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Economic Assessment for Ballast Water Management: A Guideline

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Economic Assessments for Ballast Water Management: A Guideline

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The GloBallast Partnerships Programme is a co-operative initiative of the Global Environment Facility (GEF), the United Nations Development Programme (UNDP) and the International Maritime Organization (IMO) to assist developing countries to reduce the transfer of harmful aquatic organisms and pathogens in ships' ballast water and sediments and to assist the countries in implementing the International Convention on Ballast Water Management. For more information, please visit http://globallast.imo.org

Founded in 1948, IUCN (International Union for Conservation of Nature) brings together States, government agencies and a diverse range of non-governmental organizations in a unique world partnership: over 1,000 members in all, spread across some 160 countries. As a Union, IUCN seeks to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable. IUCN builds on the strengths of its members, networks and partners to enhance their capacity and to support global alliances to safeguard natural resources at local, regional and global levels. For more information see www.iucn.org

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The aim of this guideline is to aid maritime administrators, or other lead agencies working with ballast water management, to assess and quantify (as appropriate and possible) the potential economic consequences of unintended marine species introductions. Such economic understanding is intended to support sound decision making in relation to IAS risk reduction, preparedness and response planning, and in particular as a source of information for the development of a National Ballast Water Management Strategy (see GloBallast Monograph No. 18).

The successful use of these guidelines does not require specialist knowledge of environmental economic approaches and methodologies. However, the involvement of environmental economic specialists to undertake a technical assessment is strongly recommended.

This document is also closely linked to the Guidelines on National Ballast Water Status Assessment (GloBallast Monograph No. 17). Much of the information needed in the economic assessment will already have been collected as part of the national ballast water status assessment.

Several manuals and guidelines for managing marine invasive species, with particular attention to ballast water, have been published by organizations such as the International Maritime Organization (IMO), the GloBallast Partnerships Programme, and the Global Invasive Species Programme (GISP). GloBallast, in collaboration with the IUCN Global Marine Programme, has also prepared guidelines for the development of National Ballast Water Management Strategies. These guidelines on economics assessments are intended to complement such management guidelines.

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1

Introduction

1.1 SHIPPING AND MARINE INVASIVE ALIEN SPECIES

A species, transported outside its native range and introduced to areas where it does not normally occur, may under suitable conditions become established and, in the absence of natural controls such as predators or parasites, drastically change the ecosystem, its functions and species composition (Molnar et al., 2008). Such species are called **invasive alien species** (**IAS**): non-native to the ecosystem under consideration and causing or likely to cause economic and/or environmental harm or harm to human health (Clinton, 1999).

IAS is widely recognized as one of the most significant threats to global biodiversity (Wilcove et al., 1998). Many aquatic habitats are particularly vulnerable, such as mixed island systems, lake, river, and near-shore marine systems (Heywood, 1995). In part this is due to biological or physical characteristics of these areas. Another important factor is human activity. For example, species are at times introduced intentionally, such as for aquaculture, or unintentionally associated with fishing, recreational yachting or diving. However, the main vector for species transport, and responsible for the majority of marine species introductions, is shipping (Cohen & Carlton, 1998; Ruiz et al., 2000a; and Hewitt et al., 2004).

Shipping carries about 90% of world trade in volume and moves an estimated 10 billion tonnes of ballast water globally each year. This water frequently contains a multitude of living organisms – one study estimates that 7,000 species are carried around the world in ballast water every day (USGS, 2005). The presence of these 'hitchhiker' species in ballast water has become a major environmental challenge, and there is a growing body of research and documentation of the detrimental effects of aquatic IAS.

Because containing or eradicating a marine species once it is established is nearly impossible, management of marine IAS must focus on precautionary measures (see for example Thresher and Kuris, 2004; Carlton and Ruiz, 2005). The international community, not least the shipping sector itself through the International Maritime Organization (IMO), has been addressing the issue of IAS and ballast water since the late 1980s. The International Convention for the Control and Management of Ships Ballast Water & Sediments (from here on referred to as the Ballast Water Management (BWM) Convention) adopted in February 2004 is a key tool to this end.

The BWM convention has not yet entered into force. As of September 2010, 26 Parties representing 24.44% of the world merchant tonnage had ratified the convention. To enter into force, 30 signatories are needed, representing 35% of the tonnage. This guideline has been developed to assist countries in their efforts to ratify and implement the Convention in a timely manner.

1.2 THE ECONOMICS OF MANAGING IAS – ABOUT THIS GUIDELINE

The economic impacts of invasive alien species can be very large. One of the worst marine species invasions occurred in the early 1980s when the North American comb jelly (*Mnemiopsis leidyi*) was introduced into the Black Sea through ballast water. It rapidly took hold and by 1989 an estimated 1 billion tonnes of the alien species was consuming vast quantities of fish eggs and larvae, as well as the zooplankton that commercially-important fish feed on. By 1992, the annual losses caused by drops in commercial catches of marketable fish were estimated to be at least USD 240 million.

Successfully managing IAS can provide long-term economic and environmental benefits, including conserving biodiversity and health of ecosystems, and maintaining the services they provide. This supports the case for strategic investments in prevention rather than post-invasion damage control, including ratification of the BWM Convention and developing necessary national strategies and policy frameworks.

While national policy frameworks need not be unduly burdensome, they should meet standards set forth in the BWM Convention. Associated with ratification of the convention is thus a certain cost in ensuring compliance, related to e.g. planning, monitoring, enforcement and capacity building.

Economic analysis of IAS, their possible impacts and management options can support strategic decisions regarding IAS responses, and facilitate national planning. This guideline is primarily aimed at maritime administrators, to serve as a practical tool to support the development of a national ballast water management strategy. However, it also has a broader utility for considering the economic aspects of IAS impacts and management responses, and can be used for other decision support, including making a case for ratification of the BWM Convention.

For the purposes of development of a national ballast water management strategy, a simple economic assessment based on readily available data, such as national statistics, is often sufficient. This guideline is designed to provide a straightforward and structured approach to undertaking such assessments. In some instances, however, much more detailed analysis may be desired, in which case it is recommended to engage an expert economist. While detailed methods for economic assessment and valuation are beyond the scope of this guideline, information and suggestions that are useful in commissioning detailed studies are included.

How to lay the foundation for an economic assessment, identifying methods and securing the right capacities is dealt with in Chapter 2. Chapter 3 provides information on the different types of impacts marine invasive alien species can have, with particular attention to economic implications, and provides guidance on how to go about assessing the costs of such impacts. Chapter 4 provides an overview of the costs associated with ratification of the BWM Convention and a framework for estimating these costs at the national level, and how costs are distributed among stakeholders. Chapter 5 presents guidance on how these estimates can be used to support decision-making in relation to ballast water management. Recommendations are made regarding the analysis and reporting of findings, and reference is made to more detailed methodologies that may be applied, as and when appropriate.

2

Preparing for an economic assessment

An economic assessment requires a number of preparatory actions to ensure the assessment is appropriate, yields useful information, and can support decision-making and planning. The most important preparatory phase considerations are outlined in the sections below.

2.1 LAYING THE FOUNDATION FOR ECONOMIC ASSESSMENT

Before undertaking an economic assessment of the potential impacts of invasive alien species or the implications of preventive and management action, one needs to be clear about how the assessment is going to be used. Thus it is important to identify a purpose and specific objectives: ask first what needs to be addressed and why, then ask whether economic assessment can support desired actions or decisions. Only then identify how the assessment should be carried out, and by whom. It is also important to consider target audience, to ensure the assessment is suitable for the intended end users, as well as timeline and geographic coverage.

Common reasons for carrying out economic assessment include the following (see also Emerton and Tessema, 2001):

- To demonstrate and quantify the economic values of an ecosystem and the potential impacts to these values by introduction of an invasive species;
- To integrate business and economic concerns into environmental management;
- To identify potential management plans or actions to minimize the probability of an invasive species incursion;
- To support national decisions with regards to international policy instruments, such as ratification of the BWM convention;
- To support preparation of a National Ballast Water Management Strategy (NBWMS);
- To specify funding needs to implement management policies, such as the construction of facilities to accept ballast water.

2.2 CHOOSING AN APPROPRIATE ASSESSMENT METHOD

When the aims and needs of an assessment have been sufficiently well described the assessment approach can be defined, including selecting valuation methods. Key steps include the following (see also Emerton and Tessema, 2001):

1. Identifying the total economic value (TEV) of the area in question. This is a sum of the use and non-use values or benefits.
2. Recognizing and listing services or products for which a value cannot be readily quantified. These may be of significant value for decision-making processes.
3. Identifying potential impact of IAS on the flow of benefits.
4. Identifying potential costs associated with addressing IAS impacts on ecosystem products and services, as well as human activity (such as transport and trade).
5. Identifying the economic costs associated with IAS prevention and management, such as ratification of the BWM convention.

In most cases, simply listing and outlining potential costs and benefits may be sufficient to enable better decision-making. However, in the event that a more detailed economic analysis is desired, a variety of economic techniques can be applied. The most common economic valuation techniques are summarized in Annex 1. Additionally, more detailed guidance on various valuation methodologies can be found in the many toolkits that focus specifically on economic valuation. These are listed at the end of the References section.

2.3 SECURING THE RIGHT ASSESSMENT CAPACITIES

A substantive part of the economic valuation process described in these guidelines can be carried out by the National Ballast Water Management Task Force or through the Lead Agency. By going through the step-by-step process a relatively comprehensive analysis of the possible economic implications of IAS introductions, as well as the costs associated with reducing the risk of IAS impacts through implementing the provisions of the BWM Convention can be determined. However, there are considerable complexities with regards to detailed economic valuation methods, as well as national and local economy and biological and ecological functions. It is recommended that consultations involve qualified scientists and economists with relevant experience, knowledge and skills.

Should detailed economic analysis be required, such as to obtain a comprehensive Total Economic Value of ecosystem products and services, to assign more precise economic values to regulating or supporting services of ecosystems, or to conduct a comprehensive cost-benefit analysis, it is essential that an expert environmental economist is engaged.

3

Assessing economic value of resources at risk from IAS impacts

The possible impacts of IAS are manifold, and can affect human health, infrastructure, trade and ecosystems. In all cases this may have economic implications. For example, the dinoflagellate *Gymnodinium catenatum* can cause Paralytic Shellfish Poisoning which, in extreme cases, causes muscular paralysis, respiratory difficulties and even death. The spread of this algae is associated with ballast water but also fisheries and aquaculture, and has led to human poisoning, closures of shellfish farms and bans on gathering wild shellfish. Another infamous alien invasive species is the zebra mussel (*Dreissena polymorpha*), native to Europe but spreading rapidly throughout the waterways of North America, having been introduced to the US in ballast water. Zebra mussels encrust any solid structures in the water and block water pipes. Estimates for the cost of controlling this species in North America are close to USD 1 billion over 10 years.

Assessing and valuating impacts of species introduction is thus important both for managing IAS incursions, as well as for supporting preventive action. However, assessing the economic impacts of an IAS requires a structured process for evaluating the specific attributes of the ecosystems, economies, and cultures affected.

This chapter provides an overview of the most commonly used approaches to economic assessment of ecosystem values, and outlines a simple framework for how maritime administrators based on this can make an estimate of the possible costs to society and industry arising from ballast water mediated species introductions.

3.1 THE VALUE OF ECOSYSTEMS

Ecosystems provide valuable services to human production and consumption. The Millennium Ecosystem Assessment (www.millenniumassessment.org) classifies these services into:

- provisioning services such as food and water;
- regulating services such as flood and disease control;
- cultural services such as spiritual, recreational, and cultural benefits;
- supporting services, such as nutrient cycling, that maintain the conditions for life on Earth.

Ascribing values in economic or monetary terms can be done with relative ease for some of these services such as the revenue generated by a fishery in the marketplace. For other services that are not traded in markets, however, it is much more difficult to ascribe value. For example, a coastal ecosystem acting as a fish nursery habitat is valuable because it provides a safe environment for fish to grow in before moving into other areas where they are caught. There is no direct market for the coastal ecosystem, but the price of fish can give a 'shadow value' for the habitat. This is an example of a so-called indirect use value.

Capturing the complete value of ecosystems is done through a conceptual framework called Total Economic Value (TEV). By adopting a TEV framework in the early stages of an economic analysis, direct and indirect services that are both ecologically and economically important can be identified. Importantly, TEV helps us to understand that ecosystems provide values beyond ecosystem goods and services traded in the marketplace. Further, some of these values may be critical to community livelihoods. Using the TEV framework to capture the full value of the ecosystem services avoids the pitfalls of industrial studies that may only capture marketable values.

However, establishing quantitative values for indirect and non-use values of ecosystems can require detailed studies by trained environmental economists and the use of large data sets and advanced statistical analyses. Quantification may be a costly and time-consuming exercise. Hence, in some instances, qualitative analyses to indentify the categories of values and the flow of benefits and costs to various stakeholder groups may in itself provide critical information for decision-makers.

In other words, understanding the economic values of ecological services and impacts does not require expressing them in strict quantitative or monetary terms. By expressing them in qualitative terms, decision-makers may arrive at satisfactory conclusions for setting policy as well as taking management action. Furthermore, a qualitative assessment of the categories and distribution of values may identify specific issues that require quantitative assessment. In such cases standard techniques are available for economists to employ, as described briefly in this guideline and in Annex 1.

It should be noted that economic analyses of IAS impacts often tend to focus on the direct costs of an invasion. Very few analyses to date have quantified in financial terms the biodiversity loss that has occurred as a result of an IAS, even though this may entail a most significant impact through loss of provisioning ecological services. When conducting analysis of an invasive species it is important to recognize these additional impacts and their effects qualitatively, even if the values cannot be easily quantified with the data available.

3.2 CATEGORIES OF ECONOMIC VALUE

The Total Economic Value (TEV) of an area/ecosystem is a function of its *use values* and *non-use values (Table 1)*.

Direct use values, derived from direct use or interaction with environmental resources and services, can involve commercial, subsistence, leisure or other activities, such as fisheries and tourism. ***Indirect use values***, which relate to the indirect support and protection provided to economic activity by the ecosystems natural functions, can include flood control and protection against storm surges, as well as spawning or nursery areas for commercially caught fish. ***Option value*** is the value individuals place on the option to be able to use the environment sometime in the future, expressed for example as the willingness to pay for biodiversity conservation.

Non-use values, on the other hand, are derived from people's happiness based on the knowledge of the *existence* of an ecosystem or species from which they derive no real use but that they want to know is preserved. This can also include a *bequest* value, e.g. the satisfaction one gets from knowing a resource will be passed on to future generations.

It is important to be aware of these different values when estimating the possible economic implications of IAS introductions. Identifying the full range of goods and services humans derive from their local environment enables a more comprehensive assessment of what stands to be impacted. While a relatively accurate measure of several direct use values that may be impaired or lost can be generated, exact quantification of other values is often difficult. However, considering the full range of values can help to assign, at the very least, a 'ballpark figure' to other services that may be affected. Using the services of an expert environmental economist can help further tease out these nuanced values if necessary.

Table 1. The range of potential economic values embedded in an ecosystem.

The link between ecosystem production and economic activity can clearly be seen, as well as the consequences of bioinvasions (adapted from Barbier et al., 1997, and Nunes and Markandya, 2008).

TEV	Types of values	Examples of values	Examples of damage caused by marine IAS
Use values	**Direct use values**	Recreation, fishing, aquaculture/ mariculture	Loss of tourism and recreational benefits, risks to human health, loss of fish/shellfish stocks
	Indirect use values	Ecosystem services, climate stabilization, flood control, habitat, watershed protection, natural services	Effects on marine ecosystem health, e.g. changing chemical composition of the water, toxicity through the food chain
	Option values	Future information, future uses	No insurance that marine coastal areas are free from harmful algal blooms
Non-use values	**Bequest values**	Use and non-use values for legacy	Loss of legacy benefits, e.g. no marine species for the future
	Existence values	Biodiversity, ritual or spiritual values, culture, heritage, community values, landscape	Risk of loss of existence benefits

3.3 A FRAMEWORK FOR ASSESSING ECONOMIC VALUE OF RESOURCES AT RISK

This section outlines a framework for assessing the value of resources at risk from bioinvasion and thus the potential economic implications of IAS introduction. The approach has been modeled in part on sections of the Guidelines for National Ballast Water Status Assessments (GEF-UNDP-IMO GloBallast Partnerships and IOI, 2009). Where such a status assessment has been prepared much relevant information will be readily available (see the 'Resources of economic importance' section in the BW Status Assessment guideline).

3.3.1 Key sectors

While there are numerous sectors, stakeholders and processes that may be impacted by an IAS incursion in some way, a few stand to be directly affected and/or are more vulnerable. These sectors are thus of particular importance when considering the economic impacts of IAS. Frequently, these are also the sectors for which economic value can be most easily assessed. The sections below are adapted from GloBallast Monograph No. 17 (GEF-UNDP-IMO GloBallast Partnerships and IOI, 2009).

Fisheries: Commercial, subsistence and recreational fisheries all stand to be impacted by introduction of an IAS and should be assessed in terms of total annual catch, its value, the number of people employed in or directly relying on the industry (such as for provision of food/protein) and the importance of the industry in terms of contribution to GDP and employment. This should include all harvested species including shellfish.

Coastal aquaculture: The value of coastal aquaculture should be assessed in terms similar to capture fisheries, including annual yield and value, number of people dependent on the operation and importance for the country. This may include finfish, shellfish and seaweed culture.

Other living resources: In addition to fish and shellfish, a number of other living marine resources may be used. For example, mangroves are often harvested for wood, often on a subsistence basis, and may be used for other activities such as beekeeping, and reeds from estuaries and wetlands are sometimes used for construction (e.g. thatching) and for the production of arts and crafts. Similar data should be provided for these uses as for fisheries.

Coastal tourism: In many countries coastal tourism is an important source of livelihoods as well as revenue. Data on number of people employed, economic importance in terms of contribution to GDP and reliance on natural ecosystems or species should be considered. This could pay particular attention to unique, attractive or threatened ecosystems and species, such as coral reefs.

3.3.2 Additional costs to society and industry

In addition to the potential loss of revenue through impacts of IAS on industries, there are some instances where IAS introduction will incur significant costs, regularly and/or over long periods of time. Costs for maintenance and cleaning of **coastal infrastructure**, for example related to ports (marinas, jetties, markers), power plants and industries (water intakes for cooling), may increase due to biofouling. The value of the **shipping sector itself**, both in direct economic terms as well as in terms of to what extent the country relies on it for supplies and commodities, also stands to be affected, directly by bioinvasion and indirectly through regulatory change. Lastly, there are possible **public health** impacts of bioinvasions and significant costs may be incurred both to state and private health insurers (see for example Ruiz et al., 2000, which discusses the global spread of microorganisms by ships). An interesting example can also be found in the IMO document MEPC 60/INF.15, submitted by Norway, indicating that ships' ballast water was the likely pathway of an outbreak of *salmonellosis* in cattle at the island of Bokn in Rogaland county, western Norway.

The potential costs of IAS incursions will vary enormously depending on species and actual impact, and are thus very difficult to estimate. However, it is important to be aware that IAS may have such implications.

3.3.3 Sources of information

In addition to the National Ballast Water Status Assessment, important sources of information include national statistics, line agencies as well as academic institutions. Information on living marine resource use should be available from: Ministries (Fisheries, Marine and Coastal Management, Environment, etc.); industry associations (e.g. Fishing and Aquaculture Industry Associations); Universities, NGOs, etc. Information on tourism should be available from the Tourism Ministry and/or related agencies at national provincial or local levels. Coastal municipalities may also be in a position to provide, for example, information on numbers of beach users and different activities on and around beaches.

3.3.4 A basic framework

The table below outlines a basic framework for assessing the economic value of key sectors and potential costs as a result of IAS introduction. It also covers other impact costs that may be incurred. A more elaborated worksheet is included in Annex 2.

Table 2. A basic framework for assessing economic value of key sectors and potential costs as a result of IAS introduction.

Direct use value/key sectors	Total yield	Number employed or dependent	Total value of sector	Total value % of GDP	Vulnerability to IAS	Worst case % loss	Worst case $ loss
Fisheries							
Aquaculture							
Other living harvested resources							
Coastal tourism							
etc.							

Additional costs to society or industry	Number employed or dependent	Total value of sector	Total value % of GDP	Vulnerability to IAS	Type of costs	Worst case $ loss
Shipping						
Coastal infrastruture						
etc.						

Public health	IAS Species	Impact pathways	Possible impacts	Worst case number affected	Treatment costs	Worst case $ cost
Resource users						
Seafood consumers						
etc.						

Indirect use values	Ecosystems impacted	Total area	Vulnerability to IAS	Worst case % loss	Implications of loss	Worst case $ loss
Shoreline protection						
Sediment and nutrient control						
etc.						

Non-use values	Ecosystems impacted	Total area	Vulnerability to IAS	Worst case % loss	Implications of loss	Estimated $ loss
Cultural legacy						
Religious/spiritual value						
etc.						

4

Assessing and valuating costs of enacting the Convention

The process of acceding to and implementing the BWM Convention will incur costs to several stakeholders – industry, flag states, port- and coastal states. However, as the previous section has shown, upfront costs should not deter from undertaking the steps necessary to achieve the goals of the BWM Convention, as the potential environmental, as well as economic benefits to society as a whole, are likely to greatly outweigh the costs.

Port/flag/coastal state efforts will largely be limited to the institutional infrastructure for Compliance, Monitoring and Enforcement (CME), and regular environmental monitoring of the ports. Activities related to incursion management may also be required. Most IMO member countries have a port state control regime in place, and an institutional infrastructure for port state inspections. Activities related to implementation of the BWM Convention can for the most part readily be integrated into these systems, although there is considerable variability in capacity and effectiveness between countries.

The following section aims to identify cost elements associated with ratification of the BWM Convention. The type or character of costs is discussed briefly and a structured approach to assessing their magnitude and implication is provided. It should be noted that the needs (and thereby the associated costs) will vary from country to country. In addition, in most cases it will be very difficult, if not impossible, to arrive at very precise values. Therefore, this document intends only to assist in the identification of various costs that may arise, and allow for a qualitative assessment of these, including to *whom* these costs will occur, as well as possible cost recovery or financing mechanisms.

The sections below outline costs related to the preparatory phase (4.1), compliance (4.2), other costs indirectly arising as a result of ratification of the convention (4.3), and possible financing and cost recovery systems (4.4). To assist conducting cost assessments, a template is provided in Annex 3.

4.1 PREPARATORY PHASE COSTS

The initial step to implementing the BWM Convention is to assess institutional needs (see *Guidelines for Development of National Ballast Water Management Strategies,* section 5.2). Costs associated with this will largely arise from the time spent by administration staff in carrying out the series of tasks required to develop a national strategy. In addition, overcoming inter-agency coordination challenges will require development of an inter-agency forum or communication mechanism to coordinate BWM strategies among, as well as between, national and regional level governance structures.

4.1.1 Capacity building, coordination and communication

Identifying key leverage points within the country, taking care to account for all stakeholders involved in or potentially interested in the development of the national strategy, and those who will be involved in the implementation of the BWM Convention.

To ensure effective implementation of the convention, as well as harmonization among the various stakeholders at the national level and across regions, training may be necessary. Initial capacity needs should be identified by the Lead Agency and National Task Force. This may entail commissioning a detailed needs assessment. Potential recipients of training and capacity building efforts may include port and maritime authorities, port operators, shipping industry, relevant line agencies, etc.

Recipients of training will include all parts of the maritime sector, but due to the cross-cutting nature of the IAS issue, several other sectors should also be included. The Lead Agency and National Task Force should ensure that sufficient resources are allocated to the coordination of training activities.

As an example, trainings that may be required include:

- introductory training on Ballast Water Management;
- training on Legal Implementation of the BWM Convention;
- specialised training to the shipping industry (ship- and port-side issues);
- training of Port State Control officers (compliance monitoring and enforcement); and
- training on Port Biological Baseline Surveys.

Training packages on the above topics are available through GloBallast Partnerships.

4.1.1.1 National Task Force meetings

The National Task Force provides a platform for cross-sectoral communication, and ensures the participation of a variety of stakeholders in the implementation of the BWM Convention (see *Guidelines for Development of National Ballast Water Management Strategies* Section 5.2 and Table 10 for suggested participants). The NTF will thus serve as the main mechanism for coordination of implementation of national BWM activities. Resource needs include conducting regular National Task Force Meetings and ensuring communication and information flow to stakeholders.

4.1.1.2 Regional task force meetings

Due to the transboundary nature of shipping, as well as the problems associated with IAS, regional harmonization of strategies to combat IAS through sound ballast water management increases their efficiency. Regional Task Force meetings, although costly (due in part to considerable travel expenses), can greatly assist in this regard. There may, however, be funding sources to tap into, such as the IMO Integrated Technical Cooperation Programme.

4.1.2 Legislative, policy and institutional reform costs

Implementing the BWM Convention at the national level is likely to involve reforms of legislation, policies and institutions. As mentioned earlier, a series of guidelines have been developed for this purpose, and are available from GloBallast Partnerships. Valuable steps in this process include an initial national assessment of the status of ballast water-related issues, economic assessment of resources at risk and cost implications of ratification of the convention, the development of a national ballast-water strategy, and a legislative review and implementation. Much of this work can be carried out through national institutions under the guidance of the Lead Agency and National Task Force, but will require input from a broad range of stakeholders. In some instances consultants may be commissioned to conduct reviews or studies, which can offer considerable benefits but entails additional expenditure.

4.1.2.1 National BW status assessment

A structured approach and template is provided in the GloBallast-IOI *Guidelines for National Ballast Water Status Assessment* (GEF-UNDP-IMO GloBallast Partnerships and IOI, 2009). The status assessment includes a review of the role and patterns of shipping, a description of the marine and coastal environment, case studies of marine bioinvasions, legal, policy and institutional aspects, stakeholders, sources of information, etc. National Ballast Water Status Assessments are frequently carried out under the framework of the National Task Force, or the Lead Agency.

4.1.2.2 Economic assessment

The objective of the economic assessment (outlined in this guideline document) is to provide an understanding of the economic value of resources that may be under threat of a potential bioinvasion (see previous section of this report), as well as an estimation of the costs related to precautionary action, i.e. the implementation of the BWM Convention. At the basic level outlined here an economic assessment can be carried out based on existing or easily acquired data and through the focal agency or national task force members. However, more detailed analyses usually require engaging expert consultants, at considerably higher cost.

4.1.2.3 Developing a national BWM strategy

An approach to developing a national BWM strategy is provided in the GloBallast-IUCN publication *Guidelines for Developing a National Ballast Water Management Strategy* (Tamelander et al., 2010). Costs arising from this primarily relate to conducting background studies, organization of meetings and travel.

4.1.2.4 Legislative review and implementation

The legislative process will include a review of existing legislation, as well as the amendment of legislation or drafting of a new act, as necessary. Further guidance is provided in the forthcoming GloBallast *Guidelines for the Legal Implementation of the Ballast Water Management Convention* (GloBallast Partnerships, in preparation). Costs associated with this may include procurement of a consultant, if needed.

4.1.3 Port biological baseline surveys (research and monitoring)

Port biological baseline surveys provide the baseline against which success of ballast water management practices can be measured. They also enable detection of new introductions through regular monitoring and quantification of possible impact, and are thus important for developing and implementing response strategies.

Port baseline surveys are expensive, in part due to the cost associated with diving and collecting samples, but more so due to the detailed taxonomic analysis needed. Frequently this entails engaging a team of experts who will lead surveys and also train staff in national institutions.

4.1.4 Risk assessments

Within the context of BWM, risk assessments may be needed for several issues and at multiple levels. Under the Convention, risk assessments may be carried out as per Regulation A-4, which concerns Exemptions (see also below, section 4.2.1.5). For this purpose, refer to Guidelines G7, Guidelines for risk assessment under regulation A-4 of the BWM convention, for additional information. However, a risk assessment can also be a useful tool in the preparatory phase, at the regional, national or port level.

In addition to full risk assessments, *Guidelines for National Ballast Water Status Assessment* provides a structured approach to collection of data that can be very valuable in the development of a national BWM strategy. This data can also feed into various risk assessments. Associated costs are thus largely dependent on the type of risk assessment as well as availability of information.

4.2 COMPLIANCE-RELATED COSTS

The obligations of signatories to the BWM Convention and various other stakeholders are set out in the Convention. Compliance costs can be divided into those that relate to flag state obligations, port/coastal state obligations and industry obligations.

The responsibility of port- and flag states are basically limited to monitoring and enforcement, as well as incursion management should an invasion take place. Industry obligations relate largely to installation of ballast water management systems, training, and record keeping. During the phase leading up to the worldwide application of the D-2 Standard (BW Treatment), there are also costs associated with BW Exchange operations.

4.2.1 Flag state obligations

4.2.1.1 Establishing procedures for issuing BWM Certificate

Article 7 of the BWM Convention outlines the requirements for survey and certification of ships. As outlined in detail in Section E of the Convention, all ships must have an International Ballast Water Management Certificate, which would be issued by the Flag State. The costs may therefore include:

- establishing certification requirements;
- communication of requirements and procedures to the shipping industry and IMO;

- maintenance of records of issued Certificates; and
- costs related to surveying (see section 4.2.1.4 below).

The role of Class Societies should be taken into account when estimating the costs of surveys and certification.

4.2.1.2 Approval of ships' BWM Plans

Pre-approval costs may include training of staff and establishing protocols for vetting and approving BWM Plans. Costs would include staff costs for reviewing and commenting upon BWM Plans, including coordinating with ships' Captains/owners to ensure BWM Plans comply with NBWMS.

4.2.1.3 Type approval of BWM systems

As outlined in Regulation D-3 and Guidelines G8, Administrations may grant Type Approval to BWM systems that have been deemed to fulfill the standards set out in the Convention (Regulation D-2). Cost will include establishing a procedure that is in accordance with the Convention as well as, in particular, Guidelines G8 and G9. Furthermore, as these are highly technical issues capacity may need to be built in the administration. There may also be costs incurred through review of the technical documentation and test results of BWM systems before Type Approval Certificates are issued. A sample Type Approval Certificate is provided in the annex to Guideline G8.

4.2.1.4 Surveys (Initial, Renewal, Intermediate, Annual, Additional)

As per Regulation E-1, regular surveys of BWM systems on board ships should be conducted. This includes initial surveys on installation/approval; surveys for renewal of certificates; as well as Intermediate, Annual and Additional surveys as specified in the Convention.

Once standard procedures for these surveys have been set the main cost is the time spent conducting them, as part of normal flag state inspection.

4.2.1.5 Approval of exemption applications

Regulation A-4 indicates that exemptions for a ship to comply with the Convention may be granted by a Party or Parties in waters under their jurisdiction and under certain conditions. Exemptions should be voyage specific, i.e. between specified ports or locations, and should not be granted for more than five years at a time. Exemptions should be based on risk assessments carried out in accordance with Guideline G7, and will require the approval of the administration. If the necessary capacity to process these applications exists in the Administration, the time spent by staff should be captured in the economic assessment. Alternatively, costs to procure the services of experts could be captured.

4.2.1.6 Training of crew members

Although it is the responsibility of the flag administration to ensure that crews on vessels under their flag are trained in the provisions of the Convention, this may not incur any costs to the flag administration. The role of the administration is to ensure that training is available, either at national, regional or IMO level. The actual costs will fall on the industry (see section 4.2.3 below). The administration may therefore need to provide certification to recognized training organizations.

4.2.2 Port state obligations

Port states will be obliged to follow protocol in accordance with the BWM Convention and as set out in their national legislation. Port states already have port state control (PSC) regimes in place, into which Ballast Water Management related monitoring and enforcement activities can be integrated. The resources required will vary greatly between ports and countries depending on the types of cargos/vessels handled, number of ship calls, port state control capacities, etc. However, it is reasonable to expect that the costs associated with such activities will be much less than those associated with implementing other marine environmental protection requirements (such as MARPOL). For example, BWM imposes relatively minor infrastructure requirements on ports, which do not need to have vast BW reception facilities (unlike e.g. reception facilities for oily waste). Where a sediment reception facility is required the expected infrastructure costs are likely to be small, and the facility could be operated commercially by a shipyard. Thus most of the Port State obligations should not be a burdensome cost for the Port State administration, and the main issue is to ***identify* the obligations and thus *potential* costs, in order to establish appropriate cost recovery mechanisms.** This is further elaborated on in section 5.

4.2.2.1 Compliance monitoring and enforcement (CME)

Article 9 of the Convention states that that ships "may be inspected by port State control officers who can verify that the ship has a valid certificate; inspect the Ballast Water Record Book; and/or sample the ballast water." Costs incurred under CME efforts can be sub-divided into the items described in the sections below.

Box 1: CME for BWM already a reality – a case study

In 2009, the federal court in New Orleans convicted a ship management company for violating anti-pollution laws, ship safety laws, and making false statements after a U.S. Coast Guard investigation of the Greek-owned cargo ship revealed failure to maintain accurate ballast water records.

The company was sentenced to pay a USD 2.7 million criminal fine and ordered to pay a separate USD 100,000 community service payment to the Smithsonian Environmental Research Centre. The court further ordered that all ships owned or managed by the company, currently 20 vessels, will be barred from entering U.S. ports and territorial waters for three years as a condition of the probation imposed on the company.

The prosecution was carried out under the Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990, which established a national ballast water control program in an attempt to prevent invasive aquatic species from entering U.S. waters. The ship management company pleaded guilty to violating the Act by failing to maintain accurate ballast water records.

Source: U.S. Department of Justice, Office of Public Affairs. Justice News online, Wednesday, December 9, 2009.

4.2.2.2 Inspection of ships

Ship inspections will be the responsibility of port officials. For ease of monitoring, training and transparency, it is suggested that states adopt a BW Reporting Form, such as the one presented in Assembly Resolution A.868(20). The BW Reporting Form is not mandatory under the Convention, but facilitates gathering of information and could therefore be considered as part of the national regulatory framework, either as a mandatory or voluntary instrument. An inspection regime that sets out standard practice should also developed. The use of risk assessments can help strategically reduce the number of ships requiring detailed inspections when calling at ports, while not compromising efficiency of the inspection regime.

4.2.2.3 Sampling

It should be noted that there are two main types of sampling related to the Convention:

1. Sampling for compliance with D-1 standard; and
2. Sampling to ensure D-2 compliance.

D-1 sampling is not too complicated or costly, as sampling is mainly intended to confirm records about BW exchange (i.e. to confirm BW Record Book records) and may be carried out by using e.g. a salinometer. Ballast water sampling and analysis to determine D-2 compliance may, however, be highly costly and time-consuming, in particular if sampling is intended to determine exact levels of organisms and pathogens in the ballast water. However, in most situations it is foreseen that sampling would be carried out by means of a proxy, i.e. to ensure that the installed BW Treatment system is working correctly, as the rigorous procedures to approve the treatment systems have already established their efficacy.

As set out in the Convention, inspections should not cause undue delay to the vessel, and thus it is not foreseen that testing of BW will be carried out frequently or on all ships calling a port. If the BW Record Book and the BWT System indicators are in good condition, there will be no grounds for causing delay to the ship by carrying out extensive testing. If, however, there is reason to suspect non-compliance, detailed inspections may be carried out, which will require equipment for sampling and laboratory analysis. The economic assessment should therefore take into account the costs of procuring services of a reliable laboratory or, if appropriate, developing the adequate capacity in-house.

The cost of CME will thus depend on a number of factors, such as the type, frequency and accuracy chosen for inspections, monitoring and sampling. King and Tamburri (2010) summarize how costs relate to these factors (see Table 3 below).

Table 3. Comparison of the cost and effectiveness of ballast water compliance verification alternatives.

Method	Cost	Effectiveness
Reporting: Mandatory reporting by ship master, owner, operator or person in charge that BWTS has been installed, maintained and used properly and that it is performing adequately to achieve BW discharge standards.	Nearly zero[a]	Very low[b]
Inspections: Random or targeted onboard inspections of BWTS.	Relatively low[c]	Relatively low[d]
Monitoring (Indirect Measurement): Use of sensors and data reported out by sensors to determine if BWTS is operating properly to infer compliance or to determine if BW meets discharge standards.	Moderate Installation: $5,000–$10,000/ vessel Operation: $3,000/year/vessel[e]	Relatively high[f]
Sampling (Direct Measurement): Direct sampling and analysis of BW discharge to determine if it meets BW discharge standards.	Very high $75,000–$125,000/vessel/ sampling event[g]	Low – Very high[h]

[a] Verification merely involves reviewing paperwork.

[b] There is a high likelihood of misreporting and difficulty detecting misreporting.

[c] USCG inspections of BWTS can be incorporated into the current USCG vessel inspection program.

[d] Inspections of BWTS equipment cannot assure that equipment has been installed, maintained and operated properly to achieve BW discharge standards.

[e] Based on integrated water-quality sensor packages placed on commercial vessels of opportunity for oceanographic research. Validation of sensor performance and sensor output correlation with treatment system performance is critical prior to adoption of indirect measurements.

[f] BWTS that are operated properly, especially if they are not installed or maintained properly, may not successfully treat BW at all times. On the other hand, sensors designed to verify that BW discharge meets standards (e.g. conditions exist and/or have existed which are ‘proven’ to adequately eliminate or kill organisms to meet BW standards) can be very effective.

[g] Because of the large volumes (and high flow rates) of BW being discharged and the relatively small concentrations of living organisms allowable, a great deal of BW must be sampled and analyzed to make a statistically reliable determination that BW discharge does or does not meet standards. A recent statistical study commissioned by the USCG suggest that 60 m^3 of water may need to be sampled and analyzed to determine if a treatment system meets IMO and phase-1 US discharge regulations with 95% confidence. Actual costs, of course, depend on the intensity of sampling (% of BW analyzed per vessel) and the extent of sampling (% of vessels sampled). Cost estimate based on current costs of shipboard testing of BWTS for certification.

[h] Confidence in verification of BW discharge based on direct sampling depends on the intensity of sampling (% of BW analyzed per vessel) and the extent of sampling (% of vessels sampled). In general, low and even moderate sampling results in relatively low confidence that BW discharge violations are detected. Only intensive and extensive sampling (at very high cost) results in high levels of confidence that BW discharge violations will be detected.

From King and Tamburri (2010).

4.2.2.4 Sediment reception facilities

It is important to realise that the Convention does not require the establishment of sediment reception facilities, *except* for where cleaning of ballast water tanks, and thus the disposal of sediments, occurs, e.g. dry docks (see article 5). If a decision to establish such facilities or procedures is taken, these costs should be reflected in the economic assessment. Further information is contained in Guidelines G1.

4.2.2.5 Communication of requirements to IMO and other member states

As per Article 14 of the Convention, all national requirements established should be communicated by the Maritime Administration to IMO and other member states.

4.2.2.6 Communication of BWM requirements to ships

The Administration also needs to make sure that the BWM requirements under its flag, and ships calling their ports, are aware of the BWM requirements in the country. This may entail preparation of specific information documents and communications as well as more generic outreach materials, and, at least as an interim measure, establishment of an information service.

4.2.2.7 Designation of areas for ballast water exchange

In some areas, due to the geographic and hydrographic conditions, it may be difficult or impossible to conduct BW exchange in accordance with Regulation B-4, paragraph 1. Paragraph 2 of the same Regulation therefore allows for the Port State to designate areas where BW exchange should take place. However, this designation of areas should be done in consultation with adjacent states Guidelines G14 (Guidelines on the designation of areas for ballast water exchange). However, the Convention also specifies that this should not cause undue delay to the ships, and they should not be forced to deviate from the course.

Additional guidance is given in Regulation B-4 and D-1, as well as Guidelines G11.

4.2.3 Industry obligations

Successful BWM requires the contribution and input of all stakeholders, in particular the industry itself. All regulations and requirements of the Convention will of course have an impact on the industry. The following section identifies those where additional costs may be incurred.

4.2.3.1 Training of crew members (IMO model courses, etc)

Several aspects of the Convention will require additional training of ship crew. Regulation B-6 determines that officers and crew shall be familiar with their duties in the implementation of the Ballast Water Management Plan, which also includes the safe operation of the Ballast Water Treatment system onboard. Furthermore, the Convention states that each ship must have a designated officer on board in charge of ensuring that the Plan is properly implemented (Regulation B-1.5).

Training of various other staff in the shipping industry, such as onshore crew, port managers and operators, etc., may be needed. Possible costs arising from this should also be identified.

4.2.3.2 BWM Plans

Each ship will need to have a BWM Plan that is specific to the ship and fulfills the requirements of the IMO Convention (Regulation B-1). In summary, the Plan should address safety procedures, BWM practices, procedures for disposal of sediments, designation of an officer in charge of BWM operation on board, and the reporting requirements. More detailed recommendations, including a standard format for the BWM Plan, are given in Guideline G4.

4.2.3.3 BWM Record Books

Ships will need to document their BWM through record keeping (Regulation B-2). This record keeping should become part of normal duties on board and should not entail very onerous or time-consuming tasks. A sample format for the BWM Record Book is given in Appendix II to the Convention.

4.2.3.4 BWM options

Ballast Water Management can be conducted in several ways. As an interim measure the BWM Convention allows for Ballast Water Exchange meeting a standard set in Regulation D-1, where ballast water is exchanged in the open ocean and ensuring at least a 95 per cent exchange. This will be replaced by a Ballast Water Performance Standard, whereby all BW management systems must fulfill a standard based on presence of viable organisms per unit volume of ballast water, as specified in the Convention.

BW Exchange

All BW Exchange operations will incur a cost, as the additional use of pumps will increase the use of fuel. Some types of ships may even need modifications of their ballast water pumping systems to meet the BW Exchange standard as set forth in the convention. This may involve cost both in terms of manpower and material, including potentially dry-docking of vessels. Some costs may also be incurred if vessels need to move off-course to reach an exchange zone (delay costs). Examples of costs related to BWE operations (including estimations of the relation between ship type/size, time needed for BWE and pumping costs), can be found in e.g. CIE (2007) and Anwar (2010).

BW treatment

Ballast Water Exchange is only an intermediate option for BWM, and in the longer run all ballast water discharge should fulfill the Ballast Water performance standard set out in Regulation D-2. There are already a number of BW treatment systems compliant with these standards available on the market, and more are being developed.

For the industry, installing these systems may entail a significant cost, typically ranging from USD 100,000–1,000,000 per vessel. The cost is estimated to be in the range of USD 0.01–0.2 per ton of treated BW (see Gregg et al, 2009, for examples). Costs may also be incurred in the process of selecting and testing BW systems to identify the best solution for the fleet.

It should be noted that the Convention also allows for alternative options to BWM, provided that they can provide the same level of protection to the environment, human health, property and resources, and are approved in principle by the Committee. There are several alternative BWM options being considered by the marine engineering community, which may eventually enter the market. However, at present such systems are not commercially available but, in particular for certain vessel categories, viable options may be developed as an alternative to treatment systems.

4.3 OTHER ISSUES NOT COVERED BY THE CONVENTION

4.3.1 Port biological monitoring programmes

Biological monitoring programmes are a means to detecting possible new species introductions, as well as change in populations of non-indigenous species already present, and are thus an essential part of IAS incursion management as well as prevention planning. To be effective, the monitoring programme requires some kind of biological baseline against which change can be measured (see section 4.1.3). However, in many areas of the world, this data, especially at a level of detail needed to identify and monitor invasive species, is lacking. Protocols for this have been developed (e.g. Hewitt and Martin 2001), based on which a national monitoring programme can be devised. This requires involvement of appropriate agencies (e.g. environmental protection), and often entails a significant cost.

4.3.2 Port BWM Plan development

Port BWM Plans are not a legal obligation under the convention but may constitute a valuable tool in the implementation of the convention. Issues to be covered by the Port BWM Plan include:

- BWM options and their practicality;
- reception facilities (availability/access);
- communication of information, e.g. on sensitive and/or avoidance areas;
- decision-making systems; and
- contingency arrangements.

Development of a Port BWM Plan is commonly carried out by the port authority, in association with industry and the national task force. Costs are in most cases readily absorbed by participating agencies.

4.4 FUNDING MECHANISMS AND COST RECOVERY SYSTEMS

As is clear from the sections above there are cost implications associated with the provision of most port services. There are numerous ways in which these costs can be recovered or distributed in order not to incur excessive costs to the Administration. It is reasonable to assume that most of the burden related to preventing ballast water mediated bioinvasions will be borne by the shipping industry, as a direct result of the entry into force of the BWM Convention. Parallels can be drawn to other aspects of port state control and port operations, as indicated in the following sections.

4.4.1 Funding mechanisms

The convention stipulates that ballast water has to be either exchanged at mid-sea or treated to a certain standard onboard. In some instances ballast water may be required to be discharged in a designated ballast water discharge zone. Ship owners are expected to take on most of the responsibility and thus related costs. Requirements to have BW treatment equipment or exchange systems in place on ships mean that they are bearing more than 99% of the costs associated with prevention of the IAS.

It is expected that the operational costs of BW treatment will be between USD 0.01 to USD 0.2 per ton of BW (including capital costs amortized over a life span of 20 years), depending on the size and type of ship and the BWM system used. If 10 cents per ton is taken as the average, then to treat the 5 billion tons of BW being transferred per year globally will cost each ship on average USD 10,000 per year (around 50,000 ships involved in international shipping – this cost will of course as a rule be higher for larger ships, lower for smaller ones). These are relatively small costs for the shipping industry, considering that ship operating costs lie between USD 3,000 and 10,000 per day depending on size, while construction of a new large vessel is in the range of USD 100 million. Accordingly, the shipping industry has already embraced the the BWM convention and its entering into force. Many are thus already doing mid-ocean ballast water exchange, as required by e.g. the US, and treatment systems are already being installed on newbuilds as well as older vessels.

However, depending on the situation, investments by the flag/port/coastal state may in some circumstances be necessary. If resources are insufficient, several potential additional sources can be identified. These include:

- private sector investors;
- partnerships with in-kind and monetary contributions from major stakeholders who are benefited from BWM (e.g. fishing, tourism, mariculture industries), other private and non-governmental organizations;
- commercial bank loans;
- government, i.e. through additional allocations in national budget and/or subsidies;
- multilateral donors, e.g.
  - the IMO Integrated Technical Cooperation Programme;
  - other UN agencies and programmes;
  - the World Bank;
  - the European Union;
  - regional development banks (EBRD, Asian Development Bank, African Development Bank, the Inter-American Development Bank);
  - the European Investment Bank;
  - bilateral donors.

Alternatively, various options for cost recovery could also be considered.

4.4.2 Cost recovery systems

There is significant potential for governments to identify systems for cost recovery through some activities carried out as part of PSC/CME. Current fee structures of ports around the world include fees for environmental services, such as oily bilge water treatment and garbage disposal. From these experiences (see e.g. IMO, 1999) the following options for cost recovery systems can be identified:

- **Direct fee system.** This entails payment on delivery of services.
- **Contract system,** i.e. signing a contract between the service provider and the ship owner or organization, or between several parties, including e.g. the government and intermediate organizations. Mainly applicable to ships calling the same port frequently.
- **Costs of services included in port dues/charges.** This is an indirect cost recovery system where costs are included in the existing port dues/charges. The collected charges must then be reallocated to the actual service providers. Charges may be differentiated for particular ship categories.
- **Fixed fee system,** which can be considered as a derivative of the system of including costs in the port dues/charges. Here, the costs for a specific service are separated from the port dues as a surcharge, but still have to be paid with the port dues.
- **Combined system,** which implies that every ship pays a fixed charge plus an extra charge dependent on the type of service. The extra charges are paid directly to the service provider, whereas the fixed charge is collected by the port authority or an intermediate organization who passes it on to the service provider.
- **Free-of-charge system.** This system embodies the shared-cost concept and is not actually a cost recovery system since operational costs for providing a service are not covered. However, resource may be allocated through e.g. government subsidies or revenues from specific taxes.

Different ports require different cost recovery mechanisms (see IMO, 1999, Tables 11B.2, 11B.3, 11B.4 and 11B.5 for examples).

Non-compliance with the BW convention, such as cases of illegal discharge of BW, substandard BW exchange or treatment systems, and insufficient record-keeping, can also constitute a significant, albeit irregular, source of revenue, see Box 1 above. Where fines for non-compliance are imposed, the polluter pay principle and/or the shared cost principle should be applied.

In conclusion, the funding for activities in the preparatory phase and for measures introduced by the flag/port/coastal state could be a mix of funding and cost-recovery mechanisms, as necessitated by each country choosing to use a variety of funding mechanisms. The table below summarizes the characteristics of various mechanisms, their potential revenue streams, reliability, exclusivity to BWM, etc.

Table 4. Funding mechanisms and characteristics.

The following table is an attempt to illustrate, in a very schematic way, the strengths and weaknesses of possible financing mechanisms for BWM. Modified from GloBallast Partnerships Project Document.

(L-Low, M-Medium, H-High)

Financing mechanism for BWM related costs	Potential size of funds that can be mobilized	Sustainability of funds over time	Ease of collection and administration	In line with Polluter pay principle	Political feasibility
Fines and penalties	H	H	M	H	H
Fees for services	L	L–M	M	H	H
Special port fees	H	H	H	L	L
Government funds	H	L–M	H	L	M
Partnerships with private sector, NGOS	L–M	L–M	M–H	H	H

5

Using economic data for BWM planning

Economic valuations or assessments are intended to improve decision-making processes ranging from community or industry engagement and ecosystem management to the development of national strategies and action plans to manage the risk associated with invasive alien species. This guideline seeks to facilitate this process in particular as it relates to the main vector of marine IAS introduction, shipping and, more specifically, ballast water.

Regardless of the 'depth' of economic analysis undertaken – i.e. a qualitative analysis of the value of resources or sectors that may be affected and costs related to prevention, or a quantitative valuation of the ecosystem and its services to the national economy and a detailed breakdown of the full range of management responses – the results can be applied to relevant strategies, policies and actions through the identification and comparison of critical benefits and costs.

5.1 INTERPRETING THE ECONOMIC ASSESSMENT

As this guideline focuses on a relatively low-intensity or low-resolution approach to economic assessment, this section deals primarily with compiling and synthesizing findings and drawing broad conclusions. However, a brief outline of two commonly used advanced analytical tools is also provided.

5.1.1 Synthesizing findings

The economic data on possible marine IAS impacts (Chapter 3) and costs associated with ratification of the BWM Convention (Chapter 4) are different in many ways. For example, the former by and large assesses costs as they may be incurred to society as a whole, or to specific industries that are rarely directly related to the maritime sector or under the purview of the maritime administration. The latter seeks to identify how costs are distributed between stakeholders within the maritime sector, and their magnitude. Thus the data does not lend itself to a detailed cost-benefit analysis (see section below). However, the data can be synthesized and compared in several ways that supports a decision-making process.

The matrices provided for economic assessment collate data in a format that is easily accessible, and often this will be sufficient for providing an overall comparative analysis of how an investment in preventing IAS through implementation of the BWM Convention compares to possible costs as a result of incursions that would be far more likely without the convention. Thus further elaboration or analysis may in many cases not be needed. However, a brief narrative highlighting findings of particular importance or concern should be prepared. It is also important to provide sufficient information on how data was obtained and an explanation of any analytical procedures.

In reporting findings from the economic assessment it is, as mentioned in Chapter 2, critical to keep the objective of the study and the target audience in mind. Data relevant to specific stakeholders and/or matters at hand can be highlighted and contextualized as necessary, including, for example, drawing up hypothetical scenarios. This will greatly increase the usefulness of a report both as a source of information and a basis for decisions.

However, it is also important to be aware of the limitations of the data and the constraints this places on the analysis. The approach presented here is targeted at the non-expert, and does not yield the kind of information required for advanced analysis. Findings should thus not be considered nor presented as a detailed economic valuation, but rather as a broad, 'brush-strokes' overview. Lastly, when using the assessment to compare values and potential costs it is important to ensure that these are indeed comparable and not attempt to compare apples with oranges, as well as that conclusions drawn are supported by the data gathered.

5.1.2 Advanced analytical tools

If a formal analytical process is required, e.g. prior to enacting policy, two widely-accepted analytical techniques are available: cost-benefit analysis and multi-attribute analysis. These analyze the trade-offs between management options and scenarios. While information on how to carry out such analyses is beyond the scope of this guideline, a brief outline is presented below which, along with the information in Annex 1, may be helpful in cases where expert environmental economists will be contracted to undertake a study.

Multi-criteria analysis:

Multi-criteria analysis (MCA) is a technique useful for qualitatively analyzing decisions, and as such is reliant on judgments of the decision-making team. This subjectivity can be a concern and thus the process must be transparent both in terms of how data and information is obtained and interpreted. Importantly, under MCA indicators do not always need to be quantified in monetary terms. They can be based on quantitative assessments using scores, ranks or weights. Thus non-marketable environmental values can be compared along with quantified economic benefits and costs, facilitating the use of both monetary and non-monetary indicators to improve decision-making.

Status quo or business-as-usual scenarios are often used as reference points to determine the effectiveness of pursuing various options that present themselves within a problem. Because of this sensitivity of MCA, however, the assumptions behind any alternative scenarios from the status quo need to be clearly stated so as to be understandable to the decision-makers.

Cost-benefit analysis:

Cost-benefit analysis (CBA) compares the data that has been gathered through valuation exercises on benefits and costs, and attempts to establish a preferred course of action. Governments, businesses and decision-makers often apply this technique in making decisions regarding a potential project, policy or investment.

A drawback with cost-benefit analysis is that all values must be monetized, including non-marketed ecological services. It thus requires the skills of a trained economist. Another critical challenge is that calculations are heavily influenced by choices and assumptions made regarding discount rate, as costs are often more immediate while benefits tend to accrue over longer time periods. Hence choice of variables and purpose of the analysis require a high degree of definition as well as transparency in process. However, a benefit of the technique is the ability for alternatives to be computed quickly.

5.2 USING THE ECONOMIC ASSESSMENT IN NATIONAL BWM PLANNING

This guideline outlines a straightforward economic assessment approach geared towards supporting and enabling national BWM planning. The national BW status assessment provides a foundation for the economic assessment. Together, the two assessments constitute a resource base both for the process of ratification of the BWM convention and for preparation of the NBWMS. It also has bearing on related legislative reform.

It is thus recommended that status assessments, economic analyses, preparation of national plans and legislative reform are carried out in a coordinated manner and in logical sequence. This increases the usefulness of data, reduces duplication, saves resources, improves integration and collaboration between stakeholders and thus strengthens actions aimed at reducing the risk of spreading IAS through ballast water.

Box 2: Economic assessment as a decision support tool for BWM – the case of Australia and the BWM Convention

Under Australian law, a regulation impact statement (RIS) is required when new regulations are introduced or existing ones repealed. The RIS is considered to be an effective way of increasing the public participation in the regulatory process. The Subordinate Legislation Act 1989 No 146 requires that the RIS contains, among other things, "an assessment of the costs and benefits of the proposed statutory rule, including the costs and benefits relating to resource allocation, administration and compliance." The Act also specifies that direct as well as indirect economic costs and benefits should be considered.

The process

As part of the preparations for accession to the BWM Convention, Australia therefore (through its Department of Agriculture Forestry and Fisheries, DAFF) developed a RIS. The work was carried out by the Centre for International Economics (CIE), Canberra. The objective for the RIS was to examine the impact of implementing consistent national BWM requirements, in order to implement the Convention. It also looked at the possibility to extend BWM requirements to domestically-sourced ballast water.

The benefits

The RIS identified the benefits of implementing the Convention to be the reduction in exotic marine invasions and thereby avoiding potential economic, environmental and amenity damage. It is estimated that the Australian fishing industry (including aquaculture) has an annual output of AUD 2 billion/year. However, only a small part of this is likely to be at risk from a potential marine invasion. Taking this into account, and the probability of invasions, gives a figure of AUD 2.4 million per year, of which 30% is attributed to ballast water, according to the report.

The RIS concludes that it is very difficult to make an exact estimation of the expected benefits of preventing further incursions, but that it is plausible to exceed AUD 30 million per year, if the proposed ballast water management systems were to be 100% effective.

The costs

The RIS also looked at the potential costs of implementing the convention. As indicated in the first chapters of these guidelines, the costs are easier to identify than the benefits.

The following costs were identified and estimated:

- direct shipping costs, including delays in shipping times, higher ship capital and running costs, exchange costs, treatment costs, capital costs, depreciation costs;
- additional long-run flow-on costs to other parts of the economy;
- enforcement costs (inspection costs).

The costs were further divided into initial (or temporary, until 2016) costs and the permanent costs, i.e. for the time beyond 2016. Furthermore, the various options were evaluated from the point of their economic costs and benefits, but also their effectiveness.

Looking at the option that was identified by the industry stakeholders as their preferred alternative, the accumulated costs to 2025 are estimated to AUD 169 million.

Analyzing the costs and benefits

The RIS identified the best benefit to cost ratio among the options for ballast water management regulations. The preferred option had a ratio of 1.7:1, which would mean that the national annual benefits must equal or exceed AUD 17.6 per year. This should be compared to the AUD 30 million per year assumed above. This was also the option preferred by the industry stakeholders, as identified in a series of consultations.

In addition to the cost-benefit analysis carried out, a sensitivity analysis was also made, where the uncertainty of some factors were taken into consideration. This clearly indicated that chance of costs exceeding benefits is very low for the desired option – only 13 per cent. It was also estimated that there is a 90 per cent chance that the benefits will be in the range AUD -60 million to 289 million (net present value to 2025), with a mean value of AUD 118 million, or 50 per cent chance that it will be between AUD 118–463 million.

Cost recovery systems

The report also looks, although briefly, at options for cost recovery process. It concludes that there is an agreement among jurisdictions that the majority of prevention costs should be recovered from the shipping industry, via a uniform quarterly levy, which should be applied to all ships. Other options (such as a fee per ship visit, or based on inspections conducted, annual fees, etc.) were also considered, but the quarterly levy was the option preferred by the stakeholders.

Source: Centre for International Economics, 2007: Final RIS. Ballast Water Management. A regulation impact statement. Prepared for: Department of Agriculture and Fisheries (DAFF). The full report can be downloaded from http://www.daff.gov.au/__data/assets/pdf_file/0009/93681/final-ballast-water-ris.pdf

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Additional resources

A toolkit has been developed specifically for Economic Analysis of Invasive Species:

- Emerton, L. and G. Howard, 2008, A Toolkit for the Economic Analysis of Invasive Species. Global Invasive Species Programme, Nairobi.

Another relevant publication with information on using economic data for national policy setting and planning is:

- Moran, D., and Bann, C., 2000. The Valuation of Biological Diversity for National Biodiversity Action Plans and Strategies: A Guide for Trainers. March 2000. Prepared for UNEP

More detailed information and cases of invasive species analysis can be found on the following websites:

- http://www.ecosystemvaluation.org/index.html
  A very good website for concisely reviewing the concepts, methods and applications of an economic analysis.

- http://www.invasivespeciesinfo.gov/
  This website, hosted by the USDA, contains a range of studies pertaining to international as well as US-specific valuations.

- http://www.issg.org/database/welcome/
  The Global Invasive Species Database contains a broad range of information on invasive alien species that threaten native biodiversity, and covers all taxonomic groups in all ecosystems, from microorganisms to animals and plants. Species information is either supplied by or reviewed by expert contributors from around the world.

- http://www.evri.ec.gc.ca/
  A searchable database containing case studies for use in benefit transfer analysis.

- www.earthmind.net/marine
  Contains many examples of economic valuations studies (mostly protected areas).

ANNEX 1

Analytical techniques for valuating ecosystem goods and services

Analyzing the impacts of invasive alien species and communicating this to a broad range of stakeholders can be greatly aided by the use of economic valuation. There is a multitude of techniques available, many of which require advanced skills to be carried out in a scientifically sound and statistically rigorous manner. The overview of the range of methods provided below is not intended as detailed guidance on how to apply the methods, but rather as an overview of their utility, possible limitations, process and examples of how they have been applied.

A.1 BENEFITS TRANSFER

Benefit transfer is increasingly used to value ecosystem services in one system based on analyses carried out of other similar systems. This can be effective when time, costs, and other barriers present challenges to conducting complete analyses, and can be useful where the institutional or academic infrastructure to conduct detailed direct studies is limited. The main weakness with this valuation technique is the dependence on design and execution of the original study, the validity of its findings, and the transferability of the data from the original site to the new site of interest.

Process outline

- Identify existing studies or values that can be used in the transfer.
- Consider whether:
  - ecosystems are similar or comparable;
  - service being valued is comparable to the service in the original study;
  - characteristics of relevant populations are comparable (e.g. harvested fish).
- Identify the quality of the studies to be 'transferred' – e.g. what assumptions did they make, are the ecosystems to be compared similar, does the original study identify a useful value.
- Adjust the values of the existing study to reflect values of the area under consideration.

Case study

Wetlands are often perceived to have little or no economic value. To inform decision makers, WWF used benefit transfer in a study to estimate the global total economic value of wetlands. The measurable value humans are able to extract from the ecological functioning of wetlands was determined using economic studies of 89 wetland sites and the services that they provide. Wetland characteristics were further disaggregated to arrive at a value estimate per hectare based on the primary wetland function, e.g. flood control, water supply, habitat, fuel wood, et cetera. Using these results, appropriate values were applied to unassessed wetlands based on physical and socio-economic similarities, and a global total wetland value extrapolated. The total economic value arrived at was USD 3.4 billion per year for 63 million hectares of inventoried wetland area. This is a very conservative estimate for two reasons. Due to a lack of data and a lack of comprehensive assessments, not all services or goods derived from wetlands were included. Further, incomplete inventory data of wetlands limited the area that could be included. The true extent of wetlands and probably also their value are likely to be an order of magnitude higher (Schuyt 2004).

A.2 MARKET PRICE ANALYSIS

Market prices can be used for any ecosystem goods or service that can be bought or sold, and can be applied to e.g. loss of income, loss of employment, loss of marketable goods, costs, etc. This is a comparatively inexpensive method, and requires less data intensive analysis to arrive at a value. In addition, this technique is flexible enough so that it can be used e.g. where an invasive alien species has replaced or diminished directly consumable species, when invasive alien species affect the production of marketable goods, or when invasive species themselves become marketable goods. This means that market price analysis often is recommended when a valuation study is to be conducted for an invasive alien species impact, whereas many other techniques, while valid and valuable in their own right, require much longer time periods for data collection, analysis and reporting. An added benefit is that many countries already collect the data necessary through the collection of national statistics, making this an easy technique to carry out 'in-house'.

There are a few caveats to using the information, though. If the market for goods and services is distorted by subsidies or other market externalities, the results may not reflect the true economic and social costs of an invasive alien species impact. However, awareness of such factors can be sufficient to recognize that the market prices may under- or overestimate the true costs, and make necessary corrections. Lastly, while this methodology determines the value of products derived from an ecosystem, it can miss the true (complete) value of the ecosystem due to only examining the market for goods, while excluding other non-marketable services.

Process outline

The economic variables needed for this type of analysis are straightforward and generally easy to collect and analyze through the following steps:

1. Collecting data on or specifying the change in the quantity of the good or service.
2. Collecting data on the prices of goods, taking care to note if the price is distorted by taxes or subsidies and, if so, identifying similar goods that are unaffected by such distortions. Care should be taken to acquire price data from a substantial range of time spans, including inter-annual and seasonal variation of prices and socio-economic preferences.
3. Multiplying the price by the change in quantity to determine the value of the change.

Sources of information in addition to national statistics can include international organizations relevant to the ecosystem service, commodity markets, local markets, UN FAO and World Bank Data.

Case study

Hodgson and Dixon (1988) conducted a cost benefit analysis of alternative uses of terrestrial and marine areas in the Bacuit Bay system, Palawan, Phillipines. The comparison valued the economic losses from sedimentation on the coral reefs and consequent fish mortality caused by logging against the benefits generated from logging revenue. The researchers considered two alternative outcomes, (1) to ban logging in the bay's watershed; or (2) to allow logging to continue as planned. Option two would generate logging revenue while continuing to damage the marine ecosystem and associated tourism and fisheries sectors of the economy, while option one would preserve the marine-related economy and eliminate logging revenue. The study found that continued logging over a 10-year period would produce a USD 4 million loss compared to gross revenues under a logging ban, due to losses from tourism and fisheries. This supports the notion that social, economic, and environmental benefits of fisheries and tourism outweigh those of logging in this area. (Hodgson and Dixon, 1988; Aylward and Barbier, 1992.)

A.3 NET FACTOR INCOME

Net factor income estimates the value of an ecosystem as an input into the production of marketable goods. This relatively simple method calculates the value of an ecosystem by estimating the revenue generated from commercial use or exploitation of a resource and subtracting labor and other costs associated with activities.

This technique could be suitable for application e.g. to an area that supports significant tourism due to the natural attributes of the area. For example, if sport fishing were a major attraction for tourists, the net factor income would be calculated as the revenue from sport fishing trips minus the costs of labor, equipment and time for those who organize the trips. The aggregate of the surplus (difference between revenue and costs) will roughly estimate the economic value of sport fishing tourism to the local economy. As with market prices, many of the data variables required for net factor income analysis should be easily accessible from within a country.

Process outline

1. Identify the ecosystems and services under consideration.
2. Identify the inputs that the ecosystem provides for production purposes.
3. Calculate the revenue from the product by multiplying the market price by quantity.
4. Calculate the cost of production by multiplying unit cost by quantity produced.
5. Subtract the cost of production from the revenue to arrive at net factor income.

Case study

Net factor income can be applied to derive the value of an ecosystem by analyzing the market value of the goods and services from the ecosystem. A valuation study of non-wood resources in an Amazon rainforest was conducted in 1989. Researchers surveyed one hectare of land and accounted for all trees capable of producing non-timber forest products, in this case marketable fruit and latex. They then calculated the annual volume of production per tree, and used the current per unit market price to arrive at a total annual market value for the trees output. Aggregating the results across the range of species within the hectare they found a total value of USD 697.79. After deducting costs associated with collection/harvesting, transportation and selling the products in the market, they arrived at a net value of about USD 422 per hectare per year. (Peters, Gentry et al., 1989)

A.4 COST-BASED ANALYSES

Cost-based analyses is a range of environmental economic tools that can be applied when the entire range of ecosystem goods and services that has been impaired by human use can be either replaced, mitigated, or otherwise offset by human developed solutions. Although this can be useful for determining the value of ecosystem services, it is difficult to identify all the goods and services provided by an ecosystem and to identify viable replacements for all those attributes.

Cost-based analyses are relatively complex techniques often conducted in academic studies. While the information generated may be highly valuable the analysis carried out by these studies may not always fit within or indeed be required as part of specific decision-making processes, although they may be highly valuable for development of environmental policy.

A.4.1 Replacement cost

Replacement cost estimates the cost of replacing environmental service with a man-made service, e.g. when IAS compromise water supplies or contribute to soil erosion. This is a very difficult technique because properly evaluating ecosystems and their protective function is nearly impossible.

Process outline

1. Collect data and determine the benefits associated with ecosystem good or service.
2. Identify the alternative source of product, infrastructure, technology that can provide the same service as the ecosystem.
3. Calculate costs of introducing the replacement, including labour, parts, and ongoing maintenance requirements.

Case study

Researchers applied replacement cost methods to value the pollination services provided by insects to agricultural production. Using the deciduous fruit industry in South Africa as a case study, a value was ascribed to the pollination by calculating the cost to replace it, for example with pollen dusting and hand pollination. The study found that the contribution of domesticated honeybees to pollination of commercial fruit crops is approximately USD 28–122.8 million, while wild insects contribute between USD 49.1–310.9 million per year. The researchers found that the value of non-human pollination is largely undervalued in the market, and argues for conserving the natural pollinators. (Allsopp, de Lange et al., 2008)

A.4.2 Damage cost avoided

Damage cost avoided can be applied to ecosystems that provide protection to man-made assets, for example housing in the coastal zone protected by wetlands from floods and tide inundation. It is useful for quantifying in monetary terms the value of protection that the ecosystem provides to human life, infrastructure, and economic activity. However it is based on hypothetical estimates of damages that could have been avoided because it is nearly impossible to determine what damage would have occurred had the environment not been altered.

Process outline

1. Identify protective service of ecosystem in terms of degree of protection provided and damages that would occur if ecosystem were lost.
2. Determine elements that would be hurt by loss, e.g. infrastructure, human population.
3. Obtain likelihood and frequency of damaging events under different scenarios of ecosystem loss.
4. Cost damages and determine the ecosystem services' contribution to avoiding these damages.

Case study

Researchers applied the damage cost avoided methodology to the problem of storm water runoff in Modesto, California, USA. The researchers found that the 75,629 trees in and around Modesto reduced runoff by approximately 292 million cubic meters, or the equivalent avoided capital cost of USD 616,000. The value is derived from the cost of engineering a human solution to manage and treat the storm water through infrastructure. To arrive at the value of the service provided by the trees, researchers determined the average volume of water that is diverted by the trees and multiplied the volume by the estimated cost to the city to contain the water. In this case the runoff reduced per tree was determined to be 3.2 cubic meters, and was multiplied by the costs that would be incurred to manage the water, in this instance USD 6.76 per tree. The paper concluded by arguing that the benefits that the urban forest provides outweigh the costs of maintenance, and managing the ecosystem wisely would continue to provide benefits to the community (McPherson et al. 1999).

A.4.3 Mitigating expenditure

Mitigating expenditure analyzes payments or investments to offset damage, for example when an invasive alien species replaces a food species. This method is useful for valuing ecosystem services and has a relatively small data requirement. However, mitigation does not always match ecosystem services and people's perceptions may not match with expert opinion.

Process outline

1. Identify negative effects or hazards from loss of ecosystem.
2. Locate area and population that would be affected by loss of good.
3. Obtain information on people's responses and measures taken to mitigate negative effects of loss of good or service.
4. Cost the mitigation or aversive expenditures.

Case study

Berg et al., 1998, assessed the value of coral reefs in preventing coastal erosion in Sri Lanka. They estimated that 1 km^2 of coral reef protected 5 km^2 of coastline against erosion. Applying land use values ranging from low valued land, such as rural undeveloped properties, to high valued coastal properties with high tourism value, they found the preventative value of the coral reefs to be between USD 160,000 and USD 172,000 per km^2 of reef per year (in 1994). The intrinsic value of the coral reefs is apparent when compared to the value of man-made structures that have been erected to protect the coast to replace the degraded coral reefs. These structures cost between USD 246,000 and USD 836,000 per kilometer of coastline protected. Berg concluded that investments in artificial coastal protection structures totaling USD 17 million would have to be made to provide erosion protection for only 18% to 25% of the erosion prone shorelines. Preserving the coral reefs for their protective function and tourism attraction is a better economic decision than allowing destructive harvesting of fish to continue in this area. (Berg, Öhman et al., 1998)

A.4.4 Production function method

The production function method is useful for estimating the non-market value of an ecosystem good or service by assessing its contribution to the production of a marketed good. For example, it can be used to assess damage caused by an invasive alien species directly interfering with or changing the production of goods and services that are bought and sold, e.g. as a result of resource species decline due to competition, ecosystem degradation, interference with fishing through net clogging, etc. This is a technically difficult method and requires substantial data to establish the value of goods and services.

Process outline

1. Determine contribution of ecosystem goods and services to related source of production.
2. Specify relationship between changes in quality or quantity of particular goods or service.
3. Relate changes in provision of goods or a service to physical change in output or availability of product.
4. Estimate market value of change in product.

Case study

Barbier et al. (2002) analyzed the impacts of mangrove deforestation in the Philippines on fisheries production. Mangroves provide a key input into the production of fish through the provisioning of habitat for spawning and nursery stages of fisheries. Based on an average of 30 km^2 deforestation per year caused by conversion of mangroves to shrimp farms, the welfare loss to society was estimated to be between USD 12,000 and USD 408,000 per year. The losses were calculated by analyzing data over a ten-year time period in five coastal zones of Southern Thailand, and assessing changes in fisheries production based upon the effects of deforestation.

A.5 SURROGATE MARKET APPROACHES

Surrogate market approaches look at the way the value of ecosystem goods and services are reflected in expenditures. A shadow market is then constructed to derive a value for the ecosystem goods and services from the value spent on their products and often adjusting the value according to subsidies and other pricing distortions. This is commonly done using real estate values as a proxy for value people place on an environmental good like clean air.

A.5.1 Hedonic pricing method

The hedonic pricing method determines the influence an ecosystem has on the price people pay for goods and services, such as housing prices reflecting the ease of access to water or landscape beauty. This method can in theory be applied to any good and service that is taken from ecosystems and the environment. However, it requires a large data set and highly skilled statistical analysis and is largely untested in the use of ecosystem valuation.

Process outline

1. Identify indicator to measure quality and quantity of an ecosystem good or service associated with a job or property.
2. Specify functional relationship between wages or property prices and relevant attributes associated with them, including ecosystem goods and services.

3. Collect data on wages or property prices in different situations that have varying quality and quantity of ecosystem goods and services.
4. Conduct a multiple regression analysis to obtain correlation between wages or property prices and ecosystem good or service.
5. Derive a demand curve.

Case study

Morancho (2003) examined the effect of proximity to green areas on the pricing of houses in Castellon, Spain. 810 objects were characterized in terms of conventional variables, representing the characteristics of the home, as well as three hedonic variables: the existence of views of a garden or a public park, the size of the nearest green area, and the distance of the house to the green space. The results showed that while the size of a house had the largest effect on its price there is also an inverse relationship between the selling price of a house and its distance from a green urban area. This implies that creating green spaces in a city may positively impact housing prices and increase desirability. (Morancho 2003)

A.5.2 Travel cost method

Travel costs valuation is particularly useful for ecosystem level valuation of recreational or leisure destinations, e.g. the value of a given water body for fishing activity. The method is frequently used, but it does depend on a large data set and complex statistical skills, and is very labour intensive as it depends on gathering information from visitors to recreational sites.

Process outline

1. Determine total zone from which visitors come to visit the ecosystem, divide into zones of equal distance from recreational area.
2. Analyze within each zone samples to determine the costs incurred in visiting, motivation for going, frequency of visits and socio-economic variables.
3. Obtain visitation rates for each zone, use the info to estimate total number of visitor days per head of local population.
4. Conduct a statistical regression to test the relationship between visitation rates and other variables.
5. Construct a demand curve relating number of visits to travel cost.

Case study

Nunes and Markandya (2008) used a combination of environmental economic methods to assess the costs and benefits of building a dedicated ballast water facility in Rotterdam harbor, the Netherlands, to prevent bioinvasions. Travel cost and contingent valuation methods were used to estimate the full value of protecting Zandvoort beach in North Holland, a popular recreational area. This beach was chosen because it would hypothetically be negatively impacted if a bioinvasion occurred via the nearby port. Based on a survey conducted amongst beachgoers, the recreational welfare loss of closing the beach was estimated. The travel cost function was derived by assessing the number of trips per person, the total cost per trip including travel expenditures and additional purchases during the trip, and the value of each person's time to make the trip. (Nunes and Bergh 2002) The value of a clean beach was estimated to be between EUR 55 and EUR 115 per person per year. Essentially, this monetary value would be lost to the local economies if the beach were to be closed. The survey also found that willingness to pay for beach access was between EUR 58 and EUR 101.5. Summing the two figures and multiplying by user days gives a total benefit to users of EUR 539,085,000, equivalent of 0.13% of the Dutch GDP in 2000. This enabled cost-benefit analysis and an economic argument for the installation of a dedicated ballast water facility in the Rotterdam Harbour, which was contracted in 2008 and estimated to cost EUR 100 million.

A.6 STATED PREFERENCE METHODS

Stated preference models ask people directly to state their preferences for changes in provisioning of environmental goods or services. The information that is elicited from these individuals is then used to model the values that people place on the goods and services in question, e.g. coral reef or rainforest preservation.

A.6.1 Contingent valuation

Contingent valuation is useful for valuing ecosystem services for which there is an absence of prices, markets, good or services. This technique infers a value through direct willingness to pay for the ecosystem (or willingness to accept for loss) elicited through surveys. The strengths of this technique are that it is useful for valuing the option or existence value of an ecosystem. The weaknesses are that it requires large and costly surveys, complex data sets and advanced statistical skills to analyze the data. Additionally the method is susceptible to human biases. However the US Supreme Court has ruled that it is a valid means of assessing an unvalued ecosystem in the case of man-made disasters, and for example the Exxon Valdez spill was valued through a contingent valuation survey.

Process outline

1. Elicit WTP for a particular good or service provided by the ecosystem. Survey options include the use of dichotomous choice surveys or open-ended responses, both of which present their own unique challenges.
2. Draw frequency distribution relating WTP to number of people making them.
3. Analyze data through cross tabulate with socio-economic characteristics and relevant factors.
4. Use multivariate statistical techniques to correlate responses with socio-economic attributes.
5. Extrapolate up to obtain a value placed by whole population on ecosystem.

Case study

An exploratory contingent valuation/willingness to pay study conducted in the summer of 1997 (Arin and Kramer 2002) explored the potential for funding reef management and enforcement through user fees at three major protected coral reef diving areas in the Philippines: Anilo, Mactan Island, and Alona Beach. Surveys among 129 tourists assessed their willingness to pay for conservation measures, and preferences with respect to what activities and organizations should be supported. In addition, socio-econmic and demographic information was collected to assist in modeling. The study found the willingness to pay for a one-day entrance to the marine sanctuaries to range from USD 3.4 to 5.5. This would translate to annual revenues in the range of USD 0.85 to 1 million on Mactan Island, USD 95–116 thousand in Anilao and from USD 3.5–5.3 thousand on Alona Beach. A majority of respondents considered a non-governmental organization most suitable to administer the revenue. This information can be valuable for decisions regarding introduction of user fees.

ANNEX 2

Template for identification and compilation of costs related to IAS impacts on key sectors

Direct use values Key sectors	Total yield/catch/ #users etc (where applicable)	Number employed or dependent	Total value of Sector	Total value of sector as % of GDP	Vulnerability to IAS (high, medium, low)	% loss (worst case scenario)	$ loss (worst case scenario)
Fisheries							
Commercial							
Stock 1							
Stock 2							
Stock…							
Subsistence							
Recreational							
Aquaculture							
Species 1							
Species 2							
Species…							
Other living harvested resources							
Mangrove harvesting							
etc.							
Coastal tourism							
Hotel and restaurant							
Activities (e.g. beach visits, sightseeing, yachting…)							
Other							

Additional costs to society or industry	**Number employed or dependent**	**Total value of sector**	**Total value of sector as % of GDP**	**Vulnerability to IAS (high, medium, low)**	**Type of costs possible incurred**	**$ cost (worst case scenario)**
Shipping						
International						
Domestic						
Coastal infrastructure						
Ports						
Marinas						
Power plants						
Other						

Public health	**IAS Species (with potential human health impact)**	**Possible impact pathways (e.g. food, water, recreation, etc.)**	**Possible impacts (food poisoning, physical harm, etc.)**	**Number affected (worst case scenario)**	**Treatment costs per person**	**$ cost (worst case scenario)**
Vulnerable groups						
Resource users						
Beach workers						
Seafood consumers						
etc.						

Indirect use values	Ecosystem that may be impacted	Total area of ecosystem	Vulnerability to IAS (high, medium, low)	% loss (worst case scenario)	Implications for society and industry	Estimated $ loss (worst case scenario)
Flood control						
Shoreline protection						
Sediment and nutrient control						
etc.						

Non-use values	Ecosystem that may be impacted	Total area of Ecosystem	Vulnerability to IAS (high, medium, low)	% loss (worst case scenario)	Implications for society	Estimated $ loss (if applicable)
Cultural legacy						
Religious/spiritual value						
etc.						

ANNEX 3

Template for identification and compilation of costs related to BWM

The items listed in this template follow the same structure as in the text of chapter 4. Please refer to each section for more detail.

Issue	Obligation to whom flag/port/industry (specify)	Cost to whom flag/port/industry (specify)	Type of cost (cash/time in kind, etc)	Estimated cost ($)	Possible source of funding or funding mechanism (if applicable)
PREPARATORY PHASE					
Capacity building, education and communication					
National task force meetings					
Training (CME, PBBS, etc.)					
Regional task force meetings					
Other					
Legislative, policy and institutional reform					
National BW status assessment					
Economic assessment					
National BWM strategy					
Legal review and drafting					
Other					
Port biological baseline studies (research and monitoring)					
Risk assessments					
COMPLIANCE RELATED COSTS					
Flag state obligations					
Establishing procedures for issuing BWM Certificate					
Approval of ships' BWM Plans					
Type approval of BWM systems					
Surveys					
Approval of exemptions					
Training					
Other					

Issue	Obligation to whom flag/port/industry (specify)	Cost to whom flag/port/ industry (specify)	Type of cost (cash/time in kind, etc)	Estimated cost ($)	Possible source of funding or funding mechanism (if applicable)
Port state obligations					
Compliance monitoring and enforcement					
Inspection of ships					
Introduction of BW reporting form					
Sampling					
Sediment reception facilities					
Communication of requirements to IMO and other member states					
Communication of BWM requirements to ships					
Other					
Industry obligations					
Training of crew members and onshore personnel					
BWM Plans					
BWM Record Books					
BWM options					
BW Exchange (D-1)					
BW treatment (D-2)					
Other					
OTHER					
Port biological monitoring programmes					
Port BWM Plan development					
Other					

More Information?

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