MPP-EAS/Info/99/191

Natural Resource Damage Assessment and the Malacca Straits

March 1999

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Published by the GEF/UNDP/IMO Regional Programme for the
Prevention and Management of Marine
Pollution in the East Asian Seas

Printed in Quezon City, Philippines

A GEF Project Implemented by UNDP

MPP-EAS/Info/99/191

MISSION STATEMENT

The primary objective of the Global Environment Facility/United Nations Development Programme/International Maritime Organization Regional Programme for the Prevention and Management of Marine Pollution in the East Asian Seas is to support the efforts of the eleven (11) participating governments in the East Asian region to prevent and manage marine pollution at the national and subregional levels on a long-term and self-reliant basis. The 11 participating countries are: Brunei Darussalam, Cambodia, Democratic People's Republic of Korea, Indonesia, Malaysia, People's Republic of China, Republic of the Philippines, Republic of Korea, Singapore, Thailand and Vietnam. It is the Programme's vision that, through the concerted efforts of stakeholders to collectively address marine pollution arising from both land- and sea-based sources, adverse impacts of marine pollution can be prevented or minimized without compromising desired economic development.

The Programme framework is built upon innovative and effective schemes for marine pollution management, technical assistance in strategic maritime sectors of the region, and the identification and promotion of capability-building and investment opportunities for public agencies and the private sector. Specific Programme strategies are:

- Develop and demonstrate workable models on marine pollution reduction/prevention and risk management;
- Assist countries in developing the necessary legislation and technical capability to implement international conventions related to marine pollution;
- Strengthen institutional capacity to manage marine and coastal areas;
- Develop a regional network of stations for marine pollution monitoring;
- Promote public awareness on and participation in the prevention and abatement of marine pollution;
- Facilitate standardization and intercalibration of sampling and analytical techniques and environment impact assessment procedures; and
- Promote sustainable financing mechanisms for activities requiring long-term commitments.

The implementation of these strategies and activities will result in appropriate and effective policy, management and technological interventions at local, national and regional levels, contributing to the ultimate goal of reducing marine pollution in both coastal and international waters, over the longer term.

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Regional Programme Manager
GEF/UNDP/IMO Regional Programme
for the Prevention and Management
of Marine Pollution in the East Asian Seas

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Acknowledgments

This report was prepared by Prof. Thomas A. Grigalunas and Dr. James J. Opaluch, University of Rhode Island, in partial fulfillment of a contract with the GEF/UNDP/IMO Regional Programme for the Prevention and Management of Marine Pollution in the East Asian Seas. The work represents one component of the Malacca Straits Demonstration Project, which was implemented in collaboration with the generous assistance of several government departments and agencies in the three littoral States of the Malacca Straits. These efforts were coordinated by the Environmental Impact Management Agency (BAPEDAL), Indonesia, the Department of Environment, Malaysia, and the Ministry of the Environment, Singapore.

Technical advice and support from Dr. Chua Thia-Eng and Dr. Huming Yu of the GEF/UNDP/IMO Regional Programme Office, Manila, are most appreciated. Technical assistance and copyediting by Ms. Bresilda M. Gervacio and copyediting and layout by Ms. Florisa Norina L. Carada are also acknowledged.

The Malacca Straits Demonstration Project is coordinated by Mr. S. Adrian Ross, Senior Programme Officer, GEF/UNDP/IMO Regional Programme for the Prevention and Management of Marine Pollution in the East Asian Seas.

Executive Summary

Transboundary pollution in the Straits of Malacca poses substantial threats to valuable coastal and marine natural resources of the three littoral States of Indonesia, Malaysia and Singapore. Natural resource damage assessment (NRDA) can be an important mechanism for: (1) compensating those suffering losses and restoring the environment and (2) providing financial incentives to operators to avoid pollution. For these reasons, NRDA is of increasing interest to many states concerned with sustainable approaches for preserving and restoring coastal resources threatened by marine pollution.

NRDA is a process that uses economic, scientific and legal principles to assess the consequences of pollution in monetary terms. The ultimate objective of NRDA is a monetary claim against the party responsible for pollution; hence NRDA involves inherent tensions between the interested parties—industry, government, coastal businesses, insurance companies and the public. It is relatively a new area of study and has been evolving rapidly, although many challenges remain.

This report focuses on economics and explores the feasibility of a Straits-wide approach for assessing natural resource damages in the Straits of Malacca. Emphasis is given to damages due to harm to publicly controlled natural resources, rather than to private losses, since the latter are relatively easy to assess compared to natural resource damages and the incentive and legal means usually exist to pursue such claims.

Currently, the littoral States have an umbrella legislation that prohibits and penalizes polluters, establishes guidelines for responding to spills and assessing some damages. The Civil Liability Convention and Fund Convention and the respective 1992 Protocols to those conventions also provide guidelines for compensating for some losses due to spills of persistent oils from tankers. However, international conventions adopt a restrictive view of the incidents and categories of damages covered. As a result, many pollution costs are uncompensated for under current arrangements.

This report does not recommend what individual countries should do in NRDA. Rather, it reviews damage assessment, liability and compensation regimes with a view to their application as a financial mechanism in the Straits of Malacca. The report includes an analysis of the potential for and implications of, a Straits-wide approach for damage assessment for oil and other priority pollutants from shipping activities, as well as other transboundary pollution problems. Another paper examines other sustainable financing

mechanisms for preventing and controlling pollution from shipping in the Straits of Malacca (MPP-EAS, 1999b).

Key concepts are introduced, including the nature of the services that natural resources provide directly and indirectly to the public and the various economic values (use value, passive use value and option value) attached to these services. Two broad frameworks for assessing damages are examined: (1) resource valuation and (2) resource-based restoration.

Resource valuation employs economic concepts, methods and data to estimate the monetary value (willingness to pay) that the public holds for natural resource services. Methods for valuing particular damages are reviewed, including the data requirements, strengths and limitations of each method. For the largest incidents, the high cost of site-specific original studies may be justified. These include the use of market or non-market valuation methods. Market methods use sales or cost information to estimate losses in profits to coastal businesses or price effects on consumers. Non-market valuation methods are used to assess loss of recreational uses, aesthetic amenities, habitat services (e.g., mangroves), or other natural resource services not traded in markets. These methods typically require use of surveys.

The strengths and potential weaknesses in these (and other) approaches are recognized. Much progress has been made, but many challenges remain. Generally speaking, valuation methods are likely to be more reliable for market methods and use value but become less reliable as one moves toward non-market methods and passive use value.

Simplified valuation approaches potentially useful for minor incidents are reviewed. These include compensation formula and use of computer models. *Compensation formula* use a base monetary damage per unit spilled, which is scaled up or down, depending upon the characteristics of the substance spilled, the amount cleaned up and such factors as the sensitivity and value of the environment(s) affected. *Computer models* simulate the transport and fate of the substance spilled, exposure of natural resources to the material spilled and injury to natural resources, using available dose-response toxicological relationships. The injured resources then are valued using market prices (e.g., for commercially harvested fish) or non-market values (e.g., for beach use) to provide a measure of the resulting monetary damages.

Simplified approaches necessarily require assumptions and judgment that can be justified only as a low-cost, pragmatic approach for minor incidents. In some cases, available estimates can be adopted or adapted (benefit transfer) as another simplified approach, also saving considerable time and expense.

Resource restoration is given considerable attention in this report, due to its importance in international conventions and some national NRDA approaches. Restoration may have as a goal restoring injured natural resources to their without-spill level or baseline, or additional restoration beyond baseline may be required in order to compensate for interim services lost prior to resources recovering to their baseline. Restoration can address either lost services (e.g., beach days) or lost resources (e.g., acres of mangroves), depending upon the particular natural resources and services injured in a given case. Restoration proposals should consider natural recovery and might meet several criteria: (1) feasibility; (2) cost effectiveness and (3) restoration cost which should bear a reasonable relation to the benefits to be achieved.

Although restoration avoids the need to estimate economic value directly, restoration presents its own challenges. These include the need to estimate baseline resource services and establish when recovery of the injured resources has occurred, which can be very difficult, especially for biological resources. Furthermore, it may be necessary to estimate the value of services in any event when comparing the relation of restoration costs to benefits. Finally, in many pollution cases, several resources may be affected requiring the use of multiple restoration and valuation methods.

Implementation of a Straits-wide approach for NRDA would require efforts and expertise to assemble information to support injury quantification and damage assessment, particularly if the incidents and cost categories are expanded beyond those currently perused. A basic issue concerns the role of valuation of natural resource damages—particularly non-market assessment methods—as opposed to reliance on a restoration-based approach. Should valuation methods play an important role, appropriate valuation methodologies would have to be decided upon and guidance given for the use of these methods in particular cases.

To implement a restoration-based approach for the Straits of Malacca, information on restoration options for key resources and ecosystems in the Straits of Malacca would need to be assembled and evaluated for relevance. Standards for assessing restoration would have to be established. These might include feasibility, cost-effectiveness and the grossly disproportionate principle mentioned earlier in this section. Also, a policy must be established concerning how flexible decisions would be with respect to restoration (i.e., restoring substitute resources rather than the specific resources injured).

An additional, important issue concerns whether what type of a simplified approach for assessing damages might be employed in a Straits-wide NRDA framework. Use of a computer simulation model would require a fairly substantial effort to develop. However, much data and expertise is available within the region and prior experience with computer simulation models would facilitate the development of this simplified approach. A compensation formula would be easier to establish but also raises issues discussed in the report.

If a Straits-wide approach for NRDA is pursued, a very important issue concerns the process and institutional structure within which it would be developed, implemented and refined, as necessary, over time. NRDA raises many technical and administrative issues. Development and implementation of an effective NRDA requires considerable expertise in several disciplines. Much expertise in relevant areas exists within the region, but those who might work to establish and implement a Straits-wide NRDA approach must possess or develop the appropriate, specialized knowledge and experience for use in NRDA. Continuing involvement is necessary to develop specialized knowledge and experience. Thus, an ongoing, institutional capability is needed to ensure consistent application of NRDA concepts, to learn from "doing" and for continuing professional development in this area. Continuing involvement also is needed to develop assessment and restoration concepts and methods and to refine and improve them over time, as appropriate. This suggests the need to establish a central group to focus on NRDA issues. Experts from this centralized group also would need to be available to participate in transboundary pollution cases.

At the same time, the transaction costs in damage assessments have been very high, especially in countries like the United States. Efforts that reduce the need for experts, lawyers and drawn-out processes would contribute to a greater acceptability of NRDA and increase its effectiveness. This is a very complicated issue and is easier said than done.

With experience, NRDA approaches would become more standardized and easier to implement. An ongoing process also would encourage development of additional expertise in the region—at colleges and universities, at private research establishments and in government.

For institutional purposes, it seems very desirable to have an administration center comprised of scientists, economists, lawyers and perhaps others. A single group would allow certain economies to be realized, facilitate the development of a consistent set of methods and enhance cooperation and coordination. Such a group would presumably be funded at least in part out of assessment funds collected from responsible parties after pollution incidents, although use of a small fee per barrel of oil delivered might be a better alternative. Cooperative mechanisms currently existing among the littoral States might provide a suitable institutional "home" for a central NRDA group. It might be desirable to have an NRDA group work in close collaboration with existing, regional cooperative groups focusing on spill and pollution response, given the overlap in issues facing both groups.

Another implementation issue concerns the so-called mystery spills. As noted, if compensation for response and cleanup and perhaps damages is to be provided for spills with no identified source, a fund would have to be established, raising a host of issues. These include coverage, administration and standards to be used to settle claims and subsequently pursue claims against those responsible.

Finally, NRDA inherently involves tensions between the various stakeholders. Given these tensions, any attempt to develop a Straits-wide approach might benefit greatly from involving all those concerned in an open and transparent process with the opportunity to participate and comment upon proposed measures. Efforts to adapt and improve the NRDA process over time should also enhance its acceptability and by that, its effectiveness.

Introduction

Background

Transboundary pollution in the Straits of Malacca is an important concern to the three littoral States of Indonesia, Malaysia and Singapore due to the risk of accidents and the abundance of many important resources, activities and ecosystems in the Straits that are vulnerable to pollution. The Straits of Malacca is among the busiest in the world, with some 80,000 vessels transiting each year. The combination of narrow channels, shifting bottoms, fog, shipwrecks, heavy traffic by many large vessels, extensive activity by fishing boats, ferries and other cross- and intra-country straits traffic make the Straits of Malacca particularly difficult to navigate safely.

The heavy volume of traffic, together with hazardous operating conditions, raise the risk of accidents, including strandings, groundings and collisions and subsequent marine pollution. The high risk of vessel operations in the Straits of Malacca is reflected in the 476 vessel accidents—over 5 per year—that have occurred from 1978 to 1994. Of these, 98 were tanker accidents (Chua et al., 1997; Hamzah and Basiron, 1997). From another perspective, a recent summary of international spill statistics shows that from 1960 to 1995, some 53 spills greater than 10,000 gallons occurred in the coastal waters of Indonesia, Malaysia and Singapore (Etkin, 1997)[1]. Over the same 25-year period, Singapore ranks 9th (tied with Korea) among all countries worldwide, in the number of spills greater than 10,000 gallons and Indonesia is number 18 (Etkin, 1997). Recent major accidents, including the 1997 *Evoikos* and *Orapin Global* incidents in the Singapore Straits, during which 29,000 tons of heavy crude oil were lost, further underscore the risks of transboundary pollution from shipping in the Straits of Malacca.

Vessel traffic through the Straits of Malacca is expected to increase considerably due to growth in East Asia. Japan, Taiwan, Korea and China rely upon the Middle East for much of their oil where the Straits of Malacca is the most direct route to East Asia for vessels carrying oil from this region. Many exports by Asian countries are sent through the Straits of Malacca and this activity will likely expand in the future. Thus, the risk of pollution from shipping may increase due to the increasing volume of traffic. Furthermore,

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[1] *The information provided in Etkin (1997) is for countries as a whole, and it is unclear how many of these are in the Straits of Malacca. However, the information given in maps elsewhere in Etkin (1997) strongly suggests that most of the spills off the three littoral States are in the Straits of Malacca.*

substantial offshore oil production, petroleum refinery operations and other industrial activity take place in and along the Straits of Malacca, raising the risk of transboundary pollution from these sources.

Turning to resources and activities at risk, the Straits of Malacca has valuable fisheries, mariculture operations and tourism and recreation facilities that are susceptible to injury from oil spills. Important ecosystems, such as mangroves and corals, also are vulnerable to oil in the marine environment (Calow and Forbes, 1997).

Serious damages have resulted from past spills, a concern of which is the threat of an *Exxon Valdez*-type of spill in the narrow channels that could tie up traffic in the Straits of Malacca for a substantial period and cause major losses[2]. Concerns about the risk of very large spills are not fanciful. The recent *Evoikos* incident involved the loss of at least 29,000 tons of heavy crude oil. This is about two-thirds the size of the *Exxon Valdez* oil spill which resulted in various claims and payments much in excess of US$7 billion. Selected, large vessel spills in the Straits of Malacca are summarized in Table 1.

Table 1. Selected Large Vessel Spills in the Straits of Malacca.

Incident (year)	Amount (tons)
Myrtea (1972)	1,000
Messiniaki Pnoi (1974)	180
Showa Maru (1975)	7,700
Mysella (1975)	2,000
Citti di Savona (1976) Philippine Star	1,000
Diego Silang (1976)	5,500
Anti Taras (1987)	200
Happy Giant (1990)	4,000
Al Niser Al Arabi (1991)	300
Nagasaki Spirit (1992)	13,000
Sanadaj II (1993)	4,000
Evoikos (1997)	29,000 +

Sources: Finn et al. (1979); Hamzah and Basiron (1997).

Managing the risk of spills in the Straits of Malacca raises two interrelated issues. One is the appropriate scale of measures to prevent and control spills. A second issue—the focus of this report—

[2] *Cleanup and response costs alone for the* Exxon Valdez *were on the order of US$2 billion; restoration and fishery losses may be as much as US$2 billion—not counting punitive damages of US$5 billion assessed against Exxon.*

has to do with the institutional framework, methods and standards that are used to assess the monetary value of natural resource damages when spills occur.

Many ongoing and planned actions by the three littoral States will reduce or control oil and other pollution from shipping. These include expanded use of navigational aids, such as buoys, vessel transit systems, pilots and prospective use of sophisticated electronic charts in a Marine Electronic Highway (MEH) (e.g., Chua et al., 1997; Hamzah and Basiron, 1997; MPP-EAS, 1999a). Additionally, many companies also have invested considerable amounts in safety and response equipment, training and response plans, including membership in cooperatives, such as the East Asia Response Ltd. (Chua et al., 1997; MPP-EAS, 1999a).

Safety measures such as those mentioned above will help prevent spills and response training and strategic stockpiling of equipment that will assist in efforts to control and clean up spilled oil. An important issue with respect to these measures is whether the incremental benefits—the damages avoided—are greater than the incremental costs of particular prevention and control actions. Some of the issues relating to the benefits and costs of pollution prevention and control are discussed in Grigalunas et al. (1997) and MPP-EAS (1999a), but to date no carefully done benefit-cost study of incremental benefits and costs of specific prevention or response measures appears to be available for the Straits of Malacca.

Despite many preventive and control actions, the risk of spills in the Straits of Malacca will persist. When spills happen, it is necessary to decide whether to assess damages, which losses can be compensated for, the best method(s) to be used to assess damages and the institutional framework within which such assessments take place. This is where natural resource damage assessment becomes important.

Natural resource damage assessment is a process that involves the use of legal, scientific and economic principles to assess monetary damages due to pollution. Liability for costs and damages from pollution, as quantified in an NRDA, provides an additional measure for sustainable financing by compensating for natural resource injuries and lost services due to transboundary pollution. NRDA consists of a formalized process within an institutional regime that supports the quantification of allowable losses from covered incidents and collection of resulting claims.

NRDA is a relatively new area of research. The first NRDA was done following the 1969 Santa Barbara (California) offshore oil platform spill (Mead and Sorensen, 1970). Probably the first large-scale economic study of oil spill damages was that carried out after the 1978 *Amoco Cadiz* supertanker oil spill off the coast of Brittany, France (US Department of Commerce, 1983; Grigalunas et al., 1986)[3]. However, substantial interest and active research in the field primarily stems from publication of the national natural resource damage assessment regulations by the United States Department of the Interior in 1986 and 1987 (Grigalunas and Opaluch, 1988, 1989). Thus, NRDA is a relatively new area where the concepts and approaches being used have been evolving relatively quickly.

The intended outcome of an NRDA is a claim against a responsible party. As a result, NRDA necessarily involves tensions and adversarial debate between government—which is responsible for implementing and enforcing NRDA and industry—which must respond to and pay legitimate claims and coastal businesses and users harmed by marine pollution. Critics of NRDA question the reliability and, in some cases, the appropriateness of NRDA assessments. Supporters of NRDA ackowledge the many difficulties that arise in quantifying loss but make comparisons with the many empirical challenges and imprecisions addressed as a matter of assessing damages in other contexts, such as the value of intellectual property rights, of business antitrust issues and losses from personal injury, including the wrongful death of victims, in work-related accidents. The scope of items included by governments as damages has grown, as has the size of settlements, further exacerbating tensions among the involved parties.

In spite of controversies surrounding NRDA throughout its evolution, establishing liability for damages due to oil and hazardous substance marine pollution is of increasing interest for several reasons. These include: (1) a greater awareness of and sensitivity toward, environmental issues; (2) an increasing interest in the practical significance and use of economic incentives (the polluter pays principle) in environmental policy; (3) concern about collecting for all losses caused by pollution and (4) an improved understanding of the scientific, economic and legal concepts used in NRDA.

NRDA is of interest to many parties, including littoral States, owners and operators of businesses at risk, industry and insurance companies, among others.

- Littoral States must decide the adequacy of NRDA measures for compensation for losses due to pollution. Particularly important are losses to publicly controlled or managed resources, such as open-sea fisheries, wildlife, ecosystems and public beaches. Private parties have an incentive to pursue their own losses, but have little incentive to and is legally unable (i.e., lack standing) to pursue losses to the public at large. Other issues concern compensation for response and for removal including resolution of the "how clean is clean" debate. States also will be interested in the restoration of resources harmed by a spill and may

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[3] *See also Bradley (1974) who provided an earlier framework for managing marine oil pollution and Burrows et al. (1971) who summarized results of a study of the* Torrey Canyon *spill in the English Channel.*

also be concerned with whether and how their relative competitive position is affected if they enact and implement strict and encompassing NRDA provisions.

- Owners and operators of mariculture, fishing, tourism and other coastal businesses at risk from spills are concerned about recovering lost earnings. They also are interested in how such claims can be documented at a reasonable cost and compensation received without substantial delay.

- On their part, industry understandably is concerned about the legitimacy of claims against them for losses—transaction costs for legal and expert reports and proceedings and about avoiding double counting of losses (paying twice—or more—for the same loss). They are especially troubled about the potential for damage claims based on speculative losses or losses based on unreliable or theoretical methods. Of particular worry is the potential for major claims, if damages are expanded to include non-market and other hard-to-quantify losses, especially passive use value[4], as they have in the United States, for example (e.g., US Department of Commerce, 1993; Hanemann, 1994).

- Insurance companies and international funds of course are concerned about the nature and size of claims they will face for response, cleanup, assessment and damages. In many respects, their concerns are similar to those of the industry.

Interest in NRDA by public bodies stems from its promise in helping to achieve two important environmental policy goals. First, it provides a framework for pursuing compensation for the many costs that can result when natural resources, coastal activities and property are adversely affected by oil and other marine pollution. As pointed out later, many types of pollution damages currently are not compensated for and as a result, these costs are borne by coastal states.

Second, polluter liability under NRDA requires the responsible party to bear the costs of marine pollution (polluter pays principle). Liability provides built-in incentives for polluters to avoid incidents and by that, plays to their self interest as a matter of course (e.g., Opaluch and Grigalunas, 1984; Grigalunas and Opaluch, 1988). This is consistent with worldwide trends toward the use of market mechanisms to address environmental issues as recommended, for example, in the Agenda 21.

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[4] *Passive use losses may arise if individuals feel worse off when they learn of the adverse effects of a spill on wildlife, beaches and other resources—even if they do not use these resources themselves. People might be willing to prevent such losses much as they may pay to preserve, say, a historically or culturally significant building or site, even if they never actually visit it. Many improvements in methods have been made, but reliable quantification and acceptability of passive use value as a measure of damages is still a subject of lively debate (e.g., Diamond and Hausmann, 1994; Hanemann, 1994; Portney, 1994).*

At the same time, any NRDA framework for oil and other pollution incidents raises several issues, including:

- the nature of liability;
- the scope of incidents covered;
- the scope of impacts (injuries) for which damages can be assessed;
- allowable damages;
- allowable methods for estimating damages;
- standards to apply in weighing the results of such methods; and
- means for limiting transaction costs.

These issues are considered in this report. However, any attempt to develop a Straits-wide approach for NRDA will need to address these issues in great detail.

In summary, transboundary marine pollution is an important issue in the Straits of Malacca, many valuable resources are at risk. NRDA has considerable potential for protecting and restoring natural resources injured by oil or chemical spills. The three littoral States have an umbrella legislation that prohibits pollution and deals with pollution response and liability, but no formalized system for transboundary NRDA exists.

At the international level, Indonesia and Malaysia are parties to the International Oil Pollution Compensation Fund 1971 (the 1971 Fund); Singapore is not a party to the 1971 Fund, but will be a party to the 1992 Fund Protocol on 31 December 1998 (IOPC, 1998). The Fund Conventions (and the Civil Liability Convention/CLC) provide for strict liability for cleanup and for some private costs and pollution damages due to oil spills (e.g., Osuga, 1997). Important differences between the 1971 Fund and 1992 Protocol are noted briefly below.

The 1971 Fund provides for strict liability for actual cleanup of spilled oil, but does not provide compensation for preventive measures, or for reinstatement of the environment. In contrast, the 1992 Protocol provides for compensation for preventive measures to avoid spills and pollution damages. It also allows for compensation for some costs to restore the environment. The 1992 Protocol also has a higher liability limit (Special Drawing Rights/SDR 135 million) than the 1971 Fund (SDR 60 million).

Even under the more expansive 1992 Protocol, however, the incidents and pollution damages covered are circumscribed. Many pollution costs of potential importance for the Straits of Malacca fall outside the scope of the CLC, 1971 Fund and 1992 Protocol and will be uncompensated for, unless national laws can be applied:

- Only spills of persistent oils and bunker fuel from tankers are covered under the CLC and 1992 Protocol.[5] Chemical spills and spills of non-petroleum oils (vegetable and animal oils) from tankers are not subject to compensation, nor are spills from offshore production facilities, pipelines or terminals.

- Under the CLC and Fund Conventions, damages based on abstract quantification and theoretical models are not allowed. However, what is theoretical versus real is not always clear. Compensation for assessment costs does not appear to be automatically available, making it difficult to support some potential claims.

- Compensation for non-market valued losses (e.g., lost public uses of beaches or coastal parks) due to oil contamination does not appear to be available under the CLC and Fund Conventions.

- Under the CLC and Fund Conventions, compensation for pure economic losses (e.g., losses to tourism or fisheries businesses not physically contacted by spilled oil but affected by consumer perceptions of tainting) are decided on a case-by-case basis.

- Questions arise concerning how and whether resources injured by spills will be restored under the 1992 Protocol (Brans, 1994, 1995); compensatory restoration—restoring injured resources beyond reinstatement to their without-spill, baseline level in order to make up for natural resource services lost until recovery—does not appear to be available.

- No simplified approach for assessing damages from minor pollution incidents is available for use in the Straits of Malacca.

- Compensation is unavailable in the Straits of Malacca for "mystery" oil spills—spills for which the source is unknown.

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[5] *The issue of whether compensation should be made available for spills of bunker fuel from non-tanker vessels is being studied by IMO.*

As a result of all of the above issues, the three littoral States may bear many environmental costs for which they may be compensated including environmental damages.

Effectively and responsibly done, NRDA can provide a sustainable basis for providing compensation for a range of losses due to many types of marine pollution. It also provides an incentive-based approach that encourages operators to avoid pollution. At the same time, NRDA poses many difficult issues and the development of any Straits-wide NRDA system must address many challenges, as we describe in later sections.

While the focus of this report is on NRDA as a means for providing compensation following an accident as well as for providing incentives to avoid pollution, it is worth noting that an NRDA framework can have other potential uses for addressing transboundary pollution issues. The environmental concepts, methods and data underlying NRDA may also be useful for several types of policy analyses. These include risk analyses to assess the possible effects of proposed offshore oil development and associated oil transportation modes and routes (Grigalunas et al., 1990) and benefit-cost analyses of navigational improvements, new port developments, or other proposed policy issues, such as the assessment of the benefits and costs of structural measures to reduce spillage (e.g., US Coast Guard, 1997).

Purpose and Scope

This report examines the above NRDA issues in the context of the Straits of Malacca. The report reviews damage assessment, liability and compensation regimes with a view to their application as a financial mechanism in the Straits. It includes an analysis of the potential for and implications of, a Straits-wide approach for damage assessment for oil and other priority pollutants derived from shipping activities, as well as other transboundary pollution problems.

Emphasis in this report is on assessment of natural resource damages for publicly owned or controlled resources, rather than private claims for lost earnings or pollution of real property, for example. The reason for this focus is that private parties can (and usually do) bring claims against polluters when their operations or facilities are adversely affected. Private losses are often, but not always, relatively straightforward. Furthermore, the focus here is on damages—not penalties—since the latter has important punitive elements and are not normally based on economic concepts that underlie the determination of damages. Finally, although it is recognized that response, cleanup and assessment costs can be considerable, they are not damages and as a result are outside the scope of this report.

Considerable attention in this report is given on *restoring* natural resources injured by a spill or marine pollution (resource-based restoration) as a framework for NRDA. This is because restoration has been given preeminence in international conventions and in certain national NRDA approaches, such as those in the United States under the Oil Pollution Act of 1990 (OPA '90) and the Comprehensive Environmental Response Compensation and Liability Act (CERCLA or more popularly, Superfund). Resource-based restoration's appeal stems from two considerations: (1) it seems reasonable to have as a goal the return of resources injured by pollution to their without-spill condition and (2) restoration avoids the difficulties of the alternative assessment approach that relies upon economic valuation of natural resource injuries and the resulting loss in services (terms that are explained below). However, restoration poses its own set of difficult issues and valuation using economic methods is required in any event in some cases, as is explained later. Hence, monetary valuation continues to have an important role in NRDA; valuation issues and approaches also are considered in this report.

It is stressed that it is not the intent of this report to recommend what an NRDA framework should be for vessel-caused and other transboundary pollution in the Straits of Malacca. It is also recognized that NRDA methods have been evolving internationally, differ among countries and indeed differ considerably *within* some countries[6]. Selecting an NRDA framework appropriate for different countries involves many issues as described throughout this report.

Finally, it is noted that this document focuses on economic issues. To be sure, NRDA involves issues that cut across disciplines. Legal and science concepts and issues are critical in most NRDA cases. Some of these concepts and issues are mentioned in the sections that follow. No claim is made, however, for expertise on legal and science issues in this report. Any attempt to develop and implement a Straits-wide NRDA necessarily must involve close cooperation between and among economists, lawyers, marine scientists and other stakeholders.

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[6] *For example, in the United States, the OPA '90 provides a comprehensive, national approach for assessing responsible parties for damages due to injury to natural resources and for a variety of other losses due to oil spills. However, individual states, such as Florida, Alaska and California, also have their own approaches for NRDAs for pollution incidents affecting resources under their management or control.*

Concepts and Definitions

Introduction

Throughout this report certain terms and concepts common in NRDA and economics are used. Some of the terms used reflect the jargon of NRDA practitioners and some of the concepts are unfamiliar to non-economists. To avoid confusion, this section reviews some of the basic concepts and terminologies used in later sections of the report.

Basic Issues

Under international conventions and many national laws, damage assessments typically must establish a cause-and-effect linkage between a spill, exposure of natural resources (or business operations) and injury to those resources (or business activities) from the exposure. In order to assess economic damages from lost uses and costs to private parties, it is necessary to quantify the resulting loss of services that the affected resources provide to people and ultimately the value of these lost services to affected individuals. These linkages are shown in Figure 1.

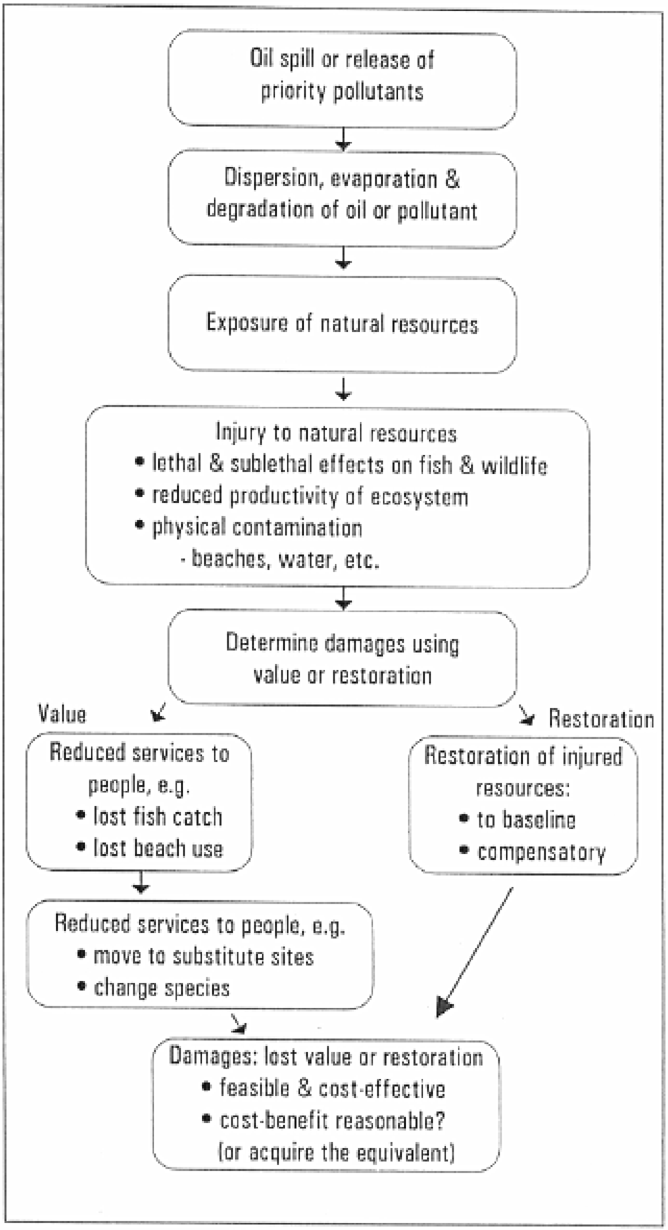

Figure 1. Simplified Representation of NRDA Process.

Note that Figure 1 reflects the fact that once injury and lost services have been quantified, two broad approaches can be used in principle to measure damages. One approach uses the *value* of the services lost until such time that the injured resources recover. The amount received then may be used to restore injured resources. The second approach uses the cost of *restoring* the injured resources as the measure of damages.[7] In practice, both approaches may be used for different categories of injuries, provided there is no double counting.

The NRDA approach using economic value is a human-based view of pollution effects. Under this approach, resources have value only insofar as they provide services that are directly or indirectly valued by *people*. This is an important (and for some, controversial) view such that it does not allow that resources may have a value in and of themselves (truly intrinsic value). It has been the guiding principle, for example, for initial regulations implementing CERCLA and OPA '90 and its predecessor Acts in the United States. However, new regulations under OPA '90 emphasize the use of a resource restoration-based approach and appear to expand the notion of damages to include intrinsic value; therefore, damages caused by oil spills may not be purely human-based in the United States.[8] Also, compensation for pollution damages under international conventions now allows for restoration costs in some cases, as explained in detail later.

Injury, Services and Damages in NRDA

Injury is defined as any adverse impact on a resource or impairment of the services provided by a resource due to exposure to a spill. The scope of allowable injuries will differ depending upon the regime being considered, but injury can be very broadly defined. For example, under OPA '90, injury includes impairment of biota and other resources, such as water and beaches. Injury to biota includes direct mortality to fish, shellfish and wildlife and destruction of coastal mangroves. Sublethal effects on biota are considered injuries, such as loss in the reproductive capacity of fish or wildlife, or in the productivity of mangroves, seagrasses, corals and other ecosystems. Impairment of non-biological resource services occurs when, for example, oiling of a public beach prevents its use by recreationists, or when a sea lane or port area is closed to shipping due to a spill and its cleanup.

Injured resources, in turn, may provide reduced *services* to people or to the environment. Examples of services provided by natural resources include: (1) ecosystems, such as mangroves and corals that help sustain fisheries for commercial and recreational

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7 *It is noted that the two approaches might lead to much different outcomes. For example, the value of services lost might not be adequate to restore the injured resources, or the value of the services might greatly exceed restoration costs.*

8 *The most recent OPA '90 states that the goal is "...to make the public and the environment whole". To the extent that the stated goal of making the environment whole is interpreted in practice as being independent of any direct or even indirect services to people, then the new regulations would represent a departure from previous regulations and extend the concept of damages to include truly intrinsic values. However, proposed restoration actions still must consider benefits relative to cost in order to assess whether costs are grossly disproportionate to benefits.*

purposes; (2) clean beaches that can be used by recreationists and tourists; (3) quality water for use in farming, commercial processing or recreation; or (4) an unobstructed water surface used for transport. Hence, services have to do with the functions provided by resources directly or indirectly to people. Under some interpretations, services may also include ecological services without regard to whether they are used by people.

Services may be *direct* or *indirect* (off-site). Services are easiest to envision in the case of direct use, for example, *in situ* harvesting of fish, wood from mangroves, or use of coral or public beaches for recreation. Use is less clear when resource services are enjoyed indirectly. Indirect use occurs for example, when people harvest or view fish or wildlife many miles from the mangroves that provided critical nursery or habitat for the species concerned. Other indirect use occurs through the food web when lost primary productivity (phytoplankton) ultimately leads to a reduction of predator species further up the food chain and used (harvested or viewed) by people. More difficult yet to visualize are services giving rise to *passive use*, which involves the appreciation of resources or sites, even if the user never actually visits the site or uses the resource directly.

Damages are defined as the amount of money that, when paid to those suffering losses caused by marine pollution, would make them whole, i.e., no worse off than they would be without the spill. Hence, damages are compensatory in nature, much like in a private case where someone who destroys a car in an accident is liable for compensating the owner for his or her loss. In the case of pollution that causes losses to the public, such as closure of public beaches, loss of biodiversity or injury to an ecosystem (e.g., a mangrove area), the public does not actually receive any money. Instead, damages are, in principle, the amount of money that, if paid, would make the public no worse off than they were without the spill.

In summary, several types of services and values can be identified, some of which are easier to quantify than others. Generally speaking, resource services are easiest to value when the use is on-site and the service is valued in the market place (e.g., fish or shellfish sold in markets). Valuation becomes increasingly hard when the service occurs indirectly (via the food web or off-site) and when it is not valued on commercial markets. Passive use of a resource or activity and its value is the most difficult to assess and the most controversial (e.g., Hausman, 1993; Diamond and Hausman, 1994; Hanemann, 1994).

Damages as a Reduction in the Value of Natural Assets

Losses often occur over an extended period of time. For example, an oil spill or other marine pollution incident may kill a certain number of fish or shellfish and it may take years for the injured stocks to recover fully. Landings and the associated damages (lost economic rent—loosely, profits) from these stocks will be reduced until recovery occurs[9].

Damages can be viewed as the change in the value of a natural asset (Freeman, 1993; Kopp and Smith, 1993). Assets—natural or otherwise—provide a stream of valuable services over time, if maintained. In the case of a fishery or mangrove area, for example, the fish stock or mangroves can provide sustainable services valued by people if the resources are properly managed. Oil spills or other marine pollution events reduce the size or productivity of the stock of affected natural resources, hence reduce the value of annual services, lowering the asset value of the affected stocks. Similar arguments apply for beaches, corals, seagrasses and other natural resources that directly or indirectly provide services valued by people. To continue the automobile example, if a car is damaged in an accident, its value as an asset is reduced—it is worth less because the services it provides are reduced (it will not operate) or degraded (it looks worse or runs poorly).

To take account of losses over time, annual injuries, services and damages must be estimated and then discounted through the period of recovery for the injured stocks. Assuming a spill occurs at time t_s and causes mortality to a stock of fish that recovers at time T_r and the annual damages are D for $t = t_s, t_{s+1}, \ldots, T_r$, total discounted damages TD are:

$$\mathbf{TD} = \Sigma_t \mathbf{D}_t / (1+\mathbf{i})^t$$

In the above simple formula, total damages, TD, is the present value of the annual damages through the period of resource recovery. Looked at another way, it is the lumpsum amount which, if received today, is the equivalent of all of the future annual damages.

Calculation of the annual damages involves estimation of lost revenue less any cost savings. If a spill causes small injuries (or even moderate injuries spread widely over time and space), then there is no noticeable change in fishing effort and hence in variable costs. In this case, damages are the same as lost revenues. If effort does change, for example due to closure of a fishery, then damages are measured as reduced revenues minus the costs saved due to reduced effort. Many resources (several types of fish, beaches, habitat, etc.) may be injured in a single pollution event, so that annual damages D_t will be the sum of the annual damages for all lost services d_{it} (i.e., d_{11}, d_{12}, d_{13},...; d_{21}, d_{22}, d_{23},...) where i are the

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9 *Basically, the number of fish or the size of a beach area are stocks; the services these stocks provide are flows.*

different lost services and t is the time period for each injured resource through the period of recovery for each.

Table 2 provides a summary of important natural assets in the Straits of Malacca and examples of the services provided by these assets. Indicated in the table are the types of economic value associated with the services and the method(s) that would likely be used to estimate value in each case.

Valuation is not a mechanical exercise. Actual quantification of natural resources injuries, lost services and their value and restoration pose many empirical (and some conceptual) challenges. In the next section, methods for assessing the monetary value of lost services are described. Then, we examine restoration as an approach for assessing damages.

Table 2. Malacca Straits Natural Assets, Selected Services, Values and Methods.

Natural Resource Assets	Selected Services**	Value*/Representative Estimation Method(s)***
Sea Lanes/Navigation	Transportation	Cost savings
Water Quality	Fish Harvests - commercial - subsistence	Net Value/Productivity, Market Prices Net Value/Productivity/Replacement Costs
Mangroves	Fish Harvests - commercial - subsistence Storm Protection Erosion Protection Wood Harvests Biodiversity - commercial - amenity - tourism - existence	Net Value/Productivity, Market Prices Net Value/Productivity/Replacement Costs Property and Damages Avoided, Market Value Property and Damages Avoided, Market Value, Least Cost Avoidance, Market Prices Net Value/Productivity, Market Prices Net Value/Productivity, Market Prices Recreational Value/Travel Cost, Contingent Valuation and Contingent Behavior, Property Value (Hedonic) Method Net Value/Productivity, Market Prices Passive Use-Contingent Valuation Contingent Choice
Peat Marshes	Same as Mangrove	Same as Mangrove
Coral	Recreation - amenity - tourism Fish Harvests - commercial - subsistence	Recreational Value/Contigent Value, Travel Cost Net Value/Productivity Net Value/Productivity, Market Prices Net Value/Productivity/Replacement Cost
Seagrasses	Fish Harvests - commercial - subsistence	Net Value/Productivity, Market Prices Net Benefits/Productivity/Replacement Cost
Marine Reserves	Wildlife and Amenities - recreation - tourism	Net Value (Consumer Surplus)/Travel Cost, Contingent Valuation, Other Net Earnings/ Productivity, Market Prices
Offshore Oil and Gas	Energy	Net Value/Productivity, Market Prices

* Calculation of net values is understood to involve subtraction of appropriate costs.

** Many of goods and services may involve subsistence uses in whole or in part, complicating estimates of value.

*** It is understood that restoration is an alternative in virtually all cases.

Methods for Assessing Damages

Valuation in the Context of NRDAs

This report focuses on economics, but NRDA depends critically on input from and collaboration with, scientists at many stages of the NRDA process. For example, oil spill modelers and on-scene observers must: (1) document the source and fate of oil spills and transboundary marine pollution and (2) quantify the resulting injuries to natural resources and their recovery over time. Oil spill modeling (and pollution fate modeling in general) has been a subject of much research and important advances have been made. For example, three dimensional, particle-based models[10] are now well within the capability of modelers. Much work on this topic has been done in the Straits of Malacca and in East Asia in general (e.g., Yu et al., 1997).

Quantification of injuries can be very difficult, especially for biological resources in open-sea settings. Nevertheless, improvements have been made in this area as well. Field sampling of course has a long history in the biological sciences and there is considerable experience with use of control areas to quantify injuries. Methods have been developed to simulate injuries in some cases and in other situations (e.g., for minor pollution cases) simplified approaches are available that side-step the injury quantification issue. Finally, when considering restoration actions, scientists and economists must work closely to identify feasible options, select cost-effective approaches from among these options and weigh the relation between benefits and costs of these options. Again, progress has been made in restoring ecosystems (e.g., Cairns, 1995), as well as in valuing the services of ecosystems.

Overview of Valuation Methods

This section provides a brief summary of economic valuation methods for use in NRDA. First, we present methods appropriate for site-specific studies of transboundary pollution. Actually carrying out such studies is a reasonably large undertaking and can be costly. Hence, use of these methods will only be justified in the case of major incidents. Then, some simplified approaches used for minor incidents are outlined, or in all but the

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[10] *Three-dimensional modeling allows for tracking of the mass-balance of a spill, its path and exposure of biota (e.g., birds) to surface slicks and to oil constituents beneath the surface (e.g., juvenile and adult fish). Use of particle-based models allows researchers to follow even tiny "spillets" as they break away from the main part of a spill. Earlier models treated oil as a "blob" that moved as a single mass due to winds and currents.*

largest incidents. These approaches are inexpensive to apply and can be done rapidly. Simplified approaches can be very useful for minor incidents where the cost of site-specific studies are not justified. In a succeeding section, the resource-based restoration as an alternative method for assessing damages is described. It is noted that, in practice, more than one of these methods may be used for a given pollution case depending upon the nature and size of the resource injuries and the services lost.

Economic valuation methods involve the use of empirical models to estimate the monetary value individuals have for changes in the quantity and/or quality of resources and the services that they provide. Valuation approaches can be used to assess the economic value of goods available in markets (e.g., fish or wood from mangroves sold commercially) as well as those not bought and sold in markets (e.g., outdoor recreation).

Four important types of valuation methods are discussed: (1) market models; (2) market-related methods; (3) stated preferences methods and (4) the productivity method. Another method, benefit transfer, is also described, although this method differs fundamentally from the others since it involves the adoption or adaptation of estimates from one site to another, rather than to undertake an original study.

A vast and rapidly growing literature reviews the available valuation methods, their conceptual basis, estimation issues and data requirements, assumptions and strengths and limitations. Standard references on this broad subject include: (1) Mitchell and Carson (1989); (2) Braden and Kolstadt (1991) and (3) Freeman (1993). Grigalunas and Congar (1995) provide a practical review of valuation methods emphasizing coastal and marine examples. Extensive discussions of valuation issues in the context of NRDA, including examples, are given in Ward and Duffield (1992) and Kopp and Smith (1993).

What follows is a very brief, non-technical review of the four major types of valuation methods, plus benefit transfer. Then, NRDA cases are summarized to illustrate the range of injuries/services and damages considered and the methods used in specific cases.

Valuation Methods for Site-Specific NRDA

Even when injuries are known, estimating damages can be difficult, since not all of the resources and activities affected by oil spills and other marine pollution incidents are valued in markets. Special studies often are needed to assess these non-market values. Several approaches can be used to estimate monetary damages from pollution.

Market Methods

This set of approaches is useful for valuing goods and services, such as commercial fishing or tourism losses, that are bought and sold in the market place. Market data normally can be used to estimate lost profits (producer surplus), much as a business would assess the impact of an event (e.g., flood damage, temporary plant closure) on its operations. For example, to establish tourism losses, it is necessary to estimate lost earnings and the associated cost savings (i.e., variable costs). Lost earnings may be reckoned, for example, by comparing tourism profits in the period following the pollution with profits in a period prior to pollution. Alternately, losses in tourism may be estimated by comparing tourism in one or more control areas not influenced by a spill with that in the area affected by a spill.

For biological resources, such as commercial fisheries, it may be necessary to construct a bioeconomic model of the affected species in order to capture lost fishery services (catch) occurring over time until the stock recovers. In this case, critical information includes biological information on pollution (non-natural) mortality, as well as on natural mortality and fishing mortality (i.e., the percent of fish harvested per period).

Market methods are needed, for example, if it is believed that pollution caused prices to drop due to tainting of fish or shellfish, an issue that is often raised following marine pollution incidents (e.g., Anderson, 1993; Mendelsohn, 1993). In this case, it is necessary to construct a market model of the affected fishery market. Typically, economic data for many years are needed in order to try to separate out the effects, if any, of the pollution from *other* factors that can be expected to have influenced the price of the affected species (e.g., availability of substitute fish or food, changes in exchange rates if the affected species is traded internationally, changes in market structure over time, etc.).

Market methods are used to estimate the increased costs to commercial and other vessels delayed at a port when a spill and the subsequent cleanup restricts vessel movement for a period. These methods are applied to assess the increases in costs caused by, for example, the shutdown of water intake pipes to avoid drawing polluted water into commercial fish or shellfish holding tanks or into facilities using water in processing or packing.

Revealed Values

Travel Cost Methods. This approach is useful for recreational activities, such as beach use, swimming, boating and fishing. Information on individuals' recreational uses and the incremental costs they incur (including the value of their time) to carry out these activities is required for analysis. Participants in effect reveal the value they attach to these activities by the costs they realize to travel to the site and how often they participate.

Briefly stated, what is needed is survey-based information for a large number of recreational participants in the affected activity(ies). The information needed includes: The number of visits they make to a site, the costs (including the value of their time) to visit that site, the costs they face to visit substitute sites and measures of quality at each site—one of which is the pollution effect of interest[11]. With this information, the loss due to the pollution issue can be estimated.

Property (Hedonic) Method. Environmental quality (e.g., water contamination, noise, air pollution, nearness to a park or marine reserve) often is an important factor affecting the market price of property, along with more obvious attributes like the size and quality of a home, lot size and distance from work and shopping and schools. A change in quality, like the discovery that an estuary is contaminated with hazardous materials, may reduce the market value of nearby property (Freeman, 1987). The change in the value of property due to the pollution, estimated using a property value (Hedonic) model, provides a measure of damages in such a case.

This method is more useful for chronic pollution, such as contaminated marine sediments or groundwater, than for a rare and temporary event, like an oil spill. However, the hedonic approach may be very useful for assessing the impacts on property value due to *cumulative* effects of many small spills in an area[12].

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[11] *In many pollution cases, pollution may cause complete closure of a beach or area. In this case, the estimate is the value of lost access due to the beach closure.*

[12] *In areas that experience many spills, it is common for "tar balls" to wash ashore. Tar balls—loose globules of oil—detract from shoreline quality, and can contaminate boats, bodies and property (e.g., floors, rugs).*

Stated Preferences

This approach uses carefully developed surveys to estimate the value people hold for well-defined changes in the quantity or quality of a resource and its services due to pollution. Three approaches are mentioned.

Contingent valuation studies ask people directly what they are "willing to pay" for specific resource services or activities rather than go without them. Statistical analyses then are used to estimate the average value of the resource or site use change. This average value then can be applied to the population of interest to estimate the value for the group. A particular study, for example, might ask users about their willingness to pay to maintain access to a beach or to a coral area used for diving.

Contingent behavior studies ask participants how their use—such as visits to a site—would change, if the quality or the cost of use of a site or activity was changed. Responses can be analyzed to estimate conditional demand and value, i.e., how behavior would change under the conditions posed, which in turn can be used to estimate the associated value of the change in quality or cost.

Contingent choice studies ask respondents to compare and rank different resource restoration or preservation programs where each program shows different resource quantity or quality levels and their associated costs. Respondents will pick the option of greatest benefit to them; given many such choices across many respondents, one can infer the priorities individuals hold for the resources involved and perhaps the economic value of a change in each resource. These approaches are similar to carefully developed surveys that businesses use all the time in marketing to assess the feasibility and potential value of (or market for) a new or different product or service.

Productivity Approach

This important method can be very useful in cases where ecosystems are impacted by pollution. For example, mangroves or corals provide many valuable ecological and other services that contribute to human uses. Among others, they serve as nursery areas and habitat contributing to the production of fish, crabs and shellfish harvested by users. These resources also protect shorelines from erosion and storm damages (e.g. Cesar, 1996).

If the value of the above ecosystem productivity services per unit area have been estimated (calculated using any of the economic methods described in this section), then damages can be estimated. To do this, one would multiply the estimates of the economic value per unit of service per area by the loss in mangrove or coral area.

Benefit Transfer

This method involves adopting or adapting estimates of site or activity value(s) done for one area (the original study site) and applying it elsewhere (the application site). Use of benefit transfer has the obvious advantages of being easy and inexpensive, which is why this method is used for rapid assessments when an answer is needed quickly and precision is not critical. Thus, for NRDA, benefit transfer is most likely to be useful for minor incidents, since in the case of major incidents large claims will be subject to careful scrutiny and benefit transfer often is too crude to withstand careful, critical review[13]. However, it is not straightforward to determine the size of an incident that requires incident-specific studies. In practice, this is often done by doing an initial assessment following an incident and deciding whether benefit transfer is a reasonable approach, given the likely size of damages.

Benefit transfer can be done two ways: (1) by using the estimated value directly or (2) by transferring the original, estimated function, with appropriate adjustments to tailor the results to the application site. For example, the economic value of a recreation day estimated at the original study site is adjusted for use at the application site by accounting for the difference in per capita income or the attributes of the activities (e.g., health, productivity and uses of corals; catch rates for recreational fishing) between the study site and the application site.

For benefit transfer to be acceptable, certain criteria must be met. The original study must be of adequate quality and the activity, area studied and quality change, must be similar to that being considered at the application site.

Table 3 summarizes valuation methods, their applicability, data needs, strengths and limitations. Considerable judgment is required to determine the best method(s) to use for a particular problem.

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[13] *Responsible parties and government officials or trustees are always free to use benefit transfer as a low-cost approach in negotiations.*

Table 3. Summary of Valuation Methods, Uses, Data Needs and Strengths, Issues and Problems.

Methods	Estimates	Examples	Data Needed	Strengths	Issues and Problems
Market Methods					
Firm/Industry Model					
Cost/Profit Change	Producer effects	Shipping, mariculture	Change in cost/profit	Uses actual market data and behavior	Data availability, bioeconomic model requires biological data & estimates of mortality due to pollution
Bioeconomic Model	Lost economic rent-commercial fish	Tourism, salt production Lost lobsters, fisheries, etc.	Data for population dynamics model	Simulates lost services (catch) over time	
Price Effects	Consumer and producer price effects	Change in fish prices due to tainting/health concerns	Prices, quantities, and other demand variables over time	Same as above	Same as above
Non-market Methods					
Property Value (Hedonic)	Implicit value of environmental attributes	Chronic pollution; odor scenic amenities; noise	Property values and each amenity by site	Based on real prop. transactons	Data availability; correlation among attributes; model specification
Travel Cost (TC)	Value of site	Recreation at site-public beaches, marine parks, coral reefs	Participation, incremental costs, demographic data	Based on actual transaction-participation	Value of recreationist's time; multipurpose trips' specification
Productivity Approach	Value of resource and ecosystem services, human capital	Ecosystems (mangroves, wetlands, seagrasses, etc.); human health; pollution impacts	Output-input relationships or dose response functions	Allows for estimation of value of natural resource functions and health	Needs biological/science estimates for productivity; data availability, especially for off-site services
Contingent Valuation (CV)	Value of activity, site, resource quality/quantity changes	Scenic amenities, pollution, abundance, biodiversity, recreation, etc.	Survey responses on WTP for resource commodity/ services	Flexible; only way to directly estimate passive use value	Hypothetical; part-whole; symbolic responses; compliance and importance bias; other
Contingent Choice	Value of natural resource series, activities	Parks, mangroves, corals, open space, etc.	Survey responses to resource/cost choices	Flexible; avoids some potental problems with CV	Choice cannot be too complex; hypothetical; symbolic effects may occur
Contingent Behavior	Value of quality or price change at site	Recreation activity	Same as TC; Survey plus responses to proposed change	Extends TC for proposed changes; flexible	Hypothetical; same as TC
Avoidance Costs Averting Behavior	Value of clean water, air, waste, shoreline	Clean air, water, waste reduction erosion and damage control	Cost (least-cost) of averting measures-air and water filter, shore revetments	Allows estimaton of non-market goods in absence of first-best data	May underestimate; joint products of purchases may prevent estimate of value for good of interest
Others					
Benefit Transfer	Flexible, can be used for many damages	Recreation, ecosystems, others	Results of acceptable valuation studies for similar activities and areas	Low-cost and quick	Appropriate studies may not exist; quality of available studies may be inadequate

Many pollution injuries are difficult to translate into a dollar measure of damages. This includes impacts to natural resources that are not privately owned or for which there is no market price. For example, an oil spill might damage mangroves or other highly productive habitats that contribute directly or indirectly to fisheries. Or a spill might impact public beaches or other natural amenities that might be important for attracting tourists. Quantifying these impacts and providing reliable measures of damages in dollar terms can be very difficult in some cases. This is especially true when the major resource services affected are not bought and sold on markets and are realized indirectly—through the food web or off-site.

Under existing institutions, these injuries are often excluded from consideration in determining damages, so that they go uncompensated. In 1980, the International Oil Pollution Compensation Fund passed an important resolution effectively making that compensation for pure environmental losses inadmissible by declaring compensation "... is not to be made on the basis of an abstract quantification of damage calculated in accordance with theoretical models."

Although it can be difficult to measure and to monetize pure environmental damages, these damages are real and can have important adverse consequences. This is especially important for an area like the Straits of Malacca, where the risk of spills and pollution from other sources is great, and many resources and ecosystems are vulnerable to pollution. In such a case, resource stocks may never get a chance to recover fully prior to the occurrence of the next spill, leading to yet another reduction in resource stocks. Under these circumstances, the fishing and tourism industries may suffer from continuous, uncompensated losses due to oil spills.

Given the difficulties involved in measuring non-market and indirect impacts from pure environmental injuries and difficulties in monetizing the associated damages, restoration has assumed central importance as a means of compensating for environmental damages. For example, although the Civil Liability Convention and the Fund Conventions do not accept the notion of compensation for pure environmental losses, they allow compensation for reasonable actions taken to restore the environment. Similarly, OPA '90 in the US makes resource restoration the primary means of compensating for oil spill damages to natural resources. Thus, even where indirect damages cannot be directly monetized, it may be possible to obtain compensation by repairing environmental injuries.

OPA contains the most specific guidance on various concepts related to restoration (e.g., US Department of Commerce, 1997). Under OPA, the party responsible for an oil spill is liable for "restoring, rehabilitating, replacing or acquiring the equivalent" (hereafter restoration) of injured natural resources with the object of making the public whole.

The regulations that implement OPA '90 have as a goal *primary restoration* and *compensatory restoration* (US Department of Commerce, 1996). Primary restoration means returning the injured resource to the baseline state that would have occurred without the spill. Compensatory restoration means providing additional restoration to compensate for interim losses that occurred from the time of the spill through the time when the resource was restored.

Consider the case where an oil spill impacts a commercial shellfish area. Primary restoration, such as seeding with young shellfish, or perhaps transplanting shellfish from an unaffected area, eventually brings the shellfish stock back to baseline conditions. However, even if the stocks are brought back to baseline, commercial fisheries still suffered from a reduction in catch from the time of the spill until the stock is fully restored. Compensatory restoration would restore the stock above baseline conditions to make up for the lost catch that occurred over the recovery period. The task then is to determine the appropriate scale for compensatory restoration to offset the interim losses (US Department of Commerce, 1997).

Determining the appropriate scale for restoration can be done in two ways, depending upon the resource or service affected—*service-to-service* or *resource-to-resource*. For example, suppose a popular beach is oiled. Suppose further that it takes six weeks for the oiled beach to be restored and during that time an estimated 10,000 beach trips are lost. Even if the beach is restored to baseline quality, the 10,000 trips may be lost[14]. In this case, the party responsible for the pollution could be asked to provide additional facilities (e.g., additional beach access or parking) to make up for the lost 10,000 trips. Hence, in this case restoration actions involve restoring lost *services*.

Suppose instead, that a mangrove area is destroyed by pollution. Planting can restore the mangrove area to baseline but it will take years before the mangrove services are fully restored. During the period the mangrove is recovering, its nursery and habitat functions and *in situ* harvests of fish, crab, shellfish, wood and other services that would have been available, but for the pollution, are lost[15]. Identifying the exact services provided by the particular mangrove stand is difficult. However, assuming that the replanted mangrove provides essentially the same services when fully restored, it is *not necessary* to quantify each of the services. Instead, the polluter would restore the mangroves lost, plus additional mangroves in order to make up for lost interim services until there is full restoration[16]. This is the case of *resource-to-resource restoration* (also called the habitat-equivalency approach).

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14 *In some cases substitute beach sites might exist, and this fact needs to be considered.*

15 *This assumes of course that mangroves are a limiting factor for all the services mentioned for the area concerned*

16 *The amount of services or resources to be restored to return to baseline and to make up for interim lost services can be solved for mathematically in any particular case. For example, using wetlands, see Mazzotta et al. (1994).*

The shellfish example given above was another case of the scaling of restoration using the resource-to-resource approach. The resource-to-resource restoration scaling approach may also apply for other ecosystems injured by pollution such as coral reefs.

Under OPA '90 several factors must be considered when examining restoration alternatives, including natural recovery, technical feasibility and cost-effectiveness. Technical feasibility means that restoration actions should be proven, not experimental techniques, such that there is a reasonable expectation that actions will be successful. Cost-effectiveness means that when several equally effective restoration actions are possible, the least costly of these methods should be chosen.

Another important restoration consideration is the standard of *grossly disproportionate*. If the cost of restoring a resource is unreasonably high as compared with the increment in value due to restoration, then the proposed restoration action is not appropriate. In such a case, under OPA '90 trustees (representing the public) may seek compensation in the form of resources that are equally valued to the injured resource. For example, if a public beach is injured and the benefits of restoration actions are not in proportion to the costs of restoration, the government may substitute an equally valued alternative resource like a substitute beach, or possibly a completely different resource like access to alternative coastal recreation activities. In such a case, it is necessary to identify public values in order to determine the relative values of the injured and restored resources. Furthermore, in order to determine whether the cost of a proposed restoration program is grossly disproportionate to the benefits, it is necessary to estimate the value of the resources, at least in terms of the general order of magnitude. Hence, one or more of the valuation methods described earlier will need to be used.

Note that in all cases, natural resource damages and restoration actions must consider the extent to which stocks recover naturally. Restoration actions may not be needed or only minimal actions may be called for, in cases where natural recovery is rapid.

Resource restoration following a spill is intuitively appealing and seems straightforward. In fact, restoration under any legal regime faces many challenging issues (e.g., Mazzotta et al., 1994; Jones and Pease, 1996). In some cases, it can be difficult to determine the baseline level of resources that would exist if the spill had not occurred. Baselines usually will be relatively straightforward to establish for beaches, mangroves and nearshore shellfish grounds. However, for biological resources like open-sea fisheries, marine birds and wildlife, setting a baseline often is much more difficult. In many cases, adequate or up-to-date studies to determine the pre-spill level of resources are not available, or the resource injury may be small relative to our ability to measure biological populations precisely.

Issues like the above complicate the task of determining the level of injury for many biological resources and the amount of restoration that is needed to bring the resource back to baseline. These complexities can be compounded by the fact that many resource stocks vary over time due to the influence of a large number of factors that are difficult to identify and quantify. For example, fish populations vary significantly year to year due to environmental and anthropogenic factors. So it may be difficult to identify the population reduction due to a spill, or to determine when the population has fully recovered to what it would have been if the spill had not occurred.

Second, it is not always straightforward to determine actions that are technically feasible to restore particular resources. Although efforts to restore natural resources have come a long way in the past several years, the success of many restoration techniques is still highly uncertain and some are best considered to be experimental. Also, it may not be straightforward to determine the level of action needed to restore a given population. For example, one means of restoring a fishery stock is to improve habitat. However, this will be successful only if habitat is limiting and even then it will typically be highly uncertain how much stock enhancement will result from a given level of habitat restoration.

Third, it must be determined whether a restoration action is reasonable, given the cost of the action and the degree of restoration that results. For example, under OPA and related court decisions in the United States, the costs must not be grossly disproportionate to the benefits that result, as noted. However, the appropriate ratio of costs to benefits is a judgment call. It would not be a strict benefit-cost test (i.e., B>C) due to the difficulty of measuring benefits and the resulting potential to underestimate value; but at the other extreme, the standard for grossly disproportionate would not be C >100B either. Furthermore, the benefits may be difficult to measure reliably which is a major factor for relying on restoration to compensate for damages in the first place. The Civil Liability Convention and Fund Convention side-step this issue by leaving the determination of what is reasonable to a case-specific judgment[17].

Note that precise estimates of benefits may not be necessary to determine whether an action is reasonable. For example, one can carry out a series of sensitivity analyses to determine a range of benefits that result from a restoration action. If the costs fall within this range of estimated benefits, the action is viewed as reasonable. In contrast, if costs are an order of magnitude higher than the upper limit of the range, then the action would clearly not be reasonable.

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[17] *One important US court decision suggested a standard of 3:1. That is, if costs are more than three times benefits they are regarded as disproportionately high. In the recently published computer model used in the US to stimulate damages for minor incidents the ratio used is 10:1.*

Another difficult issue arises when there are no technically feasible actions that may be taken to restore the resources injured by a spill event. The Civil Liability Convention and Fund Convention do not specifically address what to do when restoration of the injured resource is not technically feasible (Brans, 1994, 1995). It appears that in such a case, the damages may go uncompensated. In contrast, under OPA the injured party has the option of obtaining compensatory restoration, which takes the form of acquisition or restoration of some other resource, preferably closely related to the injured resource. For example, an oil spill impacts an important commercial fishery for which there are no known restoration actions. However, fisheries are compensated by improving a substitute fishery, or damages to a recreational beach frequented by tourists are compensated by providing access to, or otherwise improving, a nearby, substitute beach.

Finally, an important issue concerns the extent to which restoration takes into account substitutability among resources. For example, it may be very costly to restore a particular resource injured in a spill. Rather than incur very high costs to restore, say, a common species of bird, it may be possible to make society whole—or more than whole—by restoring a more desirable resource, perhaps at a much lower cost. Thus, generally speaking the more flexibility government adopts in pursuing restoration, the easier it will be to find solutions that can restore equally valued resources at a lower cost, or to restore resources more valued by society for the same cost[18].

Simplified Methods for NRDAs

Rarely, if ever, will minor spills justify the high cost of a detailed NRDA study using extensive field observations. Instead, a simplified approach is used. All such approaches necessarily involve simplifications and for such an approach to be acceptable, at the outset it has to be understood and agreed upon that participants will accept the rough approximation from the simplified approach rather than incur the high costs of detailed, incident-specific studies for every spill. Next, two simplified approaches are considered—one based on a computer simulation model, the second using a compensation formula[19].

Use of a Computer Simulation Model

Simulations that mimic the physical fate of a spill, injury, lost services and monetary damages have been developed and used extensively (e.g., Grigalunas and Opaluch, 1988,

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[18] *The position is consistent with a portfolio view of resources, whereby it is recognized that a society appreciates many natural resources and substitutability among resources is possible.*

[19] *The benefit transfer method described previously can be regarded as a simplified method. Indeed, benefit transfer is used to value lost services in the computer simulation model described as a simplified assessment method in the text.*

1989; Applied Science Associates, 1996; Grigalunas et al., 1998). Such an integrated, interdisciplinary model was developed and adopted (under Federal Regulations) for use as the simplified method for all coastal areas of the United States for assessing damages from minor oil and chemical spills.

To employ these models, a user provides certain basic information concerning the amount and substance spilled and the location and date of the incident. The user also indicates when cleanup occurred and how much was removed. The model then simulates the dispersion and degradation of the spilled material (within a mass-balance framework) and the exposure of resources on and below the surface and along the shoreline to the slick and oil constituents. To do this, the model contains a physical fates component to track the mass-balance of the spill over space and time and a biological submodel that distributes averaged biological data (including abundance and population dynamics information for major fisheries species or groups) in the marine environment. Dose-response relationships from the toxicological literature are used within the model to estimate mortality to fish and shellfish[20]. Loss of birds and marine mammals are estimated based on contact with the surface slick. Beach closure and the resulting loss of beach services can be specified by the user when relevant in particular cases. The model includes a food web submodel that captures losses of primary productivity and the resulting effect on net production up the food web, through the ultimate loss in services to people (e.g., commercial fish).

Models like the above require fairly sophisticated programming, need considerable data and can be expensive and time consuming to develop. However, a number of oil spill models have been developed and refined within the Straits of Malacca and elsewhere so that much experience now exists with this type of modeling. Furthermore, data analyses and modeling (including the development of a database within a geographical information system) are available through the work of the GEF/UNDP/IMO Regional Programme, among other sources. The availability of this information would expedite the development of a simplified damage assessment model for the Straits of Malacca.

Once developed, computer simulation models for simplified damage assessment can be user friendly, updated and improved over time and extended to other geographic areas. For example, the original model developed for assessing damages for United States coastal areas was refined in subsequent work to include a geographical information system

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[20] *A standard toxicological measure is LC_{50}, the concentration of a pollutant that leads to 50% mortality of the exposed species within 48 hours under laboratory conditions.*

and to accommodate more detailed models of particular ecosystems and more species. It also was adapted in the Republic of Korea and was employed to analyze the effects of a nearshore oil spill in the Yellow Sea, on the west coast of the Republic of Korea (Grigalunas et al., 1990).

Despite its seeming sophistication, many simplifying assumptions necessarily are used in the development of such integrated, interdisciplinary NRDA models. For NRDA model to be effectively implemented, users have to understand its strengths and limitations and its appropriate uses. Any such model has to be developed with the clear understanding that it is a simplified approach, most suitable for relatively minor oil and chemical pollution incidents, where the model assumptions are more appropriate than they would be in the case of major incidents.

Compensation Formula

A compensation formula also allows a user to quickly arrive at a damage estimate following a minor incident. Compensation formulae do not rely upon a computer simulation, but even when this simplified approach is used to reckon damages for minor incidents, one would want to adopt certain principles. For example, it is desirable to mimic the spirit of an oil spill damage function. Specifically, other things being the same, one normally would expect damages to be an increasing function of the:

- size of a spill;
- characteristics (e.g., persistence and toxicity) of the substance spilled;
- value of the resources exposed; and
- environmental sensitivity of an area or resource.

Issues concerning the size of a spill are obvious; below some *de minimis* level, the receiving waters have some assimilative capacity; damages are unlikely and assessments will not be worthwhile (though penalties for deliberate discharges may be levied). Size alone, however, does not always mean negligible damages, so setting the *de minimis* amount of a spill is not a trivial decision and necessarily involves some judgment and may differ for nearshore or estuary spills versus offshore spills, for example.

As the size of a spill goes up, the area covered and the concentration of pollutants may increase, damages are expected to increase all else being equal (i.e., in an identical environment and under identical conditions). Generally speaking, spills of a given size in nearshore areas, including estuaries, normally are a greater worry than offshore areas where spills are more easily assimilated.

The characteristics of the oil or chemical spilled are very important. These characteristics should be taken into account and substantial databases now are available that cover many potential pollutants. Critical habitat and ecosystems (e.g., mangroves, corals and seagrasses; valuable fishing grounds) or spawning areas are identified. For example, the state of Florida in the USA, adds a dollar amount per unit of coral affected by a spill on top of a base amount for the spill. One also wants to allow for—and give incentives for—oil cleaned up, particularly for oil or other pollutants cleaned up promptly, when they have the greatest potential for causing injury and damages.

Taking into account factors like the above, one develops a simplified approach involving the use of a simple compensation formula like[21]:

$$\textbf{Damage} = \textbf{Bo} * [(\textbf{Qs} - \textbf{R}) * \textbf{S} * \textbf{C}]$$

where:

Bo = base money damage per unit (e.g., gallon) spilled

Qs = amount spilled (e.g., in gallons)

R = amount of pollutant removed within a given period (say, 24 or 48 hours)

C = characteristics of pollutant spilled (e.g., toxicity, persistence, solubility)

S = sensitivity of affected environment (e.g., location, ecosystem, habitat, value)

Thus, in the above formulation, there is a base damage per unit spilled that is scaled up or down by factors that influence damages in a particular case[22]. In the USA, for example, the states of Alaska, Florida and Washington employ simplified compensation formula similar to that outlined above (e.g., Geselbracht and Logan, 1993).

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[21] *The above formula is intended to mimic damages but could be extended to include penalties, as in the Alaska approach, for example. Thus, if the responsible party is guilty of (legally determined) serious negligence, then the result of the formula might be multiplied by some factor as a penalty.*

[22] *Obviously, the exact factors to include, how each is to be weighed and the nature of the overall functions (linear, multiplicative, etc.) are all important issues to be considered.*

In Alaska, the damage determined using the formula is intended to include hard-to-quantify environmental damages and is added to losses measured using the valuation methods described earlier. Using the Alaska compensation formula to illustrate the above approach, consider the 1989 *Exxon Valdez* crude oil spill of 10.9 million gallons of crude oil. In this case, use of the formula implies damages of $18 million. Alaska also multiplies the estimate obtained using its formula by a factor of 5, if the responsible party is found to be negligent. In the *Exxon Valdez* case, where negligence was ruled a factor, the total assessment using the formula thus comes to $90 million, plus cleanup and damages calculated using other methods.

Use of a formula like the above has the obvious advantages that it is simple and can be implemented at low cost—virtues not to be dismissed lightly. If its use is generally accepted by all parties, it would act like a system of traffic violation payments where the traffic fine paid is tied to the area (e.g., higher for a school district vs. a violation on the open highway) and the seriousness of the offense (speeding just over the limit vs. reckless driving vs. reckless driving while under the influence of alcohol)[23]. As the shipping community gains a broad understanding of the scale of the structure of charges, they have a built-in incentive to adapt their behavior accordingly.

Any formula involves many assumptions and simplifications. To be implemented, there must be willingness of those affected to trade off rigor for practicality. To encourage acceptability, all stakeholders are invited to participate in the development of such an approach. This involves, for example, meetings, workshops, hearings and perhaps formal comments for the record. Such a transparent process enhances acceptability, particularly if the damages calculated are not viewed as unreasonably high.

Potential problems with a compensation formula is mentioned. One is the potential for double counting losses, a responsible party must pay for pollution damages calculated using a formula and must *also* pay for individual resource damages that implicitly are included in the formula. While efforts can be made to avoid this problem[24], the use of a formula often may obscure exactly what resources are included (a problem that does not exist with a computer simulation model). Another issue is deciding how to determine the sensitivity of environment types ("S" in the above formula) contacted by a spilled substance. One approach has been to use the most sensitive environment contacted for all of the oil spilled, although this is counter factual and inflates claims. A better approach uses the primary environment affected or to weigh the environment types affected by their exposure.

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[23] *A traffic ticket payment is more of a penalty than a damage so one must not push this analogy too far.*

[24] *For example, if important marine bird habitat sites are specifically included as a sensitive environment factor in the formula, them presumably, responsible parties ought not to be liable for damages to these same resources on the basis of a separate study of enjuries to birds.*

A potential criticism of simplified approaches is that they are "speculative" or "theoretical" and, as a result, do not merit compensation. Truly speculative claims do not deserve compensation but interesting questions arise when different examples are considered. For example, an approach that multiplied each unit volume of seawater "affected" by any oil times a constant monetary value picked out of thin air to arrive at "ecological damages" surely is speculative and unworthy of compensation. Consider, however, a simulation of damages using a computer model that employs physical fate, toxicological and other relationships found in the literature. This method is more appealing than the first approach using a constant ecological loss per unit volume of seawater, but is it also speculative? Finally, is the same computer model speculative when applied in a case, if it is validated by comparison with field measurements at the spill site?

Ultimately, all damages (and all costs, for that matter) are estimates and all estimates contain some error. A critical issue seems to be how much error is acceptable in assessing pollution damages?[25] One can argue that in many areas societal decisions (e.g., taxation, health) simplified measures (e.g., easy tax forms for small incomes and uncomplicated cases; simple diagnostics for minor health concerns) are used because they are cost-effective or the benefits of more precision are not worth the costs. Are the same principles applied for simplified NRDA for transboundary pollution in the Straits of Malacca? This is a question for others to answer[26].

Examples of NRDA

To give an idea of claims and issues in specific cases, Table 4 summarizes NRDA and related claims information for example spills from different countries. The damages or costs claimed and methods used are given and selected issues are noted. It is emphasized that not all of the claims indicated were allowed and most were settled before they reached the court.

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[25] *This raises the fundamental issues of validity and reliability.*

[26] *In NRDAs there is always the risk—supported by many examples—that claimants will overstate losses (a moral hazard or conflict of interest problem). This goes both ways, and it is always possible that responsible parties might understate costs.*

Table 4. Selected NRDA and Related Claim Estimates/Issues for Oil Spills.*

Incident (year)	Injury/Damages	Method	Comments
Saybolt/Sun Pulse (1997) Singapore	Beach pollution	Removal costs	
Katina P (1992) Mozambique	Fishing--equip, oiling fish, closure, reduced price Coastal salt production	Cleaning and replacement cost Earnings Lost earnings	Total claims were for US$10 million, but limited to about US$3 million under TAVOLOP
Sea Princess (1996) Korea	Mariculture Tourism	Lost earnings	
BT Nautilus (1990) New York	Lost use of shipping channel; damage to environment	Market–Increased costs to vessels	Several hundred thousand US$
Exxon Valdez (1989) Alaska	Commercial fishing Lost output; price decrease Passive use value Recreation Response and cleanup Restoration	Lost rent; market model Contingent valuation Travel cost Market–actual costs Market–actual costs	Damage: Hundreds of million US$ Estimated: US$2.8-$8+ billion Several millions US$ US$2 billion US$1 billion
Presidente Rivera (1989) Delaware, USA	Lost recreation - fishing Lost commercial fishing Birds Reduced wetland services	Survey/literature and benefit transfer Lost earnings Simulation Restoration costs	Overall settlement several million US$
World Prodigy (1989) Rhode Island, USA	Lost commercial fishing Lost beach use	Lost earnings Benefit Transfer/Results in computer model	Beach use losses: US$2 million. Overall settlement several million US$
No. Cape (1996) Rhode Island, USA	Lost fish-lobster Birds and environmental injuries	Restoration Lost profit Restoration	ongoing
American Trader (1990) California, USA	Beach closure (15 miles of Southern California coast) Loss of birds Boating restriction Marine ecosystem damages	Recreation studies for lost uses; Restoration	US$17.3 + million in compensatory damages; $5.3 million fine Cleanup costs & payments to private parties were US$21 million

* Not all damages/losses claims listed were allowed.

A Straits-wide NRDA Framework for Transboundary Pollution

Introduction

Transboundary pollution poses a substantial threat to the Straits of Malacca. National laws in the three littoral States prohibit pollution; national laws, the CLC and Fund Conventions provide for compensation for response and cleanup costs, costs of oil spills, including damages to real property, lost earnings and environmental damages.

However, national laws seem to establish a broad umbrella, with no clear statement of damage categories to be pursued and methods to be employed. The 1969 CLC, 1971 Fund and 1992 Protocols provide substantial guidance for admissibility of claims (IOPC Fund, 1995, 1998; Osuga, 1997). The 1992 Fund Protocol expands the costs for which compensation will be allowed and establishes a higher liability limit than the 1971 Fund, as noted in the first part of this report. An obvious course is that all regional states become parties to the 1992 Protocol hence, avail themselves of the compensation provided by this Protocol. However, even the most expansive international convention, the 1992 Protocol, adopts a relatively narrow view of the incidents covered and damages for which compensation will be paid. As a result, many incidents of potential importance in the Straits of Malacca fall outside of the scope of the conventions and will be uncompensated unless national laws can be made to apply:

- Only spills of persistent oils and of bunker fuel from tankers are covered under the 1992 Protocol. Spills of non-persistent oils (gasoline, kerosene, light diesel, etc.) or of other chemicals not covered, nor are oil spills (including bunker fuel) from non-tanker vessels.

- Spills of oil from offshore production facilities, pipelines or terminals are not compensable under the 1992 Protocol.

- Non-petroleum (vegetable or animal) oil spills are not covered by the 1992 Protocol.

- Compensation for damages from mystery spills, where the source cannot be identified, is not available in the Straits of Malacca.

- No simplified NRDA approach for minor pollution incidents is available in the Straits of Malacca.

- Non-market losses (e.g., due to lost uses of public beaches or parks) appear not to be compensable under the 1992 Protocol. In general, environmental losses based on abstract quantification and theoretical models are ruled out, but what is theoretical versus "real" may not always be clear. Furthermore, compensation seems unavailable for assessment costs to quantify injuries and damages.

- Compensation is allowed for pure economic losses, but on a case-by-case basis.

- The scope and extent of allowable restoration of natural resources impaired by oil pollution is unclear, but the 1992 Protocol appears to have a limited view of restoration and questions remain about how broad principles of reinstatement of injured resources set by international conventions will be applied in practice (Brans, 1994, 1995).

- International conventions seem not to allow for *compensatory* restoration (i.e., reinstatement of impaired resources to their without-spill baseline, plus restoration to make up for any interim losses of resource services).

As a result of all of the above, countries that rely solely upon the CLC, the 1971 Fund, or the 1992 Protocol will not be compensated for many losses due to oil spills. Transboundary pollution incidents may impose several environmental costs upon the three littoral States of Indonesia, Malaysia and Singapore for which they may not be compensated.

An effective NRDA program, in combination with other measures to avoid and control pollution from shipping and other sources, provides additional incentives to reduce the number of incidents and decrease injury to natural resources and activities. An effective NRDA program rewards careful actors and punishes irresponsible actions. For example, insurance costs may fall for those with good environmental safety records; those responsible for pollution, however, face higher claims if an effective, Straits-wide NRDA framework was adopted.

As mentioned earlier, NRDA is a relatively new and evolving area. Much progress has been made, but many issues remain. An important issue concerns the implications of a

Straits-wide approach for NRDA. Below, some of the consequences are outlined that would arise from actions necessary to develop and implement an NRDA framework for the Straits of Malacca as a whole.

Implications of a Straits-wide NRDA Approach

The introduction of a Straits-wide approach for damage assessment will have many consequences. These include: (1) the impacts that a damage assessment process will have on various parties and (2) institutional mechanisms and related issues related with the development and implementation of a Straits-wide NRDA approach.

It should be clear, however, that the implications of a Straits-wide NRDA approach will depend upon the nature of the approach adopted. Below are issues that need to be addressed in great detail during any process to develop and implement a Straits-wide NRDA framework:

- the nature of liability;
- the scope of incidents covered;
- the scope of impacts (injuries) for which damages can be assessed;
- allowable damages;
- methods for estimating damages;
- standards to be applied in weighing the results of such methods; and
- means for limiting transactions costs.

The nature of liability for pollution is a legal issue to be addressed by lawyers. We note, however, that strict liability reduces transaction costs by eliminating the need to establish polluter negligence.

An important issue concerns the scope of the incidents and damages covered. As noted, existing international conventions omit many categories of spills and many types of damages. A Straits-wide NRDA framework covers an expanded set of incidents and damages, including some of those not covered under existing practices.

If the incidents, natural resource injuries and damages listed above are not included in a Straits-wide NRDA, then many costs from pollution will go without compensation. On the other hand, considerable efforts and expertise will be required to assemble information to support injury quantification and damage assessment if the incidents and claims to be covered are expanded. These implications are given additional attention later in this section.

A related issue relates to the methods to be used to assess damages. In particular, what is the role of valuation of natural resource damages—particularly non-market assessment methods—as opposed to reliance on restoration costs?

Several valuation methods were reviewed. Should greater reliance be made on valuation methods, the available literature relevant to the region needs to be reviewed and evaluated for potential use. Appropriate valuation methodologies have to be decided upon and guidance given for the use of these methods in particular cases.

To implement a restoration-based approach for the Straits, information on restoration options for key resources and ecosystems in the Straits of Malacca would need to be assembled and evaluated for relevance. Standards for assessing restoration have to be established. These include feasibility, cost-effectiveness and the grossly disproportionate principle described earlier. Recall, however, that deciding whether restoration costs are excessive as compared to benefits requires that benefits be assessed, i.e., some valuation is needed. Also, a policy must be established concerning how flexible decisions are with respect to restoration (i.e., restoring substitutes rather than the specific resources injured).

An additional, important issue concerns whether and what type of a simplified approach for assessing damages may be employed in a Straits-wide NRDA framework. Two alternatives—a computer simulation model and a compensation formula—were reviewed. Development of a computer model requires a fairly substantial effort. However, the availability of expertise and data within the region and prior experience with these methods in other regions facilitate efforts required to develop simplified approaches.

Now, some of the implications of any attempt to develop a Straits-wide approach for NRDA are discussed. One very important issue concerns the process and institutional structure within which a Straits-wide approach to NRDA is developed, implemented and refined, as necessary, over time.

NRDA raises many technical and administrative issues. Development and implementation of an effective NRDA requires considerable expertise in several fields. These include resource and environmental economics, the marine sciences, broadly defined (e.g., physical oceanography, toxicology, ecology, biology, fisheries, etc.) and the law.

Much expertise in these areas exist within the region, but it is vital that those who work to establish and implement a Straits-wide NRDA approach possess or develop the appropriate, specialized knowledge and experience for use in NRDA. Continuing involvement is necessary to develop specialized knowledge and experience. Thus, an ongoing institutional capability is needed to ensure consistent application of NRDA concepts to learn from "doing" and for continuing professional development in this area. Continuing involvement is needed to develop assessment and restoration concepts and methods as well as to refine and improve them over time. This strongly suggests the need to establish a central group to focus on NRDA issues. Experts from this centralized group need to be available so as to participate in transboundary pollution cases.

At the same time, the transaction costs in damage assessments have been very high. Efforts that reduce the need for experts, lawyers and drawn-out processes might contribute to a greater acceptability of NRDA and increase its effectiveness. This is a very complicated issue. Further research may identify models for settling complicated disputes in other areas that may be employed in NRDA in a Straits-wide system (e.g., use of objective, third-party masters or "fact finders", who may retain experts to consider specialized issues).

With experience, NRDA approaches become more standardized and easier to implement. An ongoing process, such as that sketched out here, also encourages development of additional expertise in the region at colleges and universities, at private research establishments and in the government.

For institutional purposes, it seems very desirable to have an administration center, comprised of scientists, economists, lawyers and perhaps others. A single group would allow certain economies to be realized, facilitate the development of a consistent set of methods and enhance cooperation and coordination. Such a group may be presumably funded at least in part out of assessment funds collected from responsible parties after pollution incidents, although use of a small fee per barrel of oil delivered may be a better alternative[27]. Many cooperative mechanisms currently exist among the littoral States that would provide a suitable institutional home for a central NRDA group. It is desirable to have an NRDA group work in close collaboration with existing, regional cooperative groups focusing on spill and pollution response, given the overlap in issues facing both groups.

Another implementation issue concerns the so-called "mystery" spills. As noted, if compensation for response and cleanup—and perhaps damages—is to be provided for spills with no identified source, a fund would have to be established, which raises a host of issues.

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[27] *Potential conflicts of interest could arise if an assessment or restoration group became too dependent upon revenues from responsible parties for their survival and must be guarded against.*

Would all oil shipments be covered and if so, what would be the size of a desirable fund and fee to support the fund? Who would administer the fund, what claims can be made against the fund and what standards of proof would be required before payment of a claim would be approved? Also, the fund operator presumably would want to file a claim against a polluter, if the polluter was later identified. What legal recourse would the fund operator have to do this?

Finally, we return to a point made at the outset: by its very nature, NRDA inherently involves tensions between the various stakeholder groups. Given these tensions, any attempt to develop a Straits-wide approach might benefit greatly from involving all those concerned in a transparent process with the opportunity to participate and comment upon proposed measures. Efforts to adapt and improve the NRDA process over time also should enhance its acceptability and effectiveness.

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