One detail related to the "Rigorous Credit" option is worth noting. This option applies a mandatory reduction from BAU emissions to determine vessels' baseline emissions, to ensure that there is some environmental benefit from the credit programme. One consequence of this measure is that it may serve to exclude some shipping sources from the credit scheme that otherwise might have opted in. For example, if the baseline were set at 20 percent below BAU emissions rates, then a vessel that could only achieve emissions reductions of 10 percent at the emissions price in the land-based market would not opt into the scheme. Such a vessel would participate under the "Simple Credit" approach, however, since it would be able to sell its 10 percent reduction. Because the rigorous credit approach would reduce the number of sources willing to opt in—and the inexpensive emissions reductions that they are able to provide—it would also somewhat reduce the cost-effectiveness of the scheme.[51]

7.3.1.2. Cost Effectiveness Under Benchmarking

Benchmarking would be moderately cost-effective. It would include more sources than a credit programme, and therefore would be better at ensuring that all sources face the same incentives with respect to their emissions. (This is one requirement for ensuring that the most cost-effective measures are implemented.) On the other hand, because of the need to apply a "one-size-fits-all" approach with benchmarking, it could be more difficult to provide incentives for certain types of measures, such as cold-ironing.

Like most credit-based approaches, benchmarking would provide less of an incentive to economise on fuel or overall shipping activity than would a cap-and-trade system. In particular, a fuel-based benchmark would not provide efficient incentives for ships to reduce fuel consumption, and a benchmark based on average emission rates per

[50] The credit-based options considered here would not provide efficient incentives to reduce fuel consumption (or vessel activity) because the credits earned would be tied to the amount of fuel consumed. An alternative credit-based approach could provide a fixed number of credits to each participating vessel, instead of tying credits to fuel consumed or activity levels. The fluidity of the shipping sector could create significant problems for this approach—for example, a vessel could receive its fixed allotment of credits but then reduce its activity in European waters, while another non-participating vessel increased its activity, which would yield much fewer emissions reductions. Adopting this alternative approach to credits would be likely to impose dramatically higher administrative costs on the credit-based scheme.

[51] The exchange rate also might be thought of as changing the cost-effectiveness of the scheme, particularly if it were used as an alternative way to ensure real emissions reductions from the shipping sector. The reason is that emissions from shipping do not face the same price as emissions from the land sector. Under our "Strict Credit" option, however, the exchange rate would not reduce the environmental cost-effectiveness, because in the "Rigorous Credit" the exchange rate ensures equivalence of *impact* of emissions in different regions. The exchange rate is actually a way of correcting for an inefficiency in the "Simple Credit" approach, because it does not account for reduced impact of emissions from marine sources, relative to land-based sources.

unit of engine output would not encourage vessels enough to improve the efficiency with which that energy output was used. As a consequence, some relatively inexpensive ways of reducing overall emissions would be missed.

7.3.1.3. Cost Effectiveness Under Cap and Trade

Under a cap-and-trade programme, unlike the other two approaches a benchmarking programme, shipowners would have incentives to achieve emissions reductions using *all* available control options. This flexibility is the primary advantage of these programmes and can lead to dramatic savings, as was experienced in the US Acid Rain Program (see Ellerman et al. 2000). Thus cap-and-trade programmes are likely to be the most cost-effective at achieving a given environmental target.

7.3.1.4. Cost Effectiveness Under Taxation/Charging

The different taxation (or charging) approaches would vary significantly in their cost-effectiveness. A tax on fuel at point of sale might be effective in targeting emissions from ferries and other ships that operate almost exclusively in EU waters. However, such taxes charged at point of sale would not be very effective in reducing shipping emissions from large container ships or other large vessels, because of the possibility of purchasing and storing very large quantities of fuel from bunkers outside the EU. Thus a tax at point of sale would provide the least cost-effective incentives of the instruments considered here.[52]

Under a tax on fuel use, incentives would be slightly better, but would really only provide incentives for switching fuels or reducing consumption, and possibly limited incentives for installing abatement equipment if some form of rebate were included.

The emissions tax, on the other hand, would provide incentives to adopt all abatement measures, since for every tonne of emission reduced, regardless of the manner it was reduced, shipowners would be required to pay less tax. In effect, a tax on emissions "*automatically* minimizes the costs of control" (Tietenberg 1992, p. 373).[53]

[52] A fuel tax at point of sale could actually generate additional costs and have no—or even negative—environmental consequences. Because a tax on fuel content at point of sale would generate an incentive for ships to carry more fuel for longer distances to avoid the tax, ships might actually generate more emissions and have higher operating costs because they are carrying more weight over the course of each trip.

[53] The one measure that the tax would not provide the most cost-effective incentives for would be to reduce emissions by reducing output. Because shipping output is expected to grow, it will become increasingly difficult to achieve a fixed emissions target. Under a cap-and-trade scheme, the cap is fixed, and the price of emissions would rise automatically as shipping activity expanded and demand for allowances increased. Under an emissions tax, the price would not automatically increase, so emissions would be expected to increase. The level of the tax would have to be revised in order to impose the incentives necessary to achieve the desired environmental target. The incentives created are therefore somewhere between benchmarking/credit and cap-and-trade.

7.3.1.5. Cost Effectiveness Under En-Route Charges

An en-route charging scheme probably would not reward all forms of emissions reductions. Instead, shipowners would be rewarded for reducing their vessel's emissions rate (at the time of inspection) or switching to a route that was less environmentally harmful. Thus, certain novel solutions to reducing emissions would not necessarily be rewarded. For example, an en-route scheme would offer no additional incentives for more efficient use of fuel (unless fuel efficiency was also tested for each vessel) or improved logistics; it would therefore miss the potential to reduce emissions of NO_X or SO_2 offered by these abatement options. An en-route charging scheme that was not based on measured emissions rates, but on assumed rates, would further exaggerate these inefficiencies, because shipowners would have even fewer options for reducing emissions in exchange for an economic payoff.

En-route charging would provide better incentives than port-dues schemes for at least two reasons. First, it could include ships that do not actually stop in EU ports (although the method of collecting from such ships would have to be defined). Second, the amount charged could vary with the distance travelled, providing better incentives to reduce emissions associated with longer journeys.

A trip-based scheme would not give shipowners an incentive to improve the environmental impacts of that particular trip—although it would provide incentives to switch routes to account for the calculated environmental costs of their journey. A distance-based charging scheme, on the other hand, could track specific characteristics of each trip, giving shipowners an incentive to reduce the overall environmental impact of each route—in addition to the incentive to switch to less environmentally harmful trips. Thus, a distance-based approach would be more cost effective than a trip-based approach, though still less cost-effective than a cap-and-trade programme or the emissions tax, because estimated emissions would not be as accurate.

7.3.1.6. Cost Effectiveness Under Differentiated Dues

Because the differentiated charges probably would not be tied to *total* emissions but rather to average emissions *rates*, the incentive would be simply to reduce the emissions *rate* (at the time of inspection). Thus, novel solutions to reducing total emissions would not necessarily be rewarded. (Again, dues differentiation based merely on the presence of some control technology or fuel type, rather than a tested emissions rate, would exacerbate these inefficiencies). Differentiated dues would also not provide incentives to maintain greater distances from shore as a means of reducing environmental impacts.

Voluntary dues differentiation would be least cost-effective, because ports would be unlikely to impose the same charges, which would prevent vessels from equalising their marginal emissions abatement costs. Both mandatory (uniform) differentiation across all ports and Member State level differentiated fairway dues would create more cost-effective incentives, but still would not perform as well as many of the other instruments.

Though it is difficult to know how much of an effect these inefficiencies would have on abatement costs, environmentally differentiated dues would almost certainly result in higher abatement costs than a cap-and-trade programme, given a certain desired level of emissions reduction.

7.3.2. Dynamic Effects/Innovation

All economic instruments would generate an incentive to develop more cost-effective emissions abatement technologies and more environmentally friendly engine technologies. Because shipowners would be rewarded for reducing their emissions rates, they would have a strong incentive to find more cost-effective technologies. Similarly, increased demand for low-sulphur fuels would give petroleum firms incentives to reduce the costs of producing low-sulphur fuels. As with all economic instruments, these incentives can result in more rapid technological change than results from command-and-control regulations.

Of course, the level of incentives for innovation would vary with the level of stringency and the type of approach. The most important factors affecting the rate of innovation are the incentives provided for the efficient use of all abatement measures, which have been considered for each instrument in the previous chapter.[54] Closely related to this issue is the extent to which potential innovators can be certain that they will be able to benefit from measures that reduce emissions. Instruments that require administrative approval before a vessel could be credited for using an innovative new approach would be likely to provide lower incentives than approaches that automatically credited emissions reductions of any sort.

7.3.2.1. Dynamic Effects Under Credit-Based Approaches

Opt-in programmes would probably create the least incentives to innovate among the trading alternatives, because their voluntary nature would mean that a smaller number of sources would be covered. It could also be more administratively difficult to ensure that novel approaches to emissions reduction were rewarded under credits, since they would need to be approved and would not be credited automatically as could be the case under benchmarking or cap and trade.

7.3.2.2. Dynamic Effects Under Benchmarking

A benchmarking scheme covering all sources would give those sources incentives to find better ways to reduce emissions. The "trading consortia" option would create less of an incentive, because not all sources would have to participate in trading, although the incentives could be very similar because they would be conveyed indirectly via the price of low-sulphur fuel, for example.

7.3.2.3. Dynamic Effects Under Cap and Trade

Cap-and-trade programmes are likely to provide the greatest incentives to innovate, both because they reward all emissions abatement, and because the absolute cap means that incentives become greater as output in the shipping sector grows.

7.3.2.4. Dynamic Effects Under Taxation/Charging

The two fuel taxes described here would presumably increase demand for lower sulphur fuels, and would increase the incentives for petroleum companies to find cheaper ways of producing such fuel. (Under the point of sale tax, of course, the primary incentive might well be for shipowners to favour ships with larger bunkers that are more capable of carrying cheaper fuels purchased outside the EU.)

The incentives to innovate under an emissions tax to develop new, more affordable means of reducing emissions would, in theory, be somewhere between the incentives under benchmarking and a cap-and-trade programme. The high total cost of the tax could mean that firms would have greater incentives to devote scarce R&D resources to pursuing cost-saving innovations.

7.3.2.5. Dynamic Effects Under En-Route Charges

An en-route system would provide incentives for innovation similar to those under a port-dues scheme, although the incentives for logistical innovation could be greater. Under the distance-based approach, because the charges are more closely linked to actual emissions, there might also be greater incentives to innovate. There could, however, be some administrative delays associated with certifying new technologies as yielding the claimed emissions rate.

7.3.2.6. Dynamic Effects Under Differentiated Dues

In general, a port dues system would encourage innovation in measures to reduce emission rates, but the incentives created would not be as comprehensive as the incentives under cap and trade or emissions taxation. Thus, differentiated port dues would not induce the same level of innovation as a programme that was able to produce incentives for *every* kind of environmental improvement. Moreover, because fee rates might need to be adjusted to accommodate new approaches to reducing emissions, the incentives to innovate could be reduced.

[54] Note that the incentives for innovation might be increased for any of the instruments considered here if the programme were coupled with subsidies for specific abatement technologies, although subsidies to particular technologies could reduce incentives to pursue other equally promising technologies.

7.3.3. Tax Distortions

Net revenue-raising measures, such as a new sulphur tax or en-route charging programme—or a cap-and-trade programme with auctioned allowances—would provide revenues that could be used to reduce economy-wide tax distortions. The other options—including the other trading programmes or a revenue-neutral differentiated dues programme—would not allow this possible gain. (Because of the similarity of the various trading options with respect to effects on tax revenues, we consider them collectively here.) Whether such gains would be realized in practice would depend upon what specific tax or expenditure changes accompanied the net tax increase.

7.3.3.1. Effects on Tax Distortions Under Credit-Based Approaches

In general, trading instruments would not be expected to have beneficial effects to reduce existing tax distortions, because they would not provide revenues that could be used to offset other taxes. However, if the credit-based approach were funded through a government subsidy, this would, other things equal, increase government expenditures, potentially requiring additional taxes in order to pay for the programme.

7.3.3.2. Effects on Tax Distortions Under Benchmarking

Like most trading programmes, neither benchmarking approach would be expected to provide revenues and thus reduce existing tax distortions.

7.3.3.3. Effects on Tax Distortions Under Cap and Trade

Under a cap-and-trade programme, if the allocation were done via an auction, auction revenues could be used to offset other taxes and reduce distortions in the wider economy caused by other taxes. Otherwise, there would likely be no significant effect on taxes.

7.3.3.4. Effects on Tax Distortions Under Taxation/Charging

Because the takings from taxation approaches could be used to offset other taxes, these instruments could be used to reduce the distortions created by other taxes. To the extent that vessels receive rebates for low emission rates, or discounts (in the form of "free emissions"), this would reduce tax revenues, and therefore also reduce the potential to recycle revenues and reduce existing distortions. Of course, if these programmes were designed to be revenue neutral, they would not generate any funds for this purpose.

7.3.3.5. Effects on Tax Distortions Under En-Route Charges

The funds collected under an en-route charging system could also be used to reduce distortions caused by less efficient taxes. Again, the extent to which the en-route charging revenues would be able to do this would depend on the "free emissions" implicit in the level of the charge. As with the taxation/charging programmes, if these programmes were

designed to be revenue neutral, they would not generate any funds for the purpose of offsetting other taxes.

7.3.3.6. Effects on Tax Distortions Under Differentiated Dues

Differentiated port dues schemes could serve to reduce tax distortions if the dues schemes are not revenue-neutral, so that the additional takings are used to offset other taxes. Otherwise, the dues scheme would not affect existing taxes.

Differentiated fairway dues could be used to reduce tax distortions in cases where the activities that would be funded by new fairway dues were previously funded by general tax revenues.

7.4. Assessments Based Upon Distributional Criteria

7.4.1. Shipowner Impacts

As noted above, the Commission has indicated that it would be desirable to encourage a modal shift to shipping. The impacts of the various instruments on shipowners is likely to be a good indicator of how compatible the instrument is with this aim, all else being equal. Of course, if more stringent measures are put in place on other transport modes, any detrimental effects on shipowners could be mitigated.

One general concern for shipowners and operators that relates to all the trading alternatives is that emissions trading is likely to be unfamiliar to most of them. As a consequence, it may be necessary to undertake a substantial amount of training to help participants understand how to participate in emissions trading and how best to take advantage of the emissions market. In general, vessel owners and operators may not have the kind of commodity market experience that many large stationary sources have been able to draw on for the implementation of other emissions trading programmes. Although adapting to emissions trading is not impossible (many small and otherwise inexperienced operators successfully did so under the Los Angeles RECLAIM programme), it may involve significant initial investment of time and resources by both the regulator and the regulated. Thus while charging approaches in general are likely to impose greater direct costs on shipowners, the trading alternatives will have indirect costs that may be more difficult to quantify.

Finally, it is important to note that under all schemes, the ultimate burden to shipowners would depend in part on whether compliance costs, charges, and other costs could be passed on to other groups (e.g., forward to customers, and backward to fuel suppliers or ports).

7.4.1.1. Shipowner Impacts Under Credit-Based Approaches

Under the opt-in scheme described here, shipowners as a whole would likely *gain*—since opting in is by definition voluntary, the only ships to participate would be those that

are better off. In particular, shipowners with the opportunity to make inexpensive emissions reductions would be poised to sell allowances to stationary sources. Although individual shipowners could also gain under a cap-and-trade programme (if their gains from trade exceeded their total abatement costs), an opt-in scheme would generate *no losers* among shipowners. While those who could reduce emissions cheaply would do so, shipowners who could not reduce cheaply would be under no obligation to reduce, and would thus bear no compliance costs. This option is the most attractive from the point of view of ship owners and operators.

7.4.1.2. Shipowner Impacts Under Benchmarking

In a benchmarking programme, the burden on shipowners would depend upon the stringency of the emissions limit per unit of fuel. Shipowners would have to bear the cost of reducing emissions from the baseline level to the cap—or of purchasing allowances to substitute for reductions.

As discussed above, in general trading allows for flexibility in abatement strategies and for emissions reductions to be achieved at relatively low cost. Thus, given a specific level of emissions reductions, the out-of-pocket costs of achieving compliance would be low relative to other alternatives under a benchmarking scheme.

An additional burden would be placed on shipowners if they were required to pay for their own monitoring equipment, particularly if some of the more accurate approaches to monitoring were taken. This could represent a significant additional cost. The "tiered" approach to monitoring that would be in place under the "Consortium Benchmarking" alternative would be one way to reduce this cost, since vessels that would benefit from trading even after accounting for monitoring costs would be able to opt for trading, whereas vessels that did not believe the extra cost to be worth the effort could continue to comply with the standard command-and-control regulations and the monitoring regime that would accompany it.

7.4.1.3. Shipowner Impacts Under Cap and Trade

As with a benchmarking regime, under a cap-and-trade programme the stringency of the requirements—in this case the level of the cap—would determine the extent of the shipowners' burden. The abatement costs incurred by shipowners would be significantly lower than the costs to achieve the same total emissions levels under a command and control regulation—indeed, a cap-and-trade programme will minimize costs per unit of environmental impact. Abatement costs should also be less than the costs incurred under benchmarking, for the same reason.[55] The extent to which the burden is borne by individual

[55] Because cap-and-trade would place increasing pressure on shipowners over the longer term as shipping traffic in European waters increases, its impacts on shipowners would probably lead to higher costs in the longer term. However, if we assume that other instruments were used to achieve identical overall emissions from shipping, then the cap-and-trade approach will have a smaller impact on shipowners.

shipowners will also depend on the way in which allowances are allocated, as well as on the ease with which shipowners can reduce emissions.

7.4.1.4. Shipowner Impacts Under Taxation/Charging

If a tax on the sulphur content of fuel were implemented at point of sale, shipowners would have four options: pay the tax, use low sulphur fuels on which the tax was not levied, purchase fuel from outside the EU, or reduce operations. Shipowners would choose whatever combination of these options resulted in the lowest costs. Because shipowners would not have flexibility in their options, however, the cost to shipowners of achieving a given environmental goal would be higher under a fuel tax than under a more flexible programme. For large vessels, the increased costs of the point of sale tax would be relatively low, and would be largely logistical because of the inconvenience of having to refuel outside European waters. For other vessels spending all of their time in European waters, the costs could be substantially higher.

Similar considerations apply to a tax on fuel use. Because it too would not provide maximum flexibility to shipowners in terms of the options available for reducing emissions, it would result in higher compliance costs to achieve an equivalent emissions level. On top of this, the taxation of residual emissions, which would depend on the level of "free emissions" included in the charging structure, would add additional costs to shipowners. Indeed, both of these alternatives would impose a burden on shipowners that was similar to a command-and-control regime that specified the sulphur content of fuel. The taxation alternatives would provide some flexibility relative to a fuel-sulphur content rule, however, since they would give vessels the option of either paying the tax or paying the market premium on the lower-sulphur fuel. Finally, the monitoring costs borne by shipowners under the two fuel tax alternatives would be relatively low.

Because an emissions tax would give shipowners broad flexibility in deciding how best to reduce their emissions, it would come close to having the lowest *abatement* costs for achieving a given emissions level. As with cap and trade, however, the monitoring costs of this instrument would be high. In addition, because vessels would have to pay for their residual emissions (above whatever "free" threshold was set) the total costs of this alternative are likely to be quite high. If vessels were required to pay for all emissions, then this would be by far the most expensive alternative, and could easily result in costs that were higher than a command-and-control alternative.

Of course, if any of these programmes were designed to be revenue neutral, the impacts on shipowners would be significantly reduced.

7.4.1.5. Shipowner Impacts Under En-Route Charges

Abatement costs to shipowners would be moderate under the en-route approaches. Monitoring costs would also be low to moderate. Finally, and again depending on the level of "free emissions" implicitly contained in the charges, the overall costs could vary—from roughly the same as under a benchmarking approach, to as high as they would be under an

emissions tax. As with the charging approaches above, if any of these programmes were designed to be revenue neutral, the impacts on shipowners would be significantly reduced.

Shipowners might also be expected to bear some of the costs of periodic emissions tests.

7.4.1.6. Shipowner Impacts Under Differentiated Dues

Under differentiated port dues schemes, shipowners would face a relatively low burden, particularly if revenue neutrality of the dues were maintained. If a particular environmental target were required to be achieved under a voluntary scheme, however, then this could impose one of the higher total abatement costs, because of the possibility that many ports would not differentiate their dues sufficiently to create the necessary incentives to reduce emissions. A mandatory dues approach would fare better in this regard, but abatement costs would probably be higher under dues approaches than under the trading or emissions taxation options. Monitoring costs under differentiated dues approaches would be relatively low, and would entail only periodic inspections and some slight disruption to allow for random inspections.

The costs of fairway dues would be similar, except that because such dues are not currently in place in most Member States, it would be difficult to keep the charges revenue neutral, so that costs to shipowners would be higher than under the port dues approaches.

It is useful to consider the example of the Swedish harbour dues system here. Under the system, ships that had not made any emissions reductions continued to pay the same dues that they paid prior to the environmental differentiation (Hader et al. 2000), while ships that installed control technologies or switched to low-sulphur fuels paid lower dues than they had previously. As a whole, then, the shipping industry paid *less* in port dues under this differentiated scheme. To compensate for this lost revenue, the Swedish Maritime Administration increased fairway dues to an amount targeted to offset the lost revenue. If such a system were implemented EU-wide and overall revenues were kept constant, shipowners would collectively bear a slightly higher burden, because total expenditures on dues would be the same, and in addition, shipowners would bear compliance costs.

7.4.2. Fuel Suppliers Impacts

There are three general effects that could lead to impacts on EU fuel suppliers:

- a general reduction in shipping from business as usual ("BAU") levels
- a reduction in the average fuel consumed per ship; and
- a change in the types of fuels demand by shipowners.

In general, a reduction in shipping from BAU levels (i.e., shipping levels below what would be expected in the absence of additional regulation) would lead to less fuel being demanded overall from shipping sources. However, any reduction in shipping levels would

probably be offset—at least to some extent—by an increase in other transport modes. Since all forms of transport use some sort of fuel, it seems unlikely that the net impact of this particular effect on fuel suppliers would be very significant for most of the instruments described here.

Shipowners would also demand less fuel if they improved their overall operating efficiency. Thus, those instruments that created incentives for increasing operating efficiency would also affect fuel suppliers, because less overall fuel would be demanded.

Perhaps the primary source of impact from these programmes would stem from a shift in the types of fuels being demanded by shipowners. Specifically, all of the programmes described here are likely to increase significantly the demand for low-sulphur fuels and reduce the demand for high-sulphur fuels. Because refining fuels to reduce their sulphur content can be an expensive process, shifting the demand toward low-sulphur fuels could have a significant impact on fuel suppliers' costs. In that all of the instruments described here would create an incentive for lower-sulphur fuels, the extent of this impact would depend on the price premium which could be achieved for lower-sulphur fuels, and the flexibility that shipowners would have to reduce through other means of abatement (e.g., the use of scrubbers).

7.4.2.1. Fuel Supplier Impacts Under Credit-Based Approaches

Neither of the credit-based approaches would levy any additional costs on shipowners—if anything, they would reduce the costs of shipping. Thus, there would be no reduction in shipping volumes. The credit-based alternatives would also have minimal effects on the incentives for increasing operating efficiency. There is therefore no reason to expect a significant effect on the overall demand for fuels.

Because shipowners would have a fair amount of flexibility for reducing their sulphur emissions under credit-based programmes, the effects on demand for low-sulphur fuels, though potentially significant, effectively would be minimised under the credit approaches.

7.4.2.2. Fuel Supplier Impacts Under Benchmarking

Unlike the credit-based approaches, the benchmarking approaches would levy additional costs on shipowners. Because of the cost-effectiveness of these approaches, however, these cost increases would be lower than, for example, a purely "command-and-control" approach. The benchmarking options would also create incentives for increased fuel efficiency. Thus, there might be some reduction in overall fuel demand due to either benchmarking approach.

Like the credit programmes, benchmarking would provide shipowners with a great deal of flexibility for reducing sulphur emissions. Thus, the incentives for switching fuels would be similarly minimised.

7.4.2.3. Fuel Supplier Impacts Under Cap and Trade

Both of the cap-and-trade approaches would be extremely cost effective for shipowners. However, they would also create significant incentives to reduce fuel consumption—both through reductions in operations and increases in operating efficiency. Thus, there could be a reduction in the overall demand for fuel.

Cap-and-trade programmes provide the greatest flexibility of any of the trading options described here. Thus, they would minimise effects on low-sulphur fuel demand to the extent feasible.

7.4.2.4. Fuel Supplier Impacts Under Taxation/Charging

Both of the fuel taxation approaches described here would directly drive up the price of fuels and thus have a potentially significant effect on fuel consumption and demand. They would also provide significant incentives for an increase in operating efficiency, thus generating substantial incentives for shipowners to reduce fuel consumption. Effects of the emission tax on overall fuel demand, on the other hand, would be more similar to cap and trade.

Because the fuel taxes provide almost no flexibility in shipowners' ability to reduce costs, they would have the most significant effect of shifting fuel demand toward low-sulphur fuels of any of the approaches described here. The emissions tax would, on the other hand, have effects on fuel suppliers similar to the effects of a cap-and-trade approach.

One additional impact of a fuel tax at point of sale on fuel suppliers would be to cause shipowners to purchase more fuel from fuel suppliers outside of the EU. Large ships would have an incentive to fill up on fuel at non-EU sites in order to avoid the added cost of the sulphur tax. Thus, the demand for fuel in EU markets could be reduced significantly, depending on the size of the tax. However, because most fuel suppliers are multi-national corporations, this would probably not have a significant effect on their bottom line (though there could, of course, be an effect on EU employment levels).

7.4.2.5. Fuel Supplier Impacts Under En-Route Charges

Like most of the approaches described here, en-route charging would create additional costs for shipowners, causing them to reduce overall fuel consumption. In addition, because overall fuel consumption would be explicitly monitored, there would also be an incentive to increase operating efficiency. Thus, an en-route charge would generate a reduction in fuel demand.

Like the trading approaches, however, en-route charges provide a great deal of flexibility for reducing the charges. Therefore, the impact on the demand for low-sulphur fuels would be minimised to some extent.

7.4.2.6. Fuel Supplier Impacts Under Differentiated Dues

None of the dues schemes provide explicit incentives for shipowners to adjust their operating efficiency. Thus, there would be no effects on overall fuel consumption due to operating efficiency improvements. There might, however, be some impacts on fuel demand because of a reduction in the number of trips made by each vessel.

The dues schemes have somewhat more limited overall flexibility than the trading approaches, because they are based *only* on emissions rates. Thus, they might have greater impacts on (increasing) the demand for low-sulphur fuels than many of the other approaches described here.

7.4.3. Port Impacts

Because ports collect dues on the basis of the number of ships that berth there, the number of ships berthing in a given port affects the level of overall port dues collected. The primary source of impacts on ports would come in the form of a reduction in port dues collected due to a reduction in the number of ships berthing there.

The economic instrument programmes considered in this report could generally either affect ports overall or have distributional effects among ports. The overall effects on ports would stem from any reductions in overall shipping levels or from instruments that created specific incentives to reduce trips to port. Distributional effects among ports would generally be due to geographic components of various instruments that created incentives for ships to berth in different ports than they had previously. Thus, instruments that included elements of geographic differentiation could have both distributional and overall impacts on ports. These effects are considered in detail below.

Beyond this, ports as a group generally would not be substantially affected by the options other than port dues, except to the extent that the regulations increased the costs of shipping and thereby reduced activity at European ports—or to the extent that geographic differentiation favoured certain areas over others. The general effects on reductions in shipping levels are highly correlated to cost effectiveness and overall environmental objectives, as discussed throughout the report. Thus, these effects are not considered in detail here.

7.4.3.1. Port Impacts Under Credit-Based Approaches

The simple credit-based approach would not be designed to take account of geographic considerations and thus would probably have no effects on port activity. Even the rigorous credit approach would be unlikely to have significant effects on port activity because it would not explicitly create incentives for shipowners to reduce port activity.

7.4.3.2. Port Impacts Under Benchmarking

The universal benchmarking approach, as it is designed here, is not intended to account for a geographic component. Thus, it would not create any additional incentives for

shipowners to reduce trips to port. However, the benchmark rate for emissions in port would probably be lower than for emissions at sea, which would create some incentives for reducing port trips.

The trading consortia approach would be intended to differentiate reductions on the basis of broad geographic regions. Thus, there would be additional incentives for ships to avoid certain regions, which could have a distributional effect among ports.

7.4.3.3. Port Impacts Under Cap and Trade

The cap-and-trade approaches considered here both account for the geography of emissions. Thus, in-port emissions would be more costly than emissions out-of-port, creating an incentive for shipowners to reduce time spent in port (including the number of trips to port). These approaches could also have distributional effects among ports by making passages to ports in geographically sensitive areas more expensive.

7.4.3.4. Port Impacts Under Taxation/Charging

The fuel tax at point of sale would probably reduce incentives for ships to visit port because they would be less likely to fuel up in Europe (due to the increased cost of fuel there relative to other locations). The fuel usage tax, on the other hand, would not be explicitly tied to emissions location and thus would not have an effect on trips to port. Finally, the emissions tax approach is designed to differentiate on the basis of the location of emissions. Thus, it would have the same impacts on ports as, for example, the cap-and-trade approach.

7.4.3.5. Port Impacts Under En-Route Charges

Like the cap-and-trade approaches, en-route charging would make certain routes more expensive than others by basing the charges on the expected environmental or health effects of emissions in different locations. Thus, there would be an incentive for shipowners to reduce both trips to port in general and to ports in particularly sensitive areas in particular.

7.4.3.6. Port Impacts Under Differentiated Dues

Although a voluntary differentiated dues scheme could impact ports negatively, the scheme would be optional. Thus, port authorities would only choose to adopt the scheme if they felt it was in their interest.

The mandatory differentiated port dues schemes would require ports to establish a differentiated dues scheme established by the Commission. This would force all ports to restructure their dues, which could affect competition among ports and administrative costs in port. However, because the mandatory dues programme would not be designed to establish different differentiations in different ports, the scheme would not affect competition among ports for geographic concerns.

As noted, under the mandatory dues approach, ports would need to deal with the additional costs of administering the programme. Although the framework for charging port dues is already in place, there is little structure for monitoring or inspecting ship emissions. To the extent that ports were required to bear these costs, these would represent a burden on ports.

Because the differentiated fairway dues approach would not be explicitly tied to port dues, the fairway dues approach would have effects of a different nature on ports. The effects of a fairway dues approach would be more similar to those of the en-route charging approaches, which would be primarily distributional because they would make certain routes more expensive than others.

7.4.4. Consumer/Employment Impacts

Many of the programmes outlined here could lead to an increase in the overall cost of shipping goods into and within the EU, though in most cases the costs would be expected to be lower than under a command-and-control approach with the same environmental objectives. Nonetheless, an increase in transport costs would, in turn, lead to an increase in the overall cost of transporting goods and therefore a small rise in the overall price level experienced by consumers in the EU. Similarly, the increase in transport costs would probably lead to a decline in overseas demand for EU products. This would presumably lead to a decline in the demand for labour within the EU. However, the magnitude of these effects is likely to be small, and ought also to be weighed against the environmental and health benefits of the emissions reductions.

The extent to which each of these instruments generates impacts on consumers and employment levels again depends to some extent on the environmental goal and each instrument's cost effectiveness. That is, for a given environmental goal, the most cost-effective instruments will have the least overall effect on consumers and employment. This issue is not considered in great detail here, however, because it is addressed elsewhere in the report.[56]

7.4.4.1. Consumer/Employment Impacts Under Credit-Based Approaches

Because a credit-based programme could actually reduce the overall cost of shipping, it could have the opposite effect of the other programmes described here. That is, it could reduce the cost of consumer goods and increase demand for labour within the EU.

[56] Note also that the effects on consumers would depend on the extent to which increased costs were passed through to consumers.

7.4.4.2. Consumer/Employment Impacts Under Benchmarking

As noted, both the benchmarking approaches described here would increase the cost of shipping in the EU. These abatement costs would be passed on to consumers and reflected in a higher overall price level.

7.4.4.3. Consumer/Employment Impacts Under Cap and Trade

Like benchmarking, a cap-and-trade approach would increase the overall cost of shipping and thus increase the price level in Europe. However, as noted above, cap and trade is extremely cost effective, and thus would minimise the price increases for a given environmental benefit.

7.4.4.4. Consumer/Employment Impacts Under Taxation/Charging

Both of the fuel taxation approaches would cause increased fuel costs to be passed on directly to consumers. In addition, because the point of sale tax might shift fuel sales outside the EU, it could have an impact on EU employment levels.

The emissions tax would have roughly the same overall impact as the cap-and-trade approach with a market price for emissions equivalent to the tax level.

7.4.4.5. Consumer/Employment Impacts Under En-Route Charges

Both of the en-route approaches would also increase the overall level of shipping. These costs would probably be passed on to consumers as they would under the taxation approach.

7.4.4.6. Consumer/Employment Impacts Under Differentiated Dues

The port dues schemes, as they are designed, are intended to be revenue-neutral. Thus, any impacts on costs would be generated from added abatement costs.

In countries where there was not an existing fairway dues scheme, however, the fairway dues would levy additional costs on shipping, thus increasing shipping costs.

7.5. Assessments Based Upon Institutional Criteria

Although the primary purpose of this study is to assess the economic features of the various policy instruments considered, it is clear that institutional considerations will play an important role in the selection of policies to reduce emissions from shipping. Indeed, practical feasibility is a critical element in this study's recommendations—there is little point recommending an approach that has no chance of being implemented. We therefore discuss here the primary political, legal, and other practical issues as they relate to the instruments considered.

7.5.1. Legal Feasibility

Because all of the approaches presented here would have to operate in the same general legal framework, the legal overview provided above in Part 2, Section 3 is useful background for the discussion here.

7.5.1.1. Legal Feasibility Under Credit-Based Approaches

Because both of the credit-based approaches are entirely voluntarily, it is unlikely that they would face much challenge with respect to international law. With respect to EC law, however, there could be legal complications, because allowing ships to trade with land-based sources would probably require modification of at least two European Directives—the Large Combustion Plant Directive ("LCPD"), and the Integrated Pollution Prevention and Control ("IPPC") Directive. However, one advantage of this approach over some of the other instruments considered is that if it were to be applied to sulphur dioxide emissions, it would not necessarily require modification of the Commission's marine fuel sulphur proposal. This is because it would only give credit to those ships that reduced emissions below the limits set out in the directive, either by using lower sulphur fuel or by investing in abatement technology.

In particular, the LCPD contains provisions that require strict emission limits for combustion plants, or, in the case of existing plants (those licensed before 1987), national plans that would provide equivalent reductions. Although emissions trading by the existing combustion plants alone (under national plans) would provide flexibility to these sources, it would not be designed to increase overall emissions from land-based sources. A credit-based programme involving shipping, on the other hand, would involve increasing overall emissions from the land-based sources, and therefore it would probably be necessary to modify the legislation. (Of course, under the credit-based approach, the increased emissions from land-based sources would be compensated for by decreased emissions from shipping sources.)

As noted, the credit-based approaches could also be implemented via a government subsidy programme. Under current EU state aid rules, it is legally possible for Member States to subsidise the development and take-up of low emission shipping technologies (see Section 2.1).

7.5.1.2. Legal Feasibility Under Benchmarking

It is unclear how the "Universal Benchmarking" approach would fare with respect to international law. In order to pursue such an approach, the Commission would likely need to rely on the argument that emissions from ships in European waters were infringing upon its airspace. Although such an argument might be successful, the authority of the Commission or Member States to enforce the programme outside of their territorial seas (which extend 12 miles from the coast) could be questioned. Of course, it is equally unclear whether requiring a ship passing through a state's 200-mile exclusive economic zone to

purchase emissions rights would be considered a charge and thus a violation of the right of innocent passage. The "Universal Benchmarking" approach could also potentially be challenged for requiring the installation of monitoring equipment on ships, which could also be seen as an over-reach of Member States' authority and a violation of the right of innocent passage.

The "Consortium Benchmark" approach, however, would likely have more success with respect to international law, because it is voluntary. However, if it were to apply to SO_2, it could present some difficulty in that certain ships might exceed the sulphur fuel limits that MARPOL establishes for SOxECAs because their emissions would be offset by reductions from other vessels. Any necessary revisions to MARPOL would require IMO's approval.

Similarly, if applied to SO_2, both of the benchmarking approaches would require revision of the marine fuels directive, to allow vessels to comply with the emission limits via the use of abatement technologies, and also to allow vessels to emit in excess of the regulated limits when they purchase emission rights from other vessels. Both of these issues present political and legal challenges. The European Parliament recently considered proposals to allow emissions "offsetting" to be incorporated into the Directive, but the Commission has suggested that allowing offsetting would be premature at present.

7.5.1.3. Legal Feasibility Under Cap and Trade

The cap-and-trade approaches would face all of the political difficulties associated with the "Universal Benchmarking" approach. In addition, the need to deal with the problem of new sources, "occasional sources" (those entering European waters only very infrequently), and retiring sources would complicate the legal framework.

7.5.1.4. Legal Feasibility Under Taxation/Charging

In terms of both international and European law, the Member States clearly would have the authority collectively to establish a tax on the sulphur content of marine fuels. Of course, politically, it could be difficult to pass any such tax. (This is discussed further in the political feasibility section.)

For a straight emissions tax, and for a fuel-use tax, the case is less clear-cut. From the perspective of international law, the emissions and fuel-use charges are potentially subject to challenge on legal grounds under the right of innocent passage, because both approaches would clearly seek to *charge* vessels passing through territorial waters. (This is as opposed to a benchmarking or cap-and-trade programme where vessels would trade permits rather than be charged explicitly.) However, a fuel-use tax is probably less susceptible to challenge on the basis of concerns about equipment installation requirements, because it would not require the installation of monitoring devices, while an emissions tax (in the case of NO_X) would almost certainly require equipment to be installed. Note that a legal case could be developed to argue that the use of Member States' airspace for atmospheric waste disposal

constitutes a service being provided to vessels. Revenue-neutral approaches might be less susceptible to legal challenges, but it is likely that they would still face them.

7.5.1.5. Legal Feasibility Under En-Route Charges

In terms of international law, en-route charging would face the same potential challenge under UNCLOS as the direct taxation approaches. European law probably would not prohibit such a tax, though, again, any regulation targeting sulphur would likely require modification of the Directive on the sulphur content of marine fuels.

7.5.1.6. Legal Feasibility Under Differentiated Dues

Under international law, ports probably would have sufficient authority to enforce either of the differentiated port dues approaches. As noted in Davies et al. (2000), port states "may regulate, or impose environmentally-differentiated dues on, foreign vessels voluntarily present in its ports without restriction, other than those arising from: the (non-binding) rule of comity that the port/coastal state will generally not seek to exercise jurisdiction over matters considered part of the 'internal economy' of the ship; and its general internal obligations." In addition, the current existence of differentiated dues in a variety of ports likely provides sufficient precedent for the establishment of such dues throughout Europe. The fairway dues approach would probably face a greater legal challenge, because it would not be administered though ports, and could require significant revisions to national laws about the funding of maritime services.

7.5.2. Political Feasibility

In order to be implemented, the approaches described here would not only need to pass legal muster but also be politically acceptable to a wide range of stakeholders. This section considers the likelihood that the various approaches would face serious political obstacles to their implementation.

7.5.2.1. Political Feasibility Under Credit-Based Approaches

If a credit-based programme were funded via a government subsidy programme, the major political obstacle would be obtaining the funds for the subsidy. If a credit-based approach were to be linked to a market for land-based sources, the major political obstacle would, of course, be the current absence of any land-based trading scheme for SO_2 or NO_X. Alternatively, as already noted, in the absence of an existing programme for land-based sources, it would be possible to fund a credit-based programme using subsidies.

As mentioned above, the Large Combustion Plant Directive does allow some flexibility to Member States that would permit them to make use of emissions trading for land-based sources of NO_X and SO_2. The Directive states that EU Member States may draw up national emission reduction plans for "existing" combustion plants instead of ensuring that every plant on their territory complies with strict limit values. One key proviso is that

the same or greater overall emissions reductions from these combustion plants must be achieved nationally as would have been achieved by enforcing the limit values.

The Directive required Member States to communicate draft national plans to the Commission by November 2003. The UK, Ireland and Finland have communicated draft national plans and a number of acceding countries are known to be considering the possibility. At present national emissions plans do not provide for trading emissions between the large combustion plant sector and other industrial sectors. However, at least one Member State is considering the possibility of emission trading within its national plan. In the longer term it is therefore conceivable that land-based emitters in trading regimes could trade emissions with the maritime sector, provided that the desired environmental objectives were not compromised. If such trading schemes begin to take firmer shape in the next year or two, then there might be scope for, and interest in, including marine sources in future.

The simple credit-based approach might also meet with objections from environmental groups because it would not result in any further environmental benefit (unless accompanied by government subsidies). The rigorous credit-based approach would address this concern, however. Moreover, either credit-based approach could in fact help in the negotiation of more rigorous overall emissions targets, since the average cost of reducing emissions would be lower.

7.5.2.2. Political Feasibility Under Benchmarking

Political concerns about benchmarking approaches include both potential unintended environmental effects of various abatement technologies, as well as the difficulty of ensuring that vessels operating in excess of the average allowed benchmarks are held responsible if they are found not to hold the required number of emission allowances.

The consortium approach to benchmarking probably would make it easier to overcome some of the political obstacles to benchmarking, because it would be feasible to limit the number of vessels participating and to develop gradually the administrative procedures necessary to ensure that benchmarking were working properly. Initially shipowners and operators would have to apply to the relevant authorities with specific proposals regarding consortia, and would probably be required to accept responsibility for any failures to keep to the overall agreed emissions limits. As familiarity with the instrument increased and all parties gained confidence that it was working effectively, procedures could be streamlined and the programme could potentially be expanded.

7.5.2.3. Political Feasibility Under Cap and Trade

Cap-and-trade approaches would face all of the political difficulties associated with the universal benchmarking approach, because they would require a similarly complex enforcement regime. In addition, because a cap-and-trade scheme would not provide a mechanism to increase emissions limits as the shipping sector grew in size, it would probably face considerable opposition from most stakeholders involved in shipping.

In the case of benchmarking, it was noted that similar political obstacles could be overcome through the introduction of a less all-encompassing approach at the outset that permitted regulators and participants to develop some experience with the programme's mechanisms. Although a more simplified cap-and-trade approach is not presented here, a credit-based approach could be seen as a steppingstone toward the ultimate introduction of a cap-and-trade approach.

7.5.2.4. Political Feasibility Under Taxation/Charging

The fundamental political difficulty with all of the taxation/charging approaches is that they would likely require unanimous agreement by the European Council (see Davies et al. 2000), unless they were designed to be revenue neutral. However, even programmes designed to be revenue neutral could present a problem if revenue were to be recycled to foreign-owned ships. Taxation policy is notoriously difficult to reach agreement on, and this could prove to be an insurmountable difficulty for any of the approaches considered here. Indeed, the example of the proposed CO_2/energy tax, which failed to garner the unanimous support that it would have needed to pass, is instructive, according to Davies et al. (2000).[57] All three of the taxation approaches described here would likely face political challenges similar to those faced by the CO_2/energy tax.

7.5.2.5. Political Feasibility Under En-Route Charges

An en-route charging approach may be sufficiently similar to a tax that unanimous approval would be required for implementation, though it is somewhat unclear whether en-route charging would qualify as a tax, particularly if programme revenues were redistributed to shipowners. It is likely, however, that an en-route charging scheme would meet opposition from the shipping industry for reasons including the legal issues outlined above.

7.5.2.6. Political Feasibility Under Differentiated Dues

A voluntary differentiated dues approach is perhaps the instrument least prone to face political objections. Dues schemes are already in place, and they apply equally to vessels of all flags. Recommendations that they be differentiated are unlikely to face opposition, even from ports, provided the ultimate decision is left to port authorities.

Mandatory differentiation, on the other hand, would be likely to face strong opposition from port authorities. The European Sea Ports Organisation, for example, has indicated that it would oppose any move to impose mandatory dues differentiation on ports. There may, however, be intermediate solutions that would promote differentiation without mandatory restructuring of the way port dues are determined. For example,

[57] This said, the Maastricht Treaty offers a new possibility for enhanced cooperation, whereby a majority of Member States can pursue policy objectives without the support of the minority. This can only be pursued as a last resort, where Treaty objectives cannot be attained by applying the usual unanimity procedure.

authorities initially could permit ports to differentiate dues voluntarily in order to meet specific environmental targets. Then, if these targets were not met, authorities could impose mandatory dues differentiation.

Finally, the differentiated fairway dues approach would require a coordinated, though not necessarily unanimous, effort by Member States to institute fairway dues where these do not currently exist. This could require significant restructuring of the way that marine services are provided for, and therefore could represent a major challenge.

7.5.3. Administrative Feasibility

Almost any trading programme would probably be relatively expensive to administer—because of the mobility of sources, the variety of ships plying European waters, the variability of these ships from year to year (in that some may visit Europe once a year or less, whereas others may travel exclusively within Europe), and the sheer volume of sources (in excess of the 31,000 cited for the four months in 2000 surveyed in ENTEC 2002). Trading programmes would require that the emissions of all participating vessels be logged in registers along with the number of emissions allowances allocated or earned, purchased, and sold. Finally, it is likely that trading programmes would require a considerable amount of capacity building to familiarise ship-owners and -operators with how the system worked.

There is, however, a great deal of variability in the complexity of the trading approaches recommended here, because many are voluntary. Similarly, the various charging approaches would introduce a wide range of administrative complexity.

7.5.3.1. Administrative Feasibility Under Credit-Based Approaches

Credit-based approaches have the advantage of only applying to those ships that opt into the programme, which could reduce the administrative burden of keeping track of them. On the other hand, credit-based programmes require that emissions baselines, and usually the emissions reductions below those baselines, be certified before the credits are allowed by the regulator to count towards compliance. Depending on the rigour of the certification regime, these administrative costs have the potential to be very high.[58] Either of the two credit-based alternatives considered here could be associated with a greater or lesser degree of rigorousness.

The "Rigorous Credit" approach would also involve a significantly greater administrative burden because of the geographical differentiation that it includes. Governments or the Commission would need to determine the appropriate exchange rates to apply to emissions from different geographical areas or distances from shore. More detailed verification of the location of emissions would also be needed, which would probably require more resources.

[58] Administratively burdensome certification procedures have been cited as a major reason for the lack of success of some of the first emissions trading programmes in the US in the 1970s.

7.5.3.2. Administrative Feasibility Under Benchmarking

A benchmarking approach would not face the same baseline certification difficulties as a credit-based programme. Even so, there could be related issues associated with determining an appropriate benchmark to set for different emissions, particularly of NO_X. If benchmarks were differentiated by vessel type or predominant use, then some of the administrative burden associated with credit-based programmes could find its way into the benchmark scheme.

Under the "Universal Benchmark" option, all marine sources would be covered, so the number of sources to be dealt with could be substantially higher than under the credit-based approach.

Under the "Consortium Benchmark" option, only sources wishing to participate in trading would be required to adopt the monitoring, reporting, and liability requirements that would be necessary to implement trading. This could create a dual regulatory structure that would have additional administrative costs, but it could also serve to "cherry-pick" those operators and vessels that would be easiest to deal with administratively, while leaving out of the trading scheme smaller independent operators.

Finally, both benchmarking approaches introduce one important element into the trading system that credit-based approaches do not include, and that could add significant administrative costs. This element is related to the fact that the credit-based programmes rely entirely on land-based sources to provide demand for credits. Under a benchmarking approach, however, demand is provided by other shipping sources. This means that some shipping sources would be buyers, because they exceed the average required by the benchmark.

It is important to consider what this would mean in practice. Under current regulations, vessels could be held in port and fined if they were found to be burning fuel in excess of the 1.5 percent sulphur content. Under the benchmarking scheme, it would be expected that on average, perhaps half of all vessels could be burning fuel with sulphur content above the benchmark. As a consequence, there must be a way of distinguishing vessels that are in excess but that are or are expected to be buyers in good standing, from vessels that are in excess and that are or will be in violation. This could involve a shift from inspection of current vessel characteristics to keeping track of vessel emissions accounting. Given the intricacy of ownership and liability structures in the shipping industry, careful thought would be needed to ensure that leverage over vessels in violation would not be reduced as a result of the introduction of trading.

7.5.3.3. Administrative Feasibility Under Cap and Trade

For a cap-and-trade programme, administration could be complicated because of the complexity of the programme. Administrative costs would include the determination of initial allocations as well as setting up the trading market, including registries and compliance mechanisms. Determining allocations could be difficult, because there is

relatively little data on an individual vessel-level about historical ship emissions or fuel use—the data most often used to determine initial allocations. In addition, dealing with new sources—whether these were newly constructed vessels or vessels that had not previously entered European waters—could substantially increase the cost of administering the programme. The difficulties associated with allocation would be somewhat reduced by using an updated allocation in favour of grandfathering, but this would require that new allocations be set for each year.[59]

As with the other trading alternatives, varying the cost of emissions by geography would further increase administrative costs under any trading regime, because it would require some means of tracking the location of emissions.

7.5.3.4. Administrative Feasibility Under Taxation/Charging

The administrative feasibility of a taxation/charging scheme would depend on the particular implementation being pursued. Administering a tax at point of sale would probably be quite straightforward (except for off-shore bunkering operations) because the structure for charging fuel taxes on land is already in place. Although there would be some additional costs associated with certifying the sulphur content of various fuels, this could probably be implemented in conjunction with fuel grade inspections.

Administering the fuel-use tax would be substantially more complicated because regulators either would have to check fuel receipts and determine the appropriate charge for each ship, or would have to base the charges on self-reported or monitored estimates of fuel consumption and fuel characteristics. Such a tax could be administered through ports, or a completely separate independent body could be established to administer it. In either case, some entity would be required to collect the funds generated and possibly disperse it back to the shipping sector.

The administration of an emissions-based tax would be the most complicated of the taxation approaches, although it probably would be less expensive than a cap-and-trade scheme, and probably would be comparable to the other trading approaches. It would involve all of the administrative apparatus of the fuel-use approach, and would probably require more involved procedures for verification. Again, implementing geographic differentiation of charges would introduce substantial additional administrative complexity.

7.5.3.5. Administrative Feasibility Under En-Route Charges

Administering an en-route charging scheme could be difficult because there is no existing structure in place for introducing such charges. Administration could be simplified somewhat if the scheme were administered via ports, although this could make it more difficult for authorities to charge ships that were passing through European waters without

[59] Updating is typically criticised for not applying the best incentives to emitters, but the significance of these inefficiencies in the present case is uncertain.

stopping in port. Including transit traffic in the programme could make administration particularly complicated.

A trip-based programme would require substantial initial administrative investment to determine the relevant distances and corresponding charges for all possible trips through EU waters. Once this information had been developed, the administrators would need to track the movements of all ships moving through EU waters, presumably relying on information in vessel logs and port records. Administrators would also need to keep track of vessel emission characteristics, and appropriate inspection regimes would also need to be established. As with the other comprehensive approaches, keeping track of all ships and administering the charges could be quite costly.

A distance-based programme would avoid the large start-up cost of calculating relevant distances. However, data on location would need to be tracked for all relevant vessels. And as with the trip-based approach, this implementation would also require tracking and charging all ships in EU waters.

7.5.3.6. Administrative Feasibility Under Differentiated Dues

The structure for charging port dues is already in place. Thus, collection costs under a port dues regime would be marginal. While there would be additional administrative costs associated with the design of the differentiation scheme and the verification of vessel characteristics, the added administrative costs of a port dues system are likely to be the lowest of all instruments considered.

A differentiated fairway dues scheme would entail more administrative costs, because most Member States do not currently charge fairway dues. Again, the administration of fairway dues could be implemented via existing port dues administration, although this probably would involve considerably more work for ports. Moreover, it could also require complete reorganization of the ways that Member States provide maritime services to vessels in their waters.

7.5.4. Feasibility of Monitoring Regimes

Broadly speaking, there are two general approaches to monitoring—continuous and periodic emissions monitoring. Periodic monitoring approaches can be substantially less expensive than continuous monitoring methods, but the former are likely to sacrifice some accuracy.[60] The costs of continuous monitoring of emissions or engine activity are likely to decline as demand for these technologies increases. Groups such as SSA have suggested that

[60] In fact, there is also some evidence that, after a significant initial capital investment, a continuous emissions monitoring (CEM) system can generate cost savings. Experience from the US Acid Rain Program suggests that the use of CEM "may have encouraged more emissions trading and greater cost savings than would have been the case otherwise" (Ellerman et al. 2000). Indeed, Ellerman et al. note that for the US Acid Rain Program, in the long run, CEM "may prove to be a worthwhile investment," because it both eliminates the ongoing cost of regular inspections and gives the allowances more validity.

affordable continuous NO_X monitoring could become a viable possibility (SSA 2002). SSA, SEAaT and several other groups, in conjunction with PriceWaterhouseCoopers, are investigating the viability of various monitoring and verification techniques as part of the DEMO project. The alternative—periodic emissions monitoring combined with additional activity reporting—can achieve a high level of compliance when coupled with a stiff enforcement and penalty system.[61]

Generally speaking, the DEMO project has concluded that continuous emissions monitoring would be necessary to measure NO_X emissions with any significant level of accuracy, though continuous monitoring of engine characteristics combined with periodic emissions monitoring might provide some level of accuracy. For sulphur emissions, on the other hand, the DEMO project results suggest that periodic emissions monitoring, coupled with continuous monitoring of fuel consumption, could achieve reasonable accuracy.

7.5.4.1. Feasibility of Monitoring Regimes Under Credit-Based Approaches

The "Simple Credit" option would require periodic monitoring of vessel emission rates per unit of fuel consumed, combined with monitoring of fuel consumption (tonne-miles travelled could be substituted for fuel consumed here). Compared to the other approaches this would be relatively inexpensive, but it would still require that vessel activity be recorded. As with all periodic measuring approaches, care would have to be taken to ensure that where there are incentives not to maintain the lower emission rates at all times (for example, not to operate SCR), vessels are also required to certify that the lower emissions rate has been maintained (for SCR, this has been done by certifying the purchase of active ingredient urea).

Periodic certification does not take account of a number of factors other than control technology that can affect actual NO_X emissions, including operating conditions and engine temperature. The alternative method pursued under the "Rigorous Credit" option calls for continuous monitoring of engine characteristics like temperature and power output, which are particularly relevant for NO_X formation. This approach would be significantly more costly than a simple periodic approach, and could bring the cost of certification closer to the cost of continuous direct emissions monitoring.

7.5.4.2. Feasibility of Monitoring Regimes Under Benchmarking

Monitoring under "Universal Benchmarking" would be more complicated than under "Consortium Benchmarking". The Universal approach would require that all vessels adopt the monitoring and reporting procedures required to support emissions trading. The

[61] Such penalties can be important under a CEM regime as well, as in the US Acid Rain Program. The level at which penalties are set can be critical to the success of the programme. In theory, the penalty should be greater than the cost of abatement multiplied by the probability of being caught cheating. As Stavins (2000) notes, "[The US Acid Rain Program's] stiff penalties (much greater than the marginal cost of abatement) have provided sufficient incentives for the very high degree of compliance that has been achieved."

Consortium approach, on the other hand, would only require those sources that joined trading consortia to institute the more involved monitoring procedures, whereas other vessels would be able to maintain the same procedures that would be in place for complying with existing regulations.

For vessels covered by a benchmarking programme, the monitoring regime would be similar to what they would face under the credit programmes considered here. Vessels would need to monitor and report their fuel consumption (or tonne-miles travelled), and periodically would be required to submit certification of their emission rates per unit of fuel consumed (or per unit of some output measure). For some vessels this simply would involve certifying the sulphur content of fuel used. For others, it could require testing of the funnel exhaust when abatement equipment was running. For still others, it could require continuous monitoring of engine operating activity to estimate the actual emissions per unit of fuel burned or tonne-mile transported.

7.5.4.3. Feasibility of Monitoring Regimes Under Cap and Trade

A cap-and-trade approach for the control of NO_X emissions would involve continuous emissions monitoring for *all sources*, and would also entail monitoring vessel position to keep track of the location of emissions. Such a monitoring regime would undoubtedly be an enormous undertaking given the sheer number of marine sources. Along with the emissions tax, it would therefore be the costliest and most complicated instrument with respect to monitoring. A cap-and-trade approach to controlling sulphur emissions could have somewhat lower monitoring costs, as it is possible that monitoring of *fuel consumption*, combined with periodic emissions monitoring, would be sufficiently accurate.

7.5.4.4. Feasibility of Monitoring Regimes Under Taxation/Charging

Monitoring would not be necessary under the tax of fuel at point of sale.

The tax on fuel use would require certification of fuel sulphur content, and then monitoring of fuel consumed on each vessel in European waters, which could be done inexpensively via self-reporting, or more expensively through an automated system measuring fuel tank levels. If the fuel-use tax were administered through ports, it would also be possible for authorities to check fuel consumption during each port visit to calculate and collect the charge. These costs would be ongoing. The monitoring costs of all of these approaches would be relatively low.

The emissions tax, on the other hand, would have high monitoring costs. Emissions could be estimated via periodic monitoring of emission rates, as with benchmarking, but it may be preferable to use continuous emissions monitoring along with detailed GPS data. As with the cap-and-trade approach, periodic monitoring of emissions rates is probably more feasible for SO_2 than for NO_X, although as above it would have to be combined with monitoring of fuel consumption.

7.5.4.5. Feasibility of Monitoring Regimes Under En-Route Charges

Monitoring costs under trip-based en-route charging would be low to moderate. They would involve periodic monitoring and certification of vessel emissions rates and sizes, as well as keeping track of the journeys made by each vessel.

Monitoring costs under the distance-based en-route charging approach would be more expensive, because they would require a record to be kept of the distance travelled, as well as of the emissions rates and other characteristics of the vessel.

7.5.4.6. Feasibility of Monitoring Regimes Under Differentiated Dues

Monitoring costs under differentiated port dues schemes would be relatively low, because they would only involve periodic certification of emission rates and vessel characteristics. Fairway dues would also have relatively low monitoring costs, although there would be an added burden of applying the dues charge to transit traffic.

The Swedish system of differentiated port and fairway dues relies on a periodic system for testing and certifying NO_X and SO_2 emissions. NO_X emissions are tested and certified every three years by the Swedish Maritime Association. To benefit from reduced port dues for SO_2 emissions, shipowners must sign an affidavit, promising to use a certain type of bunker oil during all operations. Fuel characteristics are confirmed through a series of random, unscheduled checks (Hader et al. 2000). Vessels must also comply with certain requirements of their certification—for example, vessels operating SCR to reduce NO_X emissions must keep records of their purchases of the active input urea to remain certified. Thus vessels may have different monitoring requirements depending on the abatement measure. All vessels must have records available for inspection any time. For fuel sulphur content, samples are taken during most visits to port. For NO_X, inspections are significantly less frequent.

8. CONCLUSIONS AND NEXT STEPS

These analyses of market-based approaches for the shipping sector suggest some tentative recommendations for the approaches that seem most promising at this point. [62]The analyses also suggest some useful next steps for developing information to assess the desirability of a specific approach.

8.1. Tentative Recommendations

The various market-based approaches considered here share a number of advantages relative to less flexible regulatory approaches, such as a requirement that every ship achieve the same emission rate, install the same equipment, or use a certain type of fuel. Nevertheless, there are also trade-offs to be made when designing flexible instruments, and the approaches we consider reflect some of these trade-offs. As the summary assessments above suggest, there is a fundamental trade-off between: on the one hand, broader approaches that promise greater cost savings and environmental gains, but that would require substantial shifts in legal and political acceptability and significant administrative costs; and, on the other hand, more gradual approaches that would provide smaller cost savings and environmental gains, but that would involve less substantial administrative costs and fewer legal and political obstacles.

The detailed evaluations presented in this report and summarised in Table 11 suggest some tentative conclusions about the most promising approaches to regulating emissions from the European marine sector. It is important to note that, although the table provides qualitative "scores" for each of the instruments along a number of different evaluative criteria, it should not be interpreted as assigning any particular weights to the evaluation categories. (Thus, for example, the fact that there are more criteria in some categories than others does not signify that these categories are weighted more or less in the overall evaluations.) Rather, the instruments' performance against each criterion is considered in light of the overall environmental, economic, distributional, and institutional picture.

Some of the more ambitious programmes probably would be quite difficult to implement in the near term because of uncertainties about monitoring, enforceability, legal issues, and political constraints. Given this, our overall conclusion is that it would be wise to start with more gradual approaches. Because there has been relatively little experience to date with applying market-based instruments in the marine sector, these more gradual approaches could provide valuable experience. Indeed, if these initial approaches are successful, they could be expanded to include more sources and greater overall coverage.

[62] These tentative conclusions are recommendations are those of the study team and are not necessarily those of the Commission.

Although none is perfect, the three approaches listed below seem promising for at least the initial use of market-based instruments to promote low-emission shipping in EU waters, assuming a decision to go forward with some programme. Note that even these three approaches differ in the ease with which they could be introduced and thus the likely timing; the order below provides a preliminary indication of possible timing. In addition, it would be possible to combine one or more of the three approaches.

1. ***Voluntary port dues differentiation.*** This approach could build upon the experience of the Swedish system of integrated port and fairway dues differentiation, which has been positive. Indeed, the Swedish system might function as a model for what other Member States could adopt if they choose to implement port/fairway charges to finance marine services. The Commission could encourage this development by developing emissions indices and recommended differentiation formulas for ports to use. Indeed, it might be useful to create additional incentives to encourage ports to adopt these instruments voluntarily; for example, emissions targets could be established and progress monitored toward these targets, with the possibility that if the targets were not achieved more mandatory requirements could be put in place.

2. ***Consortia benchmarking approach.*** Allowing consortia of shipowners to band together to reduce the cost of meeting more stringent limits would provide gains both to shippers and to the environment. The more stringent limits would yield environmental gains, as would the development of differential ratios based upon vessel location and stricter emissions monitoring and reporting regimes. The voluntary nature of the programme would allow vessels that are able to benefit from emissions trading to do so. This approach, however, would still face legal and political challenges—notably the changes that would be required in the IMO and fuels directive—although the obstacles are likely to be smaller than for the credit-based approach. The primary difficulty would be to develop new rules and procedures for vessels that wish to be buyers on the emissions market.

3. ***Rigorous credit-based approach.*** This approach would provide experience with the market-based approach and also provide some environmental benefits as well as considerable incentives for shipowners to participate. Implementing the approach would still require legal and political actions by the Commission. Moreover, the approach would not be feasible without the development of either a cap-and-trade approach for land-based sources of SO_2 and NO_x (which could build upon the substantial US experience) or an explicit government subsidy programme.

8.2. Next Steps

All three of these approaches would build upon existing regulatory structures and provide incremental shifts rather than a wholesale transition to a market-based approach. Nevertheless, each of these three alternatives would require additional specification in order to provide the basis for a specific legislative/administrative proposal.

Key issues that would need to be investigated in order to develop specific detailed proposals for one or more of the tentative recommendations include the following.

- *Certification of credits*. For the credit-based approach, it would be important to develop procedures for certification of relevant baselines. As noted, there is a tradeoff between complexity of the certification/baseline procedures and likelihood of substantial credits being generated.

- *Legal/political requirements*. For all approaches it would be important to resolve any potential legal questions as to how the instrument would relate to the provisions of the Law of the Sea Convention and to existing Community law, and also to canvas Member States and stakeholders about their likely political acceptability.

- *Geographic differentiation*. It would be important to provide guidelines for the appropriate degree of geographic differentiation of emissions

- *Monitoring requirements*. It would be important to develop additional analyses of the precise monitoring requirements.

- *Subsidisation*. It would be useful to explore in more detail the possibility of subsidising ship emissions reductions, as a stand-alone measure and in parallel with other approaches.

- *Compliance requirements*. It would be important to specify precisely how compliance would be determined, and how violations would be treated.

9. REFERENCES

California Air Resources Board. 2000. *Air Quality Impacts from NO_X Emissions of Two Potential Marine Vessel Control Strategies in the South Coast Air Basin.* Final Report. Prepared by the California Air Resources Board and the South Coast Air Quality Management District in Consultation with the Deep Sea Vessel/Shipping Channel Technical Working Group. Sacramento, CA: CARB. November.

Corbett, James J. nd. "Updated Emissions from Ocean Shipping." Newark, Delaware: University of Delaware.

Davies, M.E., G. Plant, C. Cosslett, O. Harrop, and J.W. Petts. 2000. *Study on the Economic, Legal, Environmental and Practical Implications of a European Union System to Reduce Emissions of SO_2 and NO_X.* Middlesex: BMT.

Ellerman, A. Denny, Paul L. Joskow, Richard Schmalensee, Juan-Pablo Montero, and Elizabeth M. Bailey. 2000. *Markets for Clean Air: The US Acid Rain Programme.* Cambridge: Cambridge University Press.

Ellerman, A. Denny, Paul L. Joskow, and David Harrison, Jr. 2003. *Emissions Trading: Experience, Lessons, and Considerations for Greenhouse Gases.* Prepared for the Pew Center on Global Climate Change. Arlington, VA: Pew Center on Global Climate Change.

ENTEC UK Limited. 2002. "Quantification of emissions from ships associated with ship movements between ports in the European Community." European Commission. July.

European Commission. 2001. *European Transport Policy for 2010: Time to Decide.* Luxembourg: Office for Official Publications of the European Communities.

Hader, Dipl.-Geogr. Arnulf, Prof Dr Berthold Volk, and Prof Dr Manfred Zachcial. "Incentive-based Instruments for Environmentally Acceptable Sea Transportation." Bremen: Institute of Shipping Economics and Logistics. Project Number 2258.

Harrison, David, Jr. 1997. *Considerations in Designing and Implementing an Effective International Greenhouse Gas Trading Programme*, Cambridge, MA: National Economic Research Associates, October.

Harrison, David, Jr. 2002. "Tradable Permit Programmes for Air Quality and Climate Change," in *International Yearbook of Environmental and Resource Economics,* Volume VI, Tom Tietenberg and Henk Folmer (eds.). London: Edward Elgar.

Harrison, David, Jr. and Daniel B. Radov. 2002. *Initial Allocation Options for a European Greenhouse Gas Emissions Cap-and-Trade Program.* Cambridge, MA: National Economic Research Associates, Inc.

Harrison, David, Jr., S. Todd Schatzki, Thomas F. Wilson, and Erik Haites. 2000. *Critical Issues in International Greenhouse Gas Emissions Trading: Setting Baselines for Credit-Based Trading Programmes—Lessons Learned From Relevant Experience*. Palo Alto, CA: Electric Power Research Institute.

Hirst, David. 2002a. "Emission Reductions Trading for Shipping." Shipping Emissions Abatement and Trading ("SEAaT"). 8 December.

Hirst, David 2002b. "Which Emissions Reductions Should Shipping Trade." Shipping Emissions Abatement and Trading (SEAaT). 8 December.

International Marine Organisation ("IMO"). 2003. "Implications of the United Nations Convention on the Law of the Sea for the International Marine Organization." IMO. 6 January.

Kågeson, Per. 1999. "Economic Instruments for Reducing Emissions from Sea Transport." T&E Air Pollution and Climate Series 11, T&E 99/7.

Lemieszewski, Stefan. 2003. Conversation with NERA. 30 October.

MARINEK. 2000. "Study of Greenhouse Gas Emissions from Ships." IMO. March. URL: http://unfccc.int/issues/imoghgmain.pdf

Mariterm. 1999. "Utvärdering av miljödifferentierade avgifter för sjöfarten" ("Evaluation of environmentally differentiated maritime charges"). In Swedish. December.

Murphy, Tom M., Ray D. McCaffrey, Kathy A. Patton and Douglas W. Allard. 2003. "The Need to Reduce Marine Shipping Emissions: A Santa Barbara County Case Study." Paper #7055. Santa Barbara, CA: Santa Barbara County Air Pollution Control District.

Netcen. 2000. Benefits of Emissions Reductions. AEA Technology.

Nichols, Albert L. 1998. *Accounting for Location in NO_X Emission Trading Programmes: Empirical Results from the OTAG Region.* Palo Alto, CA: Electric Power Research Institute, Inc.

Nichols, Albert L. and David Harrison. 1994. *Key Issues in the Design of NO_X Emission Trading Programmes to Reduce Ground-Level Ozone.* Palo Alto, CA: Electric Power Research Institute, Inc.

Organization for Economic Cooperation and Development. 2001. *Environmental-Related Taxation in OECD Countries.* Paris: OECD.

Shipping Emissions Abatement and Trading (SEAaT). 2003. "SEAaT Presentation to Ms Hautala." 21 January.

Stavins, Robert N. 2000. "Experience with Market-Based Environmental Policy Instruments." Discussion Paper 00-09. Washington, D.C.: Resources for the Future.

Swahn, Henrik. 2002. "Environmentally differentiated fairway charges in practice—the Swedish experience." European Commission.

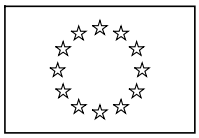
Swedish Maritime Administration ("SMA"). nd. "Environmentally Differentiated Fairway and Port Dues." Stockholm: Swedish Maritime Association.

Swedish Maritime Administration ("SMA"). 2001. *Annual Report*. SMA.

Swedish Shipowners' Association ("SSA"). 2002. "Emissions Trading Scheme SO_2 & NO_x." Prepared by Öhrlings and Price Waterhouse Coopers. June 26.

Tietenberg, Tom. 1992. "Environmental and Natural Resource Economics." Harper Collins Publishers. Third Edition.

ANNEX A: TECHNICAL ANNEX



EUROPEAN COMMISSION
DIRECTORATE-GENERAL
ENVIRONMENT
Directorate C - Environment and Health
ENV.C.1 - Air and Noise

TECHNICAL ANNEX

Study to assess the feasibility of market-based instruments to promote low-emission shipping in EU sea areas

1. INTRODUCTION

While the environmental performance of shipping is relatively good compared to other transport modes, atmospheric emissions from ships are a major concern in the European Union. A recent emissions quantification for the Commission[63] suggests that by 2020 ships in EU sea areas will emit almost as much NOx and SO2 as all land-based sources including other transport modes.

The Commission has been considering actions to reduce atmospheric emissions from ships, which will be set out later this year in a Commission Communication on a Community strategy to reduce atmospheric emissions from seagoing ships[64]. The pollutants covered by the strategy will be sulphur oxides (SO2), nitrogen oxides (NOx), volatile organic compounds (VOCs), particulate matter (PM) and greenhouse gases, principally carbon dioxide (CO2). As part of the strategy the Commission intends to publish a proposal to regulate on the sulphur content of marine fuels used in the EU (more details will be made available after publication of the Commission proposal later this year).

In developing the strategy, we recognise that market-based instruments could potentially complement or replace other regulatory measures, and help reduce ship emissions in an environmentally and economically effective manner. A previous study for the Commission in 2000 considered that the creation of an EU-wide emissions levy and rebate scheme could be feasible and desirable[65].

In its White Paper on a Common Transport Policy[66], the Commission also committed itself to developing an infrastructure-charging framework for all

---

63 Entec UK Ltd study for the European Commission, July 2002, "Quantification of emissions from ships associated with ship movements between ports in the European Community. http://www.europa.eu.int/comm/environment/air/chapter2_ship_emissions.pdf

64 For more details, see http://www.europa.eu.int/comm/environment/air/future_transport.htm.

65 BMT study on the implications of an EU system to reduce ship emissions of SO2 and NOx http://www.europa.eu.int/comm/environment/enveco/studies2.htm - 27

66 European transport policy for 2010: time to decide, COM(2001)370, published 12/9/2001. http://europa.eu.int/comm/energy_transport/en/lb_en.html

transport modes. Consequently, as part of the strategy, the Commission will propose to consider in more detail the possibility of developing market-based instruments as a means of reducing ship emissions in EU seas beyond levels currently achievable with international and EU regulatory standards.

2. OBJECTIVE

The objective of the study is to develop an option or set of options for possible market-based instruments to reduce atmospheric emissions from ships in the seas surrounding the enlarged European Union[67], and to make one or more recommendations on options for the Commission to pursue.

3. WORK REQUIRED

The contractor is required to assess the feasibility of a number of market-based instruments to reduce atmospheric emissions from ships in EU sea areas, and prepare an interim and then a final report on their findings. It is envisaged that the work will involve a detailed literature review, discussions with key stakeholders, and subsequent analysis.

3.1. The contractor should conduct an assessment of a number of market-based instruments, against a set of specific criteria.

The instruments and criteria are listed below; the contractor must consider at least these, but may also consider instruments and criteria in addition to those listed. As part of the assessment, the contractor should review existing or proposed schemes and legislation, as indicated in the footnotes.

List of market-based instruments which must be assessed (not exhaustive)

A. Emissions trading

- Between ships only (on the basis of absolute tonnes emitted or average emissions)[68]
- Between ships and land-based sources, (absolute tonnes only)[69]

B. Taxation

- On inputs (eg sulphur in fuel)[70]
- On emissions

---

67 Baltic Sea, North Sea, English Channel, Irish Sea, East Atlantic, Mediterranean Sea and Black Sea

68 See Shipping Emissions Abatement and Trading proposal at http://www.seaat.org/

69 See Swedish Shipowners Association proposal at http://www.europa.eu.int/comm/environment/air/consultation_responses/swedishshipowners_response.pdf

70 See Norwegian fuel sulphur tax at http://odin.dep.no/fin/engelsk/p4500279/p4500285/006041-990407/index-dok000-b-n-a.html

C. *En-route charging*

Based on emissions and/or kilometres travelled corresponding to the costs generated

D. *Differentiated charges or dues*

Differentiation of port or fairway dues in accordance with the level of emissions and costs generated[71]

List of assessment criteria which must be used (not exhaustive):

(1) *Environmental effectiveness*, in terms of likely reduction of emissions of different pollutants (principally SO2, NOx, but also CO2, PM and VOCs), and the likely location and therefore impact of those reductions

(2) *Practicality / enforceability at EU level*, including a consideration of institutional issues (who would be responsible for overseeing the operation of the instrument?)[72] and a consideration of possible classifications of vessels in accordance with the level of pollution they generate

(3) *Economic effectiveness*, including an assessment of likely overall cost variation, who would meet those costs, and how this might affect the competitive position of the maritime sector

(4) *Compatibility with existing EU and international legislation*[73]

(5) Likely *political acceptability*

3.2. The contractor should also address the following questions:

– With reference to the law of the sea and previous Community legislation, what, if any, legal barriers are there to the application of EU market-based instruments to EU sea areas? The answer should include a discussion of the geographical scope of such measures and where they might be enforced (ports, territorial waters, exclusive economic zone, pollution control zone, EU-wide, or even beyond?).

---

71 See Swedish Maritime Authority differentiated dues scheme at http://www.sjofartsverket.se/tabla-b-eng/pdf/b142.pdf

72 See Directive 2002/59/EC establishing a Community vessel traffic monitoring and information system, and Regulation (EC) No 1406/2002 establishing a European Maritime Safety and Ship Pollution Prevention Agency http://europa.eu.int/eur-lex/en/oj/2002/l_20820020805en.html

73 Including the UN Convention on the Law of the Sea, available from http://www.un.org/Depts/los/convention_agreements/texts/unclos/closindx.htm; Annex VI of MARPOL 73/78 (http://www.imo.org/), Directive 92/81/EC on the harmonization of the structures of excise duties on mineral oils, Directive 96/61/EC concerning integrated pollution prevention and control, and Directive 99/32/EC relating to the sulphur content of certain liquid fuels, (all available via Eur-lex search engine at http://www.europa.eu.int/eur-lex/en/search/search_lif.html)

– Are suitable emissions monitoring and communication technologies available or in the pipeline to allow verification of reduced emissions? If so, what are these technologies, and how much are they likely to cost? [The Commission will be able to provide the contractor with contact details of some experts in this field]. To what extent is the availability of such technologies a prerequisite to the effective operation of a market-based instrument to reduce emissions?

3.3. The contractor is required to present an interim report of their assessment at a stakeholder workshop, which will be organised by DG Environment. They should then finalise the report, taking into account the workshop proceedings. The final report should include:

– an executive summary setting out the pros and cons of each market-based instrument considered, against the criteria listed under 3.2

– a record of the proceedings of the workshop

– one or more recommendations for future action by the Commission in both the short term and medium term.

If future work is recommended, the contractor should include draft terms of reference setting out the scope of that work.

4. TIMETABLE

This is a nine month contract from date of signature. The contractor is expected to commence work immediately after signature of the contract, and to submit an interim report to the Commission four months later - ideally, by the end of April 2003, when it is envisaged that the stakeholder workshop will be held.

A draft final report should be submitted within eight months, and the final report completed within nine months after signature of the contract.

5. DELIVERABLES

The contractor should submit the interim report in electronic format to the Commission four months after signature of the contract, and subsequently give a presentation of the interim report at a stakeholder conference.

The contractor should then prepare a final report identifying one or more recommendations for the Commission services to take forward, and providing draft terms of reference for any subsequent work. The draft final report should be submitted in electronic format. The final report should be submitted in electronic format and in print (30 hard copies).

The contractor should allow for two meetings in Brussels as part of the tender. It is anticipated that a kick-off meeting will be held shortly after the beginning of the project, with a second meeting after submission of the interim report.

6. DESIRABLE CRITERIA OF THE SUCCESSFUL CONTRACTOR

It is envisaged that the successful contractor will be a team (including sub-contractors if necessary) with some expertise in each of the following areas:

- **economics**, with experience of the practical application of market-based instruments in environmental policy
- **law**, with knowledge of the EU and international law relating to the reduction of atmospheric emissions
- **engineering**, with up-to-date knowledge of different emission control and monitoring technologies for mobile sources
- **shipping**, with practical experience of the maritime industry

7. AWARD CRITERIA FOR THE CONTRACT

(1) Understanding: this criterion will be used to assess whether the tenderers have fully understood all aspects of the services required for the contract, as presented under point 3 of the technical annex as well as the content of the final product.

(2) Methodology: this criterion will be used to assess whether the method to be used will deliver results of the appropriate quality and accuracy.

(3) Availability and project management: this criterion relates to the rapid availability of the contractor, quality of project planning and organisation of the team to cope with and fulfil the obligations of the contract in the time required for the completion of the project.

Points: A maximum of 30 points shall be attributed to criterion 1, a maximum of 30 points to criterion 2 and a maximum of 40 points to criterion 3. Selected companies will have to score a minimum of 20 points for criterion 1, 20 points for criterion 2 and 30 points for criterion 3 with a minimum total of 70 points.

Budget: The budget is a maximum of €140.000 (including fees and all other costs).

Price: The bid offering the best value for money will be chosen, providing the minimum number of points is achieved. This is calculated by dividing the price by the number of points awarded.

ANNEX B: SUMMARY OF SHIP EMISSIONS STAKEHOLDER WORKSHOP 5 SEPTEMBER 2003

The Commission held a two-day workshop in Brussels for stakeholders in September 2003. The second day of the workshop (5 September) was devoted to a discussion of four broad categories of market-based instruments—emissions trading, differentiated dues, taxation, and en-route charging—and NERA's preliminary findings concerning these instruments. The workshop also covered general topics related to all instruments, including monitoring and verification, environmental impact, costs and revenues, and how to link a programme controlling ship emissions with programmes for other sources.

- **Participants discussed the criteria to be used to evaluate the prospective instruments.** Participants agreed that environmental effectiveness and cost (efficiency) were key evaluation criteria. Some participants also felt that political and legal feasibility and compatibility with international conventions should be given more prominence. Others advocated consideration of the speed with which the instrument could realistically be introduced. There was broad consensus supporting the need to ensure that any instrument was consistent with wider European transport policy, particularly the stated European policy of effecting a modal shift towards cleaner and more efficient water-based transport. Unfair distortions of distributional impacts also should be avoided.

- **Participants discussed the parameters to be used to establish the details of specific proposals.** NERA presented a list of parameters that included environmental goals and values, participants and areas covered, the extent of geographic and temporal flexibility provided by the instrument, "allocation" options for emissions trading, and monitoring, reporting, compliance and enforcement. Participants also discussed the distinction between local- and foreign-flagged vessels, as well as the specific gases to be covered and options for linking to other policies for reducing emissions.

- **The workshop considered specific alternatives outlined by NERA and other participants.** Participants agreed that any of the trading options probably would require modification of existing legislation at the national, European, and international levels. A slight majority appeared to favour the benchmarking approaches over the credit-based approaches. Some participants raised concerns about the possibility of local exceedance of emissions limits under emission s trading. The charging alternatives garnered less support due to concerns about potentially higher costs and distortions to competition in the shipping industry, possible state aids concerns associated with revenue recycling, as well as the potential need for unanimity across all Member States. It was suggested that harmonisation across transport modes could be easier with charges, however.

- Results of the DEMO pilot project on monitoring were reported and discussed along with general issues related to monitoring and verification. Results of early

DEMO trials suggested that accurate continuous monitoring of emissions or emissions proxies, and of position, is feasible. However, foolproof and tamper-proof methods currently would be quite expensive. A balance may need to be struck between accuracy and cost, and also between the monitoring of emissions and the verification of data and procedures used. However, many operators may support accurate monitoring in order to safeguard the value of emissions reductions. The adequacy of existing IMO and ISO standards was discussed.

- **Participants discussed the need for and possibility of geographically differentiating the instruments considered.** There was general consensus that different regions had different environmental sensitivity—these differences are already reflected in international agreements and European legislation. Ideally the instrument or instruments chosen also would be able to reflect such differences. It was also suggested that further study of the impacts of marine air emissions, particularly on land-based receptors, were needed to be able to design a cost-beneficial instrument with appropriate emissions reduction targets.

- The workshop concluded with a review of issues related to integration with other EU policies, and a discussion of the distribution of costs and revenues. One participant suggested that state aids issues associated with revenue recycling could pose a problem. Participants affirmed their concern that shipping was not disadvantaged relative to other transport modes was also reiterated.

The following is a summary of the key outcomes of the workshop.

- **Market-based instruments (MBIs) for reducing ship emissions raised considerable interest,** particularly sulphur emissions trading possibilities, which have been promoted by some industry groups, and supported in principle by Alexander De Roo MEP, European Parliament rapporteur on the marine fuel sulphur proposal. NERA used the workshop as an opportunity to seek input from stakeholders for the study examining the feasibility of various different MBI options. At the time of the workshop, not all of the specific details of each of the MBI options to be considered had been finalised. In addition, most of the MBIs presented would require accurate emissions monitoring technology, which is still being developed.

- **The Commission services stated that MBIs offer considerable potential to achieve cost-effective environmental benefits.** For shipping, one particular advantage of MBIs is that they could offer incentives for foreign-flag ships to abate their emissions while in EU waters. With regard to the possibility of sulphur trading, the Commission services indicated that they remain committed to the proposed 1.5 percent fuel sulphur limit for all ships in the Baltic Sea, North Sea and English Channel SO_XECA—a key element of the EU marine fuel sulphur proposal and of MARPOL Annex VI, which is yet to enter into force. After the

entry into force and implementation of the SO_XECA, ship sulphur emissions trading could be considered by the EU and the IMO as one option to deliver incremental emissions reductions in future. As a follow-up to the NERA report, the Commission services stated that they will examine the use of MBIs for all shipping emissions in the context of the CAFE programme.