GloBallast Partnerships

Economic Assessment of Ballast Water Management:

A Synthesis of the National Assessments conducted by the Lead Partnering Countries of the GEF-UNDP-IMO GloBallast Partnerships Programme

GloBallast Monograph Series No.24

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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.

The World Wide Fund for Nature (WWF) is recognized as the leading conservation organization globally, employing over 5400 staff in more than 100 countries and with more than 5 million supporters across the world. WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable and promoting the reduction of pollution and wasteful consumption.

InterSus – Sustainability Services is a small environmental policy consultancy (Small-Medium Enterprise/SME) based in Berlin, working since 2006 for various national and international clients, including the EU Commission, World Bank, OECD, WWF and various Environment Ministries/Agencies. It is specialized in environmental policy and socioeconomics, with a focus on implementation and impact assessments of policies and measures, project monitoring and evaluation. Further specialization lies in water economics as well as capacity building and moderation/facilitation.

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Disclaimer

This publication has been prepared by the GEF-UNDP-IMO GloBallast Partnerships Programme, InterSus Sustainability Services and the World Wide Fund for Nature in order to illustrate the work done by the GloBallast Lead Partnering Countries in their national economic assessments for ballast water management (BWM). Although all possible efforts have been made to provide a comprehensive and accurate document, its main purpose is to provide a discussion of the relevant concepts and lessons learned, and none of the authors and/or editors take responsibility for the implications of the use of any information or data presented in this publication. Therefore, the publication does not constitute any form of endorsement whatsoever by the GEF, UNDP, IMO, the GEF-UNDP-IMO GloBallast Partnerships Programme, InterSus Sustainability Services and the World Wide Fund for Nature, and individuals and organisations that make use of any data or other information contained in the Monograph do so entirely at their own risk.

Executive Summary

1. This publication presents, compiles and analyses the National Economic Assessments (NEA) of the Lead Partnering Countries (LPCs) of the GEF-UNDP-IMO GloBallast Partnerships Programme (GloBallast). The reports were prepared based on the GloBallast Monograph No. 19 (2010), which outlines a framework and conceptual methods for conducting economic assessments.
2. The aim of NEAs for Ballast Water Management (BWM) is to assess and quantify the values of resources at risk from the introduction of Invasive Aquatic Species (IAS introduction), potential costs from IAS introduction and expected implementation costs of the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention). The potential costs and benefits presented in the NEAs should be taken into account by each country to make an informed decision on the implementation of BWM measures and regulations.
3. This Monograph has three main objectives: a) present a global report on the economic values at stake as well as on the potential economic impacts of invasive aquatic species (IAS) transferred through ships' ballast water; b) communicate the costs and benefits resulting from implementing the BWM Convention; and c) raise awareness about the strategic importance of BWM and improve the understanding of the economic perspectives. This will further support sound decision-making in relation to IAS risk prevention and reduction, an aim which was also pursued by the GloBallast Monograph No. 19.
4. Chapter 1 briefly describes the issue of the transfer of IAS through ships' ballast water and outlines the variety of existing responses to this problem. It focuses on the negative economic impacts of IAS introduction and gives a short overview of the preventive measures that are available. The chapter also provides a brief review of other existing publications and case studies that assess the economic implications of IAS and BWM. From this brief literature review it may be concluded that the economic impacts tend to be significant. The analysed publications often advocate application of the preventive approach, for reasons of both cost and effectiveness.
5. Chapter 2 explains the framework outlined in GloBallast Monograph No. 19, based on which the countries conducted their NEAs. It also contains a brief description of the main underlying categories of Monograph No. 19: value of resources at risk and potential costs from IAS introduction.
6. Chapter 3 summarizes the information in the NEAs conducted by 14 GloBallast LPCs. Beyond information on economic values of resources at risk, potential costs of IAS introduction and implementation of the BWM Convention, the national summaries contain tables and fact boxes with additional information on IAS and their economic impacts.
7. Chapter 4 analyses the outcomes of the NEAs and provides a synthesis of key findings, comparing the economic values of resources at risk, the potential costs from IAS introduction and the implementation costs of the BWM Convention. While most countries only provided figures for direct use values such as fisheries and coastal tourism, others also estimated values for diverse indirect uses supported by coastal ecosystems. All these sectors play a crucial role for the economies of the countries in question, their relative importance varying from country to country. The economic value and vulnerability to IAS introduction of resources at stake was often rated as high, even where no quantitative calculations were presented due to methodological limitations and lack of available research data. In all analysed cases, expected negative economic impacts from IAS introduction are significantly higher than estimated costs of implementing the BWM Convention. The reports therefore advocate urgent ratification and implementation of the BWM Convention and associated measures.

8. Chapter 5 outlines broad conclusions and the necessary steps to improve the situation regarding economic assessments. It concludes that by preparing economic assessments, the 14 LPCs have taken an important step towards a better understanding of the values at stake and the risks of not implementing preventive measures. The NEAs also provide a clear picture of the costs that can be expected when implementing the BWM Convention, which can be of help to national decision-makers in enhancing their planning to prevent and reduce the risks from IAS introduction.

9. Finally, the publication also identifies some knowledge gaps and makes a clear case for the importance of conducting research on the potential economic impacts from IAS introduction. Economic assessments should take a central role in future policies promoting the implementation of BWM regulations, and should be integrated into the decision-making process at the earliest possible stage.

Glossary & Abbreviations

Add.	Additional
An.	Annual
BWM	Ballast Water Management
BWM Convention	Ballast Water Management Convention; the abbreviated title of the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004
CBD	Convention on Biological Diversity
CME	Compliance Monitoring and Enforcement
CPI	Consumer Price Index
CPT	Container Port Throughput
FAO	Food and Agriculture Organization
GloBallast (GBP)	GEF-UNDP-IMO GloBallast Partnerships Programme; the joint initiative of IMO, UNDP and GEF to assist developing countries to reduce the risk of aquatic bio-invasions mediated by ships' ballast water and sediments
GDP	Gross Domestic Product
GEF	Global Environment Facility
GVA	Gross Value Added
HAB	Harmful Algal Bloom
HAOP	Harmful Aquatic Organisms and Pathogens
IAS	Invasive Aquatic Species; any aquatic species that is not native to the ecosystem under consideration and whose introduction or presence may pose threats to human, animal and plant life, economic and cultural activities and the aquatic environment. (In some jurisdictions this may not include a non-indigenous species lawfully or historically introduced for sport fishing). In many sectors AIS also refers to Alien and Invasive Species
IMO	International Maritime Organization
int$	International Dollar; is a hypothetical unit of currency that has the same purchasing power parity that the US$ had in the United States at a given point in time
LPC	Lead Partnering Country of the GloBallast Partnerships Programme
LPIR	Legislative, Policy and Institutional Reform
National BWM Strategy	National Ballast Water Management Strategy

NEA	National Economic Assessment
NIS	Non-Indigenous Species; same as alien and exotic; a species, subspecies, or lower taxon occurring outside of its natural range (past or present) and dispersal potential (i.e. outside the range it occupies naturally or could not occupy without direct or indirect introduction or care by humans) and includes any part, gametes or propagule of such species that might survive and subsequently reproduce
PBBS	Port Biological Baseline Survey
GloBallast PCU	Project Coordination Unit of the GloBallast Partnerships Programme
SDG	Sustainable Development Goal
TEU	Twenty Foot Equivalent Unit
TEV	Total Economic Value
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
WRI	World Resources Institute
WTP	Willingness to Pay
WWF	World Wide Fund for Nature

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Introduction and aim of the study

1.1 BACKGROUND

This chapter briefly describes the issue presented by the transfer of Invasive Aquatic Species (IAS) through ships' ballast water and outlines the existing responses to tackle this environmental problem. It outlines the negative economic impacts of IAS and the approaches available to address them. It further sets the context for this publication, namely analysing the negative economic impacts from IAS introduction and the costs and benefits of implementing BWM measures. Section 1.3 of this chapter provides a brief overview of other existing literature on the economic impacts of IAS.

1.1.1 THE PROBLEM OF IAS

IAS are currently viewed among the five greatest threats to the world's oceans and marine biodiversity (the other four being overexploitation of resources, pollution, habitat destruction and ocean acidification). Introduction of non-indigenous species (NIS) can occur through many pathways, but hull fouling and ships' ballast water are the two main acknowledged vectors for the introduction of marine IAS (Ruiz et al., 2000; AMOG Consulting, 2002).

Pictures 1 and 2: Ships discharging ballast water. (Source: *GloBallast*)

Under suitable conditions these NIS can become established and, in the absence of natural controls such as predators or parasites, may cause severe harm to affected ecosystems (Molnar et al., 2008). Possible impacts of marine IAS are highly varied and can be grouped into (Tamelander et al., 2010):

- **Ecological impacts,** including loss of native biodiversity due to preying on or competing with native species; decreased habitat availability for native species; smothering and overgrowth; parasites and disease; as well as hybridisation, causing genetic dilution.
- **Environmental impacts,** including changes in nutrient cycles and decreased water quality, which can in turn have negative impacts on e.g. shipping, fishing and availability of drinking water.
- **Impacts to human health and wellbeing,** including decreased recreational opportunities, overgrowth of aquifers and smothering of beaches, as well as an increase in parasites and disease.
- **Cultural impacts,** arising from the demise of native species populations used for subsistence harvesting or degradation of culturally important habitats.

- **Economic impacts,** resulting from interference with biological resources that support fishing and coastal aquaculture (e.g. collapse of fish stocks), interference with fisheries (e.g. fouling of gears), disruption to tourism, damage to infrastructure (e.g. through fouling) and costs of treatment, clean-up or control.

All these types of impacts are interconnected, tending to influence and exacerbate one another. For example, the notorious North American comb jelly *(Mnemiopsis leidyi)*, which was introduced into the Black Sea through ships' ballast water in the early 1980s, caused both a severe damage to the marine biodiversity in general and tremendous losses of hundreds of millions of US dollars (US$) per year to the fishing industry. It is not the aim of this publication to discuss general IASrelated issues in more detail; other publications of the GloBallast series have already done so (e.g. GloBallast Monographs Nos. 18 and 21).

1.1.2 EFFECTIVELY TACKLING THE PROBLEM OF IAS IN SHIPS' BALLAST WATERS

One of the main problems with marine IAS and non-indigenous species (NIS) in general is that once they have become established in a new environment, it is very expensive and also nearly impossible to eradicate them. For this reason, the efforts directed at tackling the issue of IAS in ships' ballast water are focussed on preventive measures. These measures are multi-dimensional and usually comprise technical, legal, institutional and economic components.

Various **technical tools** and procedures were developed over the last few years to address the problem of IAS introduction through ships' ballast water. Some examples are Port Biological Baseline Surveys (PBBS) and BWM technologies such as physicochemical inactivation through UV light or heat and chemical inactivation through biocides.

To facilitate the application of these technical tools, several **legal instruments** have been developed and adopted as both hard and soft law. Some examples of global soft law documents on this topic include Agenda 21 of the 1992 Rio Declaration on Environment and Development[1] and the 1992 Convention on Biological Diversity's (CBD) Aichi Biodiversity Target 9[2]. Most recently, on 1 January 2016, the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development were adopted. Particularly two Goal Targets, 14.2 and 9.4, contain links to the IAS issue, although not explicitly mentioned, and can be seen as an important impetus to further strengthen efforts in this field.

Picture 3: The vital links between achievement of SDGs and the IAS issue.
(Author and source: *Max Gudczinski*)

1 See paragraph 17.30(a) (vi) of chapter 17.
2 The Aichi Biodiversity Target 9 reads: "By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.

The key international hard law instrument is the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention), adopted in 2004, under the auspices of IMO, to introduce global regulations to control the transfer of potentially harmful aquatic organisms and pathogens (HAOP) through ships' ballast water. After the latest ratifications, the treaty will enter into force on 8 September 2017. Among other measures, the Convention requires the implementation of a BWM plan by ships to ensure that any microorganisms or small marine species are killed off before ballast water is released into a new location.

Institutional support is crucial to facilitate establishment of BWM practices. This can be achieved through designation and training of specialist personnel in state administrations, as well as via the application of cross-sectoral methods of stakeholder involvement and awareness-raising.[3]

Finally, in addition to ecological consequences, the **economic aspects** of IAS introduction are also starting to be taken into account by conducting economic assessments of values of resources at risk from IAS introduction and quantifying the potential damages to these resources to support decision-making processes on the ballast water/IAS issue.

In 2000, as part of the response to the global IAS problem, the Global Environment Facility (GEF), the United Nations Development Programme (UNDP) and the International Maritime Organization (IMO) joined forces to assist developing countries to reduce the transfer of HAOP in ships' ballast water and implement the BWM Convention and its associated guidelines. The GloBallast pilot phase (2000-2004) assisted developing countries in implementing effective measures to control the introduction of marine NIS and successfully focused on 6 demonstration sites (in Brazil, China, India, Islamic Republic of Iran, South Africa and Ukraine), intended to represent the six developing regions of the world. Building up on the progress made in the pilot phase of the project, the GEF-UNDP-IMO GloBallast Partnerships Programme (GloBallast, 2007-2017) focused on national policy, legal and institutional reforms in targeted developing countries with an emphasis on integrated management, sustaining the global momentum in tackling the ballast water problem and catalyzing innovative global public-private partnerships. With the help of tools developed and lessons learned from the pilot phase, this Programme worked to expand government and port management capacities; instigate legal, policy and institutional reforms at national level; develop mechanisms for sustainability and drive regional coordination and cooperation, to prepare the countries for implementation of the BWM Convention. The GloBallast Partnerships works with 15 Lead Partnering Countries (LPCs): Argentina, Bahamas, Chile, Colombia, Croatia, Egypt, Ghana, Jamaica, Jordan, Nigeria, Panama, Trinidad and Tobago, Turkey, Venezuela and Yemen. Further to its LPCs, GloBallast also supports activities in more than 70 Partnering Countries (PCs).

Pictures 4 and 5: Examples of ballast water sampling and analysis activities in Turkey (above) and Georgia (left) in the framework of the GloBallast Partnerships Programme. (Source: *GloBallast*)

3 See GloBallast Monograph No.17 for more details.

1.1.3 SETTING THE CONTEXT FOR THIS PUBLICATION

The focus of this publication is on the negative economic impacts caused by IAS introduction, as well as on the cost of taking preventive measures against IAS in general and the cost of implementing the BWM Convention.

One of the methods of addressing economic impacts caused by IAS is through ecosystem valuations (e.g. based on the Total Economic Value (TEV) methodology), calculating the value of resources that have been identified as being at risk and determining the potential costs and benefits from IAS introduction. Available global quantitative estimates indicate that these figures can be very significant. Management and eradication of IAS from an ecosystem can be very costly and difficult and often mitigation of the impacts of the IAS is the only option (e.g. Genovesi, 2016; refer to section 1.3 for more information).

While several publications already favour the adoption of preventive measures for reasons of both cost and effectiveness (see e.g. WWF, 2009; Coutts and Sinner, 2004), the GloBallast Project has promoted a comprehensive assessment and quantification of the economic impacts of IAS, response costs and implications of not implementing preventive actions. This will provide an informed basis for governments and industry to respond more effectively to the issue of IAS introduction through ship's ballast water. To this end and to assist its LPCs in the preparation of respective national economic assessments, in 2010 the GloBallast Project Coordination Unit (PCU) published its Monograph No. 19.[4] Based on the methodology outlined in this Monograph, 14 LPCs prepared their national economic assessments for BWM from 2010-2016, which form a significant source for this publication.

1.2 OBJECTIVE AND SCOPE OF THE STUDY

This Monograph presents, compiles and analyses the NEAs of the GloBallast LPCs. Based on the results of these NEAs, the publication has three main objectives: a) to generate a global report on the economic values at stake as well as on the potential economic impacts of IAS transferred through ships' ballast water; b) to inform about the costs and benefits of implementing the BWM Convention; and c) to raise awareness of the strategic importance and improve the understanding of BWM from an economic perspective. This will further support sound decision-making in relation to IAS risk prevention among the target audience of this publication, an aim also pursued by the GloBallast Monograph No. 19.

In more detail, the publication includes the following elements:

- Descriptive summaries of the NEAs prepared by 14 LPCs.[5]
- Analysis and comparison of the information in the NEAs.
- Compilation of the outcomes in tabular form. A short summary table in chapter 4, section 1, provides a synthesis of the main findings reported in each economic assessment. More detailed outcomes and quantitative values are included in the table in Annex I.
- Broad conclusions that can be presented from the reports of the GloBallast LPCs.

1.3 OVERVIEW OF ADDITIONAL LITERATURE ON THE ECONOMIC IMPACTS OF IAS

While the focus of this publication is on the NEAs of the GloBallast LPCs, further literature existing on this topic has also been briefly analysed and evaluated. This analysis does not have a claim of completeness, and in the present section only the main results from additionally analysed literature have been included. More specific examples can also be found throughout the text of this Monograph as "fact boxes."

In addition to some global value estimates, the reviewed literature provides examples of the following aspects related to BWM:

- Ballast water treatment technologies, their global emerging markets and implications on the shipping industry through the establishment of ballast water regulations on a global scale.

4 GloBallast Monograph Series No. 19, "*Economic Assessment for Ballast Water Management: A Guideline*".

5 Argentina, Bahamas, Chile, Columbia, Croatia, Egypt, Ghana, Jamaica, Jordan, Nigeria, Panama, Trinidad and Tobago, Turkey and Yemen.

- Case studies on cost-benefit analysis of IAS management; and
- Research on economic impacts of IAS introduction in a country or region.

As already discussed in section 1.1.3 of this chapter, the global economic values of resources at risk, while far from being assessed in their entirety, are generally expected to be very high. For example, de Groot sets the total value of ecosystem services in a range between 490 int$/year/hectare, for the whole bundle of marine ecosystem services that can potentially be provided by an average hectare of open ocean, to almost 350.000 int$/year/hectare, for the potential services of an average hectare of coral reefs (de Groot et al., 2012). In another study, the global value of ecosystem services provided by different marine and terrestrial biomes in 2011 was calculated to average $125-145 trillion/year in 2007 US$ (Costanza et al., 2014).

With regards to the expected and incurred costs from IAS introduction, the results of some global and regional studies confirm that they are likely to exceed a range between hundreds of millions and tens of billions of US dollars, depending on the spatial scale of the study, the type and number of examined IAS, etc. (e.g. Perrings et al., 2002; Kasulo, 2000; Volovik, 2000; Lundin, 1995; Cohen and Carlton, 1995; Cohen et al., 1995). For example, WWF estimated economic losses attributed to marine NIS at 7 billion US dollars per year (WWF, 2009). Another example deals with the invasions by harmful algal blooms (HABs), which have had a major impact on the cultured shellfish industries of developing nations and on global human health through shellfish poisoning: the estimated annual cost to the United States in 1987-93 was over 35 million US dollars and, when economic multipliers are taken into account, over US$100 million. A similar experience has been reported for Japan. Extrapolation of the US and Japanese cases to the more than 50 countries with HAB problems indicates that global costs are very significant in economic terms (GESAMP, 2001).

It also must be kept in mind that existing calculations of damages often concentrate on direct economic impacts from IAS introduction,[6] i.e. costs to fisheries, tourism, water supply systems and coastal infrastructure. Few studies take also into account the indirect economic impacts inflicted upon marine biodiversity and habitats. These can result in a wide range of negative effects, from reduced ability of key ecosystems to provide valuable ecosystem services, to losses in cultural and non-use values, etc. If properly accounted for, these indirect economic impacts are likely to further increase the costs from IAS introduction at least by one order of magnitude.

Compared to the above, the overall projected global costs for governments to respond to the threat of IAS through the adoption of BWM preventive measures can be assessed as significantly smaller. However, few quantitative figures are currently available on this issue.

BOX 1: GLOBAL ECONOMIC IMPLICATIONS OF BALLAST WATER REGULATIONS ON THE SHIPPING INDUSTRY SECTOR AND WORLD TRADE

King (2013) takes the impending implementation of ballast water regulations as a starting point and analyses its potential financial impacts on costs to shipping companies, import prices and world trade. Based on a calculation of compliance costs for affected ship owners and taking into account the particular status of the global shipping industry in world trade (e.g. high inelasticity of demand for shipping), he concludes that the overall impacts of ballast water regulations on the global shipping industry and other stakeholders are likely to be insignificant, as the industry might be able to increase freight rates slightly to pass its compliance costs forward to shippers and importers. According to King, annual compliance costs for the world shipping industry are not high compared to its annual earnings (costs of about US$12 billion annually vs. earnings of US$380 billion).

In addition, King comes to the conclusion that while numbers for individual nations will differ, the economic value of global trade is so high that the overall economic impacts of ballast water regulations on world trade, international markets, and global economic welfare are probably not statistically distinguishable from zero (i.e. the average price paid by households for goods and services could increase around 0.005%).

Regarding existing research on ballast water treatment technology markets, some up-to-date results are available for past and future projected growth after the BWM Convention enters into force. According to existing estimates, the global market for ballast water treatment systems reached nearly US$1.4 billion in 2012 and nearly US$5.2 billion in 2015, and is projected to grow to nearly US$36 billion by 2020 with

6 Direct economic impacts are the actual monetary costs caused by the species in their invaded environments.

a compounded annual growth rate (CAGR) of 47.1% for the period of 2015-2020 (BCC Research, 2016 and 2013). The global demand for Ballast Water Treatment System (BWTS) units in the following years is projected to be in the order of magnitude of approximately 70,000 units.[7] A BWTS market will need to emerge over the next few years to create opportunities for ship operators to comply with IMO ballast water regulations and to allow those regulations to succeed (King et al., 2012). The analysed publications also discuss existing challenges for the development of ballast water treatment markets and implementation of the BWM Convention and contain some thoughts on addressing these challenges (King, 2016a and b).

Several papers address the economic impacts of individual NIS/IAS species or groups. The existing analyses mainly concentrate on the United States (Cusack et al., 2009; Lodge and Finnoff, 2008; Adams and Lee, 2007; Lee et al., 2007; Rockwell, 2003; Pimentel et al., 1999; O'Neill, 1997), although some examples are also available on economic impacts of IAS in Canada, United Kingdom (UK), Ireland, Australia, South Africa, India and Brazil. While the studies apply different bio(economic) models and approaches, the general consensus is that NIS have a large negative impact on biodiversity and national economies. For example, an assessment of the economic damage caused by introduced pests to crops, pastures, and forests (provisioning ecosystem services) in the US, UK, Australia, South Africa, India, and Brazil estimated the cost at nearly US$230 billion annually. Assuming similar costs worldwide, damage from invasive species would be more than US$1.4 trillion per year, representing nearly 5% of the world's economy (Pimentel et al., 2001). More specifically, negative economic impacts to the US economy have been estimated at approximately US$6.03 billion/year from invasive fish species, US$1.12 billion/year from zebra mussels and US$122 million from aquatic weeds[8] (Cusack et al., 2009). Overall, it can be concluded that the impact of IAS costs Canada and the US hundreds of millions of US dollars each year (Bailey, 2011). This situation is likely to be similar in many other countries.

Furthermore, available case studies on cost-benefit analysis of IAS management demonstrate that the costs of controlling and eradicating already introduced species can be significant, with expected success rates often characterized by considerable uncertainty (compare e.g. Coutts et al., 2004).

It can be concluded that the examined literature strongly supports the hypothesis that the economic impacts from IAS introduction tend to be significant and that the application of preventive measures can be beneficial both in terms of economy and effectiveness. However, there are considerable knowledge gaps, especially on the impacts of IAS introduction and the potential benefits of BWM in countries and regions that have not been considered in the research published to date. These gaps need to be addressed more systematically in the future to provide a more balanced picture and encourage decision-makers to implement BWM measures and regulations.

BOX 2: ECONOMIC IMPACTS OF ZEBRA MUSSEL INVASION IN THE US

O'Neill (1997) identified and quantified significant economic impacts of the zebra mussel (*Dreissena polymorhpa*) invasion in the US. The infestation occurs throughout much of the eastern half of North America and greatly affects raw water-dependent infrastructure, such as drinking water treatment plants, industrial facilities and electric power generation stations. A detailed survey was conducted, as a result of which 339 facilities reported total zebra mussel-related expenses of US$69.07 million. Moreover, it was concluded that total annual expenditures have risen significantly from 1989 (US$234,000) to 1995 (US$17.75 million), as the mussel's North American range and the number of facilities affected increased. These funds have been spent on a wide range of zebra mussel related activities, like, monitoring, preventive measures, research, training, planning and engineering, facility retrofitting, chemical/non-chemical controls and mechanical removal of zebra mussels.

7 Corresponds to about 60,000 ships, taking into account the likelihood that many large vessels will need multiple systems.
8 All values are adjusted to US dollars in 2008.

Picture 6: Zebra mussels attached to a boat propeller (Author: T. Britt - Source: *Flickr commons*).

2

Underlying methodology presented in GloBallast Monograph No. 19

In 2010, as part of the GloBallast Monograph Series, the GloBallast PCU published its Monograph No. 19 providing some guidance for the development of economic assessments for BWM. The aim of the Monograph was to serve as a practical tool to support the development of a National BWM Strategy by maritime administrators. However, it was also envisioned to have a broader utility for considering the economic aspects of IAS introduction and management responses, and for other decision-making purposes, including making a case for ratification of the BWM Convention.

The methodology proposed by Monograph No. 19 for conducting a NEA is divided in three main parts:

Part 1 – a basic framework for assessing the economic value of resources at risk from IAS introduction, based on the Total Economic Value (TEV) approach,[9] and potential costs from IAS introduction.

Part 2 – recommendations on how to estimate the costs of enacting the BWM Convention.

Part 3 – some directions on how the obtained estimates can be used to support decision-making and BWM planning at national level.

BOX 3: DIFFERENTIATING BETWEEN VALUE OF RESOURCES AT RISK FROM IAS INTRODUCTION AND COSTS FROM IAS INTRODUCTION

Value of resources at risk from IAS introduction: This concept encompasses all assets of a country in the wider sense (such as fisheries, infrastructure, coastal and marine ecosystems) which can be potentially affected by an IAS introduction. Their value can be expressed in economic terms based on specific valuation methods, such as the Total Economic Value (TEV) approach.

Costs from IAS introduction: This includes all (potential) costs which can be directly or indirectly attributed to a case of IAS introduction in a country. For example, direct costs from IAS introduction could be economic losses to the fisheries as a result of fish stocks' collapse. Examples of indirect costs from IAS introduction are costs resulting from damaged marine biodiversity, such as reduced ability of ecosystems to provide important services, loss of cultural and non-use values for present and future generations etc. Also response costs incurred through mitigative measures such as control and eradication of IAS can be attributed to this category.

The framework in Part 1 (chapter 3 and Annex 2 of the Monograph 19) is conceptualized to obtain value and cost estimates in five main categories:

- **Direct use values;** the methodology suggests to cover at least the key sectors fisheries, coastal aquaculture, other living resources and coastal tourism.
- **Additional costs to society and industry;** the Monograph explicitly mentions two sectors, in which these can be incurred – coastal infrastructure and shipping. In the coastal infrastructure sector, increased costs can be incurred e.g. as a result of rising maintenance and cleaning of ports and coastal power plants due to biofouling. The value of the shipping sector can be negatively affected either directly by IAS introduction or indirectly through regulatory change, both in

9 One of the main advantages of TEV is that it helps the understanding that ecosystems provide values beyond ecosystem goods and services traded in the marketplace. TEV also makes it possible to obtain qualitative values when establishing quantitative values appears too costly and/or time consuming, which may already provide critical information for decision-makers.

direct economic terms as well as in terms of to what extent the country relies on it for supplies and commodities.

- Public health; the methodology proposes to specify different vulnerable groups, such as resource users, seafood consumers etc.
- Indirect use values; these include, but are not limited to, shoreline protection, sediments and nutrient control, and flood control.
- Non-use values; these include bequest value for future generations, religious and spiritual value of resources and similar.

For each category and related subcategories, the countries were encouraged to obtain and fill in information on a number of issues. For example, for the category "Direct use value", key information for the Fisheries sector included: total yield/catch/number of users, number of employed persons or dependents, total value of sector, total value of sector as percentage of Gross Domestic Product (GDP), vulnerability to IAS (high, medium, low), monetary loss in US$ from IAS introduction (worst-case scenario) and percentage-based loss from IAS introduction (also worst-case scenario).[10] Annex 1 to the GloBallast Monograph No. 19 additionally presents diverse existing analytical techniques for valuating ecosystem goods and services, which is thought as an overview of the utility and possible limitations of these methods and shows examples of how they have been applied.

BOX 4: MARKET PRICE ANALYSIS AND TRAVEL COST METHOD

Market price analysis can be used for any marketable ecosystem goods or services. Its main advantages are that it is relatively inexpensive and less data-intensive when compared to some other methods and quite flexible. It is thus well-suited to conduct a valuation study on IAS impacts (e.g. where an IAS has replaced or diminished directly consumable species, when IAS introduction affects production of marketable goods, etc.). An added benefit is that many countries already have the necessary data readily available from their national statistics, making this an easy technique to apply 'in-house'. The main weaknesses of the market price analysis method are: possible distortions of true economic and social costs from IAS introduction through existence of subsidies and other market externalities; and the danger that the true value of the ecosystem is underestimated as non-marketable ecosystem services such as clean air, climate and flood regulation etc. are excluded from the calculation.

Travel cost method determines the value of an ecosystem based on the amount of money spent to reach the particular destination. It is especially useful for ecosystem level valuation of recreational or leisure sites, e.g. the value of a given water body for fishing activities. The basic premise of the travel cost method is that the time and travel cost incurred by people to visit a site represent its "access price". Thus, people's willingness to pay to visit a site can be estimated based on the number of trips that they make at different travel costs. The method is frequently used but it requires a large data set and complex statistical skills. It is also very labour intensive as it involves gathering information from visitors to recreational sites.

In Part 2 (chapter 4 and Annex 3), the Monograph provides suggestions on identifying cost elements associated with ratification of the BWM Convention as well as assessing the expected costs of implementation.

The Monograph acknowledges however that the needs (and thereby the associated amounts/shares) will vary from country to country. Possible costs of implementing the BWM Convention are grouped in three main categories according to the time of their occurrence and their distribution: (1) preparatory phase costs (chapter 4, section 1 of the Monograph), (2) compliance-related costs (chapter 4, section 2 of the Monograph) and (3) other indirect costs from issues not covered by the Convention (chapter 4, section 3 of the Monograph). Each of these main categories is further broken down to subcategories. Thus, for example, the preparatory phase costs encompass:

- Capacity building, coordination and communication;
- Legislative, policy and institutional reform costs;
- Port Biological Baseline Surveys (PBBS) and,

10 See GloBallast Monograph No. 19, Table 2, p. 9 and Annex 2, pp. 34-47 for detailed templates.

- Risk assessments (related to exemptions procedures under the BWM Convention for instance).[11]

The second category of compliance-related costs is additionally structured according to stakeholders who will incur these costs, i.e. flag States, port States and the (shipping) industry. Furthermore, costs for the implementation of the BWM Convention can be grouped in one-time costs and ongoing costs.

Costs incurred during the preparatory phase are (as the term already suggests) mostly comprised of expenses incurred at the first stages of implementing the BWM Convention. Some of them are one-time costs, such as preparation of a national BWM strategy or a risk assessment study. Other costs, e.g. for national task force meetings, which are the main platform for cross-sectorial communication and coordination of implementation of BWM activities, or exemption procedures, will occur on a regular basis. Compliance-related costs are costs incurred to ensure adherence to the BWM Convention and encompass processes such as certification, monitoring and inspection. Also these costs can be grouped into one-time costs (e.g. development of compliance measures) and ongoing costs (e.g. regular surveys of BWM systems on board of ships, inspection of ships etc.).

In Annex 3, the Monograph provides a template for identification and compilation of costs related to BWM and BWM Convention implementation.

Finally, the concluding part 3 of the Monograph (chapter 5) gives some directions on how the estimates can be used to support decision-making and BWM planning at the national level. As the focus of the Monograph is on a relatively low-intensity or low-resolution approach to economic assessment, chapter 5 mainly focuses on compiling and synthesizing findings and drawing broad conclusions. In this regard, the Monograph highlights that the economic data on possible marine IAS impacts (chapter 3 of the Monograph) and costs associated with implementation of the BWM Convention (chapter 4) are different in many ways. For example, the economic data on possible impacts from IAS introduction mainly includes costs to society as a whole, or to specific industries that are not necessarily directly related to the maritime sector or under the purview of the maritime administration. The detailed listing of BWM Convention enactment costs provides guidance on how costs are distributed between stakeholders within the maritime sector, and their magnitude.

Therefore, the Monograph No. 19 concludes that while the data does not lend itself to a detailed cost-benefit analysis, it can be synthesized and compared in several ways that support a decision-making process. It also mentions that 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 invasions that would be far more likely without the Convention. However, it also provides a brief outline of two commonly used advanced analytical tools - cost-benefit analysis and multi-criteria analysis for orientation.

BOX 5: COST-BENEFIT ANALYSIS OF MANAGEMENT OPTIONS FOR CARPET SEA SQUIRT IN NEW ZEALAND

Coutts et al. (2004) and Sinner et al. (2003) provide an example of an analysis, conducted to learn about the costs and benefits of managing an invasion by carpet sea squirt (*Didemnum vexillum*) in New Zealand, which was suspected of posing a significant threat to New Zealand Greenshell™ mussel industry. Based on their analyses, the authors concluded that the costs of non-action or delayed action for the New Zealand Greenshell™ mussel industry are considerably higher, than costs of management options, with the added high risk that the organism will spread further and control options will become more expensive and less effective. Thus, it was estimated that non-action would cost the Greenshell™ mussel industry around US$807,000 over five years, whereas the expected benefits of the most-favoured Option were US$712,000 vs. costs of US$173,000, with a success rate of 90%. In 2004, due to delays in infestation management, the expected costs of non-action increased (total expected costs over five years estimated at US$1.16 million). Therefore, the benefit cost-ratio and likelihood of success became significantly smaller.

11 For a detailed listing of all possible cost items please consult the GloBallast Monograph No. 19, pp. 10-17.

3

Main outcomes of national economic assessments of the GloBallast LPCs

All the assessments were conducted over a range of years (2010 to 2016), and their values are either based on data from different years, or are mean values or the year is not specified at all. For the sake of simplification it has been assumed that all data is from the year in which the report was completed and published.

Three countries (Bahamas, Turkey and Yemen) provided part of their estimates in national currencies,[12] whereas all other national assessments used United States dollars (US$). Therefore, to take account of processes such as inflation and to make values comparable, several approaches have been applied:

(1) All figures provided in US$ were updated to 2016 estimated values, using the Consumer Price Index (CPI)/inflation rate for the US$.

(2) National currency for Turkey and Yemen have been updated to 2016 values, using their national CPI/inflation rates. Non-US$ values from Turkey and Yemen were then converted to US$ using the OANDA currency-converter website.[13,14]

(3) For the Bahamas, an update to 2016 values was not necessary, as the report was published in 2016. Non-US$ values provided by the Bahamas have been converted using the same website as above.[15]

The table in Annex I contains only the figures updated to 2016 values. However, in the national report summaries in chapter 3, original figures, as provided by the countries, were retained (i.e. not updated to 2016 values). That way, when analysing each country individually, the original format of the data is used; while figures updated to a common date and currency are used for comparability purposes.

12 Bahamian Dollar (BSD), Turkish Lira (TRY) and Yemeni Rial (YER).
13 See OANDA website: https://www.oanda.com/currency/converter/, accessed January 2017.
14 For Turkey and Yemen, the official currency rates valid on 30 June 2016 were used, which is the middle of the year 2016.
15 For the Bahamas, which completed its report in June 2016, the official currency rate valid on 15 June 2016 was used.

3.1 ARGENTINA

Argentina completed its national economic assessment in 2012. Shipping is of particular importance to the country's economy, with 90% of foreign trade based on maritime traffic. Apart from the 4,665 km long shoreline, the Río de la Plata basin's navigable rivers are frequented by ocean-going vessels, and it is further envisaged to interconnect navigation routes with the riparian states Uruguay, Paraguay, Bolivia and Brazil for a year-round navigation. The biggest problems related to ships' ballast water are reported in river ports accessible to ocean-going vessels. To date, 39 marine NIS have been recorded in Argentina (Orensanz et al., 2002) but the real number is likely to be higher. Of these 39 species, 4 species have been intentionally introduced for exploitation (the Japanese oyster and 3 species of salmonid fish), and the rest have been introduced accidentally in different areas of the coast. At least 7 are considered invasive, however only 3 are subject to some type of local control: the seaweed *Undaria pinnatifida*, the golden mussel *(Limnoperna fortunei)* and the Japanese oyster *(Crassostrea gigas).*

Economic values of resources at risk and potential costs from IAS introduction were not estimated in the Argentinian report. However, it does mention that the trade balance in the fisheries sector is US$1.15 million on average and provides a general description of the resources at risk and economic sectors relevant to BWM. Finally, the report also provides a cost estimate for enacting the BWM Convention.

BOX 6: CASE STUDIES OF FOUR IAS IN ARGENTINA

Schwindt & Repizo (2010) identified that the seaweed Undia pinnatifida, introduced in 1992 in the port of Puerto Madryn probably through ballast water or as biofouling. Local dispersion (translocation) was most likely performed as fouling through small fishing and recreational vessels. The species is distributed in very high densities from the San José Gulf to Puerto Deseado. It has generated ecological changes on native biodiversity in all areas where it was introduced (Casas and Schwindt, 2008; Wallentinus, 2007; Casas et al., 2004;). The seaweed also has economic impacts due to the costs of its constant removal to keep the recreational diving areas and tourist beaches clean. For example, cleaning the beaches in the areas under the Municipality of Puerto Madryn has an annual cost of approximately US$10,000.

The golden mussel *(Limnoperna fortunei)* was introduced in 1991, probably as ship fouling (adults) and/or in ballast water (larvae), in a spa near the city of La Plata (Pastorino et al., 1993). It quickly colonized much of the La Plata basin, including Argentina, Uruguay and Brazil, at an average dispersal rate of 250 km per year (Boltovskoy et al., 2006). In addition to its ecosystem effects (Darrigran and Damborenea, 2006), the most notable impact can be detected in industries such as hydroelectric plants, nuclear plants, distilleries and refineries, due to the high densities causing obstruction of filters, pipes and tanks. While the cost of maintenance of the mussel-free industries has not been estimated for Argentina, in Uruguay, a survey of eight private and state companies confirmed maintenance costs of over US$10,000 per year for 62% of the companies (Brugnoli et al., 2006).

Picture 7: Green crab. (Author: B. Wilson, 2010 - Source: *Flickr*)

The green crab *(Carcinus maenas)*, native to the north-eastern Atlantic is a known generalist predator in intertidal and subtidal areas, causing a decrease in the population size of native bivalve and crab species (Grosholz et al., 2000). This species was introduced around 2000 in Comodoro Rivadavia and is currently covering about 500 km of coast (Hidalgo et al., 2005). Although significant effects of this species have not yet been detected, probably because of their relatively recent introduction, it is estimated that their impact could be significant given the scarcity of other intertidal predators and the effects of this species on other introduced areas.

The cirriiped Balanus glandula was introduced in the late 1960s in the port of Mar del Plata, probably as fouling of the boats, and colonized the intertidal rocks and ports along the coast of Argentina, covering 17 degrees of latitude at a rate of 244 km per year, with current distribution known from San Clemente del Tuyú to Río Grande (Schwindt, 2007). The effects of this species on native biodiversity have not been studied. It is known that it generates problems as a fouling organism in the various piles of docks in almost all seaports of Argentina. A peculiarity of this species, which differentiates it from the other introduced species, is its ability to colonize environments never inhabited before, even in its native area, such as marshes (Schwindt et al., 2009).

The national economic assessment highlighted that a comprehensive assessment on the costs of implementing the BWM Convention was not feasible, partially due to the confidential nature of commercial data.

It concludes that although exact economic values could not be established, the value of the resources at risk and the disruption to infrastructure are considerable. The benefits of IAS prevention exceed the costs, and the money and resources employed to combat or prevent IAS should be therefore regarded as an investment, not a cost.

3.2 THE BAHAMAS

The national economic assessment of the Bahamas was completed in June 2016. The stakes of shipping are high in the Bahamas, as it is an important flag State with one of the world's largest fleet (over 1.400 registered vessels) and it imports approximately 90% of its material resources by sea or international shipping. Therefore, the country's vulnerability to IAS introduction is considered high. Specific identified IAS include lionfish and harmful algal blooms (HABs).

The report from the Bahamas presents economic values of resources at risk from IAS impacts, where available, and an estimate of the BWM Convention enactment costs. Potential costs from IAS introduction could not be estimated due to the lack of research and data on this topic. The methodology used to determine values of resources at risk is Total Economic Value (TEV). BWM Convention implementation costs were calculated based on a desktop review of similar costs in other countries and interviews with relevant stakeholders/ national ballast water experts to determine needs and capacity. Additionally, these costs were grouped based on their frequency (one-time costs vs. ongoing annual costs). For example, development of PBBS in the preparatory phase is attributed to the category of one-time costs, whereas conducting regional meetings (preparatory phase) and port biological monitoring (other costs) are both categorized as ongoing annual costs.

The national economic assessment contains qualitative descriptions of key sectors at risk from IAS introduction as well as economic value estimates for some of these sectors. The overall economic value of resources at risk from IAS introduction (including fisheries, coastal tourism and ecosystem services) has been calculated at approximately US$1.6 billion[16] per year.

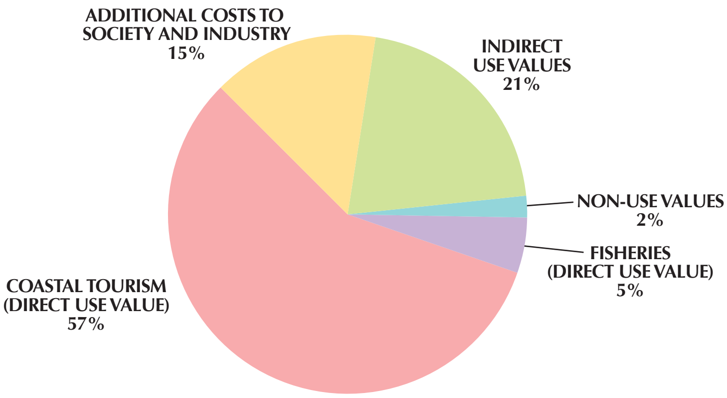


Figure 1: Resources at risk from IAS introduction in the Bahamas: share of individual sectors in the overall TEV

However, the assessment highlights that there are significant knowledge gaps concerning ecosystem services, option, existence, altruistic and bequest values. Therefore, the TEV figure would be significantly higher for a complete valuation of all coastal and marine resources.

The costs of enacting the BWM Convention were estimated at approximately US$1.7 million[17] in one-time costs and US$110,000[18] in ongoing annual costs (as incurred by the State); and a range of US$5,000 to US$3 million[19] per vessel depending on its type and size (as incurred by ship owners).

16 Equals B$ (Bahamian Dollar) 1.625 billion, converted at currency rate from 15.06.2016.
17 Equals B$ (Bahamian Dollar) 1.731 million, converted at currency rate from 15.06.2016.
18 Equals B$ (Bahamian Dollar) 111,000, converted at currency rate from 15.06.2016.
19 Equals B$ (Bahamian Dollar) 5,016 – 3.005 million, converted at currency rate from 15.06.2016.

The report arrives to the conclusion that the figures provided, particularly for ecosystem services, represent a small fraction of the total value for these resources. However, while available data is incomplete, it is enough to reveal that marine and coastal resources are a highly valuable commodity for the Bahamas. Table 1 below presents a synthesis of available information on the value of these resources and illustrates the difficulty to determine the value of all the resources at risk.

Table 1: Coastal and marine resources of the Bahamas: economic value and persons employed

TYPE OF VALUE	SECTOR/RESOURCE	VALUE (B$)	# OF PERSONS EMPLOYED	NOTES
Direct use	Shipping	245,000,000	11,500	2014 Gross Value Added (GVA)
	Coastal tourism	922,000,000	80,000	2014 GVA
	Fisheries	80,000,000	9,300	2014 GVA
	Aquaculture	–	–	No current value but expected to increase significantly in the future
	Marine resources	–	–	Per year value; would be significantly higher if calculated for all the Bahamas
Indirect use	Ecosystem Services (only captured for Andros, Exuma and part of Grand Bahama)	347,000,000	–	
Option		–	–	No studies found
Existence, altruistic and bequest		31,500,000	–	Refer to p. 57 of this Monograph for more information
TOTAL		**1,625,500,000**	**100,800**	Would be significantly higher if value of all resources is included

Even based on the compiled values, the report reasons that the economic value of resources at risk from IAS introduction exceeds by far the costs of enacting the BWM Convention. The national assessment therefore strongly recommends to consider implementing the BWM Convention and to fund development of an effective BWM Strategy.

3.3 CHILE

Chile finalized its national economic assessment in January 2012. While geographic and climatic conditions prevent IAS introduction into Chile to a certain degree, the country is still considered vulnerable This is due to its long coast (6,435 km) with a dismembered shoreline (totalling 20,000 km), high traffic volumes in the Strait of Magellan and the Drake Passage, its "tri-continental" geopolitical location relating to South America, Oceana (Easter Islands) and Antarctica, and its export-based economy that relies on maritime transport. Few studies exist on IAS and their economic impact in Chile, and due to a lack of awareness, IAS are generally not perceived as a major threat to the country.

The report follows the methodology of GloBallast Monograph No. 19 and provides: (a) economic values of resources at risk from IAS impacts, for which the Total Economic Value (TEV) methodology was applied; and (b) an estimate of the BWM Convention enactment costs, based on desktop research and stakeholder consultations.

BOX 7: BALLAST WATER AND IAS INTRODUCTION IN CHILE

In a study by Castilla and Neill (2009), a total of 51 alien species were identified in Chile, many of which were introduced intentionally for aquaculture (e.g. oysters, abalones and salmonids). The study found that most of the IAS (about 30) came from the west coast of North America and from the west coast of Asia. This high number of IAS coincides with a high volume of maritime traffic to/from these regions. Other identified regions of origin for IAS are the South Pacific (Australia and Peru), with 2 species; the north Atlantic (east coast of North America), with 4 species; the South Atlantic (Argentina and West African coast), with 2 species; and the Mediterranean and North seas, with 9 species. Overall, the authors estimate that 18 of the 51 species were introduced through ships' ballast water.

Considering the high volume of maritime traffic in Chile, ships' ballast water is highlighted as a source of IAS introduction also in a report by CONAMA (2009). As an example, the introduction of the tunicate *Pyura praeputialis* in the Bay of Antofagasta is mentioned, traced from Australia through ballast water and now spread along a 70 km stretch of the coast in the inter- and sub-tidal zones. While Castilla and Neill (2009) mention potential benefits of this species for local fishermen, its impacts on the ecosystem are not known. The same CONAMA report also mentions the great spider crab *(Hyas araneus)*, a species originating from the Arctic Ocean and North Atlantic. It was registered around the Antarctic Peninsula, an area that had until then been considered free of IAS. Considering the increased maritime traffic in the region, ballast water is considered as the probable vector for its introduction.

The TEV of the resources at risk accounts for over US$90.4 billion, based on the valuation of fisheries resources, marine reserves, marine biodiversity and tourism. If the present value is calculated in perpetuity,[20] it rises even higher up to US$1.13 trillion (using a discount rate of 8%) or US$2.26 trillion (using a discount rate of 4%). The overall potential costs from IAS introduction are not estimated due to a lack of underlying data. However, the report presents a few cases demonstrating potential economic costs that could affect the fisheries, aquaculture, tourism and public health sectors, as well as other effects.

20 Perpetuity is explained in the report as the assumption that the benefits will be maintained over time, if the conditions do not change. It is calculated by dividing the value by the respective discount rate. No explanation is given on how the respective discount rates were obtained.

BOX 8: EXAMPLES DEMONSTRATING POTENTIAL ECONOMIC IMPACTS OF IAS INTRODUCTION ON PUBLIC HEALTH AND ELECTRICITY

Environmental monitoring in Chile during a cholera outbreak in Haiti in 2010 accounted for a cost of US$264,000. The cholera outbreak in Peru in 1991, which was introduced from Asia through ballast water, had a total cost of US$770 million.

IAS have also caused higher maintenance costs of 21 thermoelectric power stations of up to US$3,717 per plant for each additional cleaning (due to loss of generated power during the cleaning).

The costs of implementing the BWM Convention in Chile are estimated to be around US$5.6 billion. 82 vessels (>400 gross registered tonnage) form the basis for the cost estimation for BWM Convention enactment costs. According to the assessment, the costs for enacting the BWM Convention in Chile would account for 6.19% of the value of goods and services provided by marine ecosystems. If the ecosystem value is calculated in perpetuity, the ratio becomes even lower (0.5% with a discount rate of 8%, and as low as 0.25% applying a discount rate of 4%). Therefore, the report concludes by recommending the ratification and implementation of the BWM Convention by Chile as an important mechanism to control IAS introduction.

3.4 COLOMBIA

Colombia's national economic assessment was completed in January 2011. The report cites several studies on marine biodiversity and ballast water in Colombia, which highlight the vulnerability of the country in respect of IAS.

The value of resources at risk and potential costs from IAS introduction are described mostly in qualitative terms due to a lack of information. Nevertheless, the assessment suggests that costs from IAS impacts on fisheries and aquaculture, marine ecosystems, coastal infrastructure and navigation, tourism and public health may well account for several millions of US$ per year. It also mentions some specific examples (see Box 9):

BOX 9: EXAMPLES OF NEGATIVE ECONOMIC IMPACTS OF IAS INTRODUCTION ON SHRIMP FARMING, CORAL REEFS AND COASTAL LAGOONS

An existing case study on the black striped mussel *(Mytilopsis trautwineana)* in aquaculture farms near Cartagena estimates that potential economic losses in shrimp farming due to IAS introduction are about US$9,000 per ha/year. Although no overall cost has been calculated, it is known that 4,000 ha are under shrimp farming in Colombia (especially in the Caribbean), resulting in approximate potential costs of US$36 million per year.

Potential costs for coral reefs in Colombia from IAS introduction are estimated to lie above US$250,000 per ha/year (based on studies conducted in Australia, Aruba and Jamaica).

An earlier study in Colombia by Costanza et al. (1997) concludes that the potential costs on coastal lagoons and estuaries are at least US$23,000 per ha/year. The national economic assessment of Colombia emphasizes that the real figure is likely to be much higher.

The report provides a quantitative estimation of costs for enacting the BWM Convention. The total costs were estimated at around US$81 million. Yet, the report highlights that the costs for enacting the BWM Convention could initially be lower – at around US$50 million - by disregarding the costs for D-2 sampling,[21] which will not be mandatory in the early years of implementation. 52 vessels under Colombian flag with >400 gross registered tonnage form the basis for the estimation of BWM Convention enactment costs in this assessment.

Although the resources at risk and potential impact costs through IAS could not be comprehensively quantified due to lack of available research, the report concludes that the economic, social and cultural impacts of IAS would negatively affect the sustainable development of the country. It therefore recommends the ratification of the BWM Convention.

21 The D2 standard covers approved ballast water treatment systems, and specifies levels of viable organisms left in water after treatment.

BOX 10: CASE STUDIES ON BALLAST WATER AND IAS INTRODUCTION IN COLOMBIA

Besides one inventory of marine and coastal IAS in Colombia (Gracia et al., 2011), the introduction of IAS through ballast water in Colombia is documented in various specific case studies, among them:

- Analysing the impact of ballast water in the Cartagena Bay, Cañon et al. (2005) and Rondón et al. (2003) detected species of phytoplankton and zooplankton that had previously not been reported.
- Tous (2007) found that 29% of analysed vessels had ballast water that exceeded the permissible *Escherichia coli* and *enterococci* levels.
- In the Port of Santa Marta, Montoya et al. (2008) found 56 species of zooplankton in the ballast water of international vessels, of which 20 were alien and one cryptogenic.
- Also in the Port of Santa Marta, Rangel and Vidal (2008) found 23 harmful and 3 toxic species of phytoplankton species in the ballast water of arriving vessels.
- González et al. (2009) report the introduction of the spotfin lionfish *(Pterois volitans)* in the Tayrona National Natural Park, in Santa Marta and in the San Andrés island, being the first register of this species in South America.
- In a case study on ballast water in the Bahia Portete and Puerto Bolivar, Quintana et al. (2008) found that 12% of analysed vessels had ballast water that exceeded the permissible *Escherichia coli* and *enterococci* levels.

3.5 CROATIA

The NEA of Croatia was finalized in September 2013. The rugged coastline of the Adriatic Sea and the ongoing economic development of Croatia have favoured the establishment of numerous ports and marinas. Of these, 6 major ports in the larger coastal cities (Rijeka, Zadar, Šibenik, Split, Ploče and Dubrovnik) are serving international trade. In recent years, investments in port infrastructure and transport capacities of Croatia were steadily rising, corresponding with an increase in shipping traffic and in the amount of discharged ballast water.

The report provides: (a) an assessment of economic values of resources at risk from IAS introduction, based on Total Economic Value (TEV) approach; (b) an estimate of potential costs from IAS introduction in the Adriatic Sea; and (c) an estimate of BWM Convention implementation costs. The cumulative economic value of resources at risk is not provided in the report, but by adding up individual values in the report, it can be estimated at US$9.6 billion. The report also contains several figures on potential costs from IAS introduction, which are approximately US$2.8 billion. Table 2 below provides a synthesis of available information on the value of resources at risk and potential costs from IAS introduction.

Table 2: Coastal and marine resources of Croatia: economic value, persons employed and potential costs from IAS introduction

TYPE OF VALUE	SECTOR/RESOURCE	VALUE (US$)	# OF PERSONS EMPLOYED/ DEPENDENTS	WORST–CASE LOSSES (US$)
Direct use	Fisheries	208,000,000	13,000	110,000,000
	Aquaculture	–	1,000	18,000,000
	Other living harvested resources	1,200,000	200	600,000
	Coastal tourism	9,000,000,000	2,000–3,000 (partial number)	2,700,000,000
Additional costs to society and industry	Shipping and port activities	320,000,000	–	–
	Coastal infrastructure	146,000,000	–	11,000,000
Public health			–	6,500,000
Total		**9,675,200,000**	–	**2,846,100,000**

Croatia also prepared an estimate of costs resulting from the implementation of the BWM Convention. According to the report, approximately US$1.4 million will be incurred by the state for institutional capacity building and in fulfilment of its flag State and port State obligations. The report also estimated a further US$65.4 million to be incurred by the shipping industry, based on an approximated cost of installing BWM systems on board ships registered under the Croatian flag. The report concludes that the overall costs of the implementation of BWM Convention in Croatia are significantly smaller than assumed negative economic impacts due to the potential introduction of IAS transferred via ships' ballast water.

3.6 EGYPT

Egypt completed its NEA for BWM in December 2011. Several unique marine habitats of the Red Sea, including coral reefs, mangroves and sea grass beds, provide key resources for Egypt's coastal population by supplying food, ensuring shoreline protection and securing economic benefits from tourism. The most important sectors threatened by IAS introduction include fisheries, coastal tourism and maritime transport, all presenting very significant sources of income for Egypt's economy. At the same time, the report mentions that there is a lack of adequate information on the type, numbers, status and spreading magnitude of IAS (if present) in Egyptian Red Sea waters.

The NEA applied the following general approach: the part of the report dedicated to assessing economic values of resources at risk from IAS introduction is based on the conceptual framework of TEV. The report also mentions that the economic assessment was conducted applying two basic economical assessment methods - market price analysis method and travel cost method. The report was prepared based on two principal sources of information: National Statistical Yearbooks for 2008 and 2010 and Annual Reports on Fisheries Statistics. It does not apply TEV-methodology as such, but rather provides a general description of the resources at risk, including coral reef ecosystems and economic activities such as fishing, coastal tourism and maritime transport as well as potential and existing threats to these resources. The report also contains examples of economic assessments of coral reefs' value in Egypt and costs of their degradation caused by unregulated tourism.

In respect of indirect and non-use values of key marine ecosystems in Egypt, the report further mentions that as many parts of marine ecosystems are not traded in markets, they do not have an obvious economic value. From this background, it expresses the concern that the risks of ballast water activities for natural habitats could be ignored and stipulates the importance of fully considering environmental impacts to achieve people's welfare.

Overall potential costs to the Egyptian economy from IAS introduction are estimated to be US$2.6 billion in a worst-case scenario. Total cost of implementing the BWM Convention in Egypt are calculated at US$4.5 million. When compared, costs from IAS introduction are much higher than Convention implementation costs.

The report highlights that if also non-marketed ecosystem services, non-marketable environmental values, costs of possible cleaning activities for IAS and "cultural value" losses were additionally included in the calculation (in the report only the direct use values are quantified), the BWM Convention implementation costs would become even smaller compared to the negative economic effects of IAS introduction. Based on this, the report concludes that it is feasible to implement BWM requirements.

Picture 8: Coral reef life (Source: *GloBallast*).

BOX 11: ECONOMIC ASSESSMENT OF CORAL REEFS IN EGYPT

Egypt's coastline possesses a significant proportion of the coral reefs found in the Red Sea with about 3,800 km2 of reef area (Spalding et al., 2001) and 1,800 km length (PERSGA, 2010). Two-thirds of approximately 300 hard coral species in the Red Sea are found in the Egyptian reefs, including some endemic species (Kotb et al., 2008). The coral reefs are part of Egypt's natural capital. Based on global estimates of the economic value of coral reef fisheries, tourism, and shoreline protection, the costs of destroying 1 km of coral reefs range between US$137,000 and 1.2 million over a 25-year period (World Bank, 2002). Properly managed coral reefs can yield an average of 15 tonnes of fish and other seafood per km2 each year. This means that the approximately TEV of Egypt's Red Sea coral reefs is estimated at a range of 205.5 million – 1.8 billion and can yield about 1,400 tonnes of seafood annually. The cost of coral reefs and fisheries degradation in the Egyptian Red Sea area, caused by unregulated tourism activities, was estimated to be between US$2.63 – 2.67 billion per year.

3.7 GHANA

Ghana's NEA was published in 2011. 85% of Ghana's international trade (by volume) is carried by sea, which implies a high exposure to IAS. This risk is expected to rise further with the recent commencement of oil drilling in commercial quantities coupled with expected increases in the import and export volumes and increased shipping traffic calling at the ports of Ghana. The report points out that so far no serious steps have been taken to address the issue of IAS introduction (e.g. keeping records on BWM practices by ships calling on Ghana's ports).

For calculating the costs of implementing the BWM Convention, the report uses the methodology proposed by the GloBallast Monograph No. 19 and describes in some detail two commonly applied economic assessment methods: market price analysis and travel cost that have been applied when preparing the estimates presented in the report.

The NEA contains value estimates of key economic sectors such as fisheries, aquaculture and coastal tourism, as well as potential costs caused by an IAS introduction for fisheries, aquaculture, coastal tourism and public health. In addition to the data provided in the national report, the Ministry of Fisheries reported that the contribution of Ghana's fisheries sector to the country's GDP in 2011[22] was 1.7%, i.e. approximately US$672.6 million.[23] The economic value of coastal tourism was also significant and was estimated at US$500 million in 2011.[24]

The report also contains a detailed calculation of the BWM Convention implementation costs, totalling US$183 million.

An interesting addition in Ghana's report is a cost estimate for conducting Port Biological Baseline Surveys (PBBS)[25] in two of its main ports (Takoradi and Tema), chosen among five high risk areas on Ghana's coast. Table 3 provides the calculation for the port of Takoradi.

22 Ghana's GDP in 2011 was US$39.565 billion; see UNCTADstat database at: http://unctadstat.unctad.org/wds/TableViewer/tableView.aspx, accessed February 2017.

23 Statistics and Reports, Ministry of Fisheries and Aquaculture Development, Republic of Ghana at: http://www.mofad.gov.gh/publications/statistics-and-reports/fish-production/, accessed February 2017.

24 Since no data for coastal tourism could be found, it was estimated to be approximately 50% of the overall value for travel and tourism; see Travel and Tourism. Economic Impact 2016 Ghana. WTTC at: https://www.wttc.org/-/media/files/reports/economic-impact-research/countries-2016/ghana2016.pdf, accessed February 2017.

25 Port biological baseline surveys provide the baseline against which success of BWM 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 (section 4.1.3 of GloBallast Monograph No. 19).

Table 3: Estimation of Port Biological Baseline Survey (PBBS) costs in Ghana

ITEM	NUMBER OF TIMES/ QUANTITY	COST (GH CEDI)	TOTAL COST (GH CEDI)	TOTAL COST (US$)
Accommodation for 4 scientists, 2 technicians and 1 driver	30	150	31,500	19,687
Boat hiring	30	1,000	30,000	18,750
Laptop computer	1	1,800	1,800	1,125
Field/laboratory allowance for 4 scientists	30 working days	80	2,400	1,500
Field/laboratory allowance for 2 technicians	30 working days	40	1,200	750
Global Positioning System (hand held)	2	1,200	2,400	1,500
Hiring of divers	7 days	200	1,400	875
Printer	1	1,500	1,500	937
Hiring of vehicle/driver	30	300	9,000	5,625
Fuelling	30	300	3,000	1,875
GIS analysis	1	1,000	1,000	625
Awareness creation workshop			3,000	1,875
Soft substrata/fisheries			4,980	3,112
Hard substrata analysis			14,368	8,980
Nutrient and water quality analysis			7,320	4,575
Plankton analysis			4,530	2,831
Reporting data processing			3,300	2,062
SUBTOTAL			**122,698**	**76,686**
30% Administrative/contingency			36,809	23,005
TOTAL			**159,507**	**99,692**

The national economic assessment concludes that BWM Convention implementation costs are definitely lower than the potential economic harm expected from IAS introduction and that it is possible to allocate the amount of US$24.21 million necessary to implement the Convention in Ghana (excluding ballast water treatment costs) with external support, in order to counteract the significant threat posed by IAS. According to the authors of the report, the outcome of the NEA clearly demonstrates that BWM measures are economically feasible compared to the high costs that the country may incur if it does not put in place the necessary mechanisms to halt further spread of marine IAS.

3.8 JAMAICA

The NEA of Jamaica was finalized in October 2016. The island's proximity to major international shipping lanes in the Caribbean makes it a major trans-shipment hub for several shipping activities between the Panama Canal, North America and South America. Several cruise ship terminals attract a large tourist market from Jamaica's northerly neighbour, the United States. The size of vessels as well as their traffic is expected to increase at most if not all ports on the island after completion of the expansion of the Panama Canal in 2016. For this reason, the majority of vessels calling at Jamaican ports are foreign registered vessels with only 25 ships flying the Jamaican flag.

The use and management of ballast water in Jamaican waters is currently a voluntary arrangement between shipping agents and national authorities. Therefore, the discharge or uptake of ballast water in Jamaica is unregulated and unreported at the moment. According to the Jamaican NEA, coral reefs will be the primary habitat affected by IAS introduction. Coral reefs provide very important ecosystem services including, but not limited, to coastal protection, sand production for beaches, fisheries for both artisanal and commercial sectors, and biodiversity for dive tourism. For example, the loss of beaches due to reduction in beach protection from coral reefs could cost the country US$23 million per year at its current rate, based primarily on the reduction of island visitors due to poor coastline health.

Existing case studies on marine invasions in Jamaica document an introduction of three IAS, which are present in ports or in their proximity: the Indo-pacific green mussel (Perna viridis), the Indo-pacific red lionfish (Pterois volitans) and the Asian tiger shrimp (Penaeus monodon). Another example provided by the NEA is the maintenance costs reported by power stations in Kingston Harbour, which have increased due to colonization of seawater cooling systems by the green mussel.

BOX 12: INVASION OF THE INDO-PACIFIC RED LIONFISH *(PTEROIS VOLITANS)* IN JAMAICA

The presence of lionfish was first documented in the Atlantic and Caribbean region in 1985 along the eastern coast of the US. It was first recorded in Jamaica in 2008 on the north-coast reefs, and since then, it has established itself in every marine environment in Jamaica. Lionfish thrive in the Caribbean Sea for two main reasons: first, as an apex predator it is successfully feeding on a variety of small fish and crustacean, and second, it is not a prey for many species in the Caribbean Sea. In addition, the lionfish has a rapid reproduction rate, with one female producing approximately 2 million offspring annually (National Ballast Water Status Assessment and Economic Assessment of Jamaica, 2016).

The lionfish is a concern to marine resource stakeholders because of its potential threat to fisheries, biodiversity, fish nurseries, numerous microhabitats and human health. The economies of Caribbean islands like Jamaica are particularly vulnerable to the lionfish invasion because of the extensive use of natural resources to maintain domestic livelihoods (FAO, 2012). A decline in fish stocks in the coral reef habitats from the lionfish population growth can cause significant losses to the value of the marine biodiversity and the quantity of fish landings of the commercial fisheries sector of Jamaica. Should the trends of the lionfish population growth remain unchecked, then the potential cost of the lionfish stock would exceed the total value of the reef fish stock in Jamaica.

Picture 9: Lionfish dwelling in the Wider Caribbean region (Author: *D. Buddo*)

The report mentions that the economic impact of marine IAS on Jamaica's Gross Domestic Product (GDP) has not been fully researched. However, the value of the contribution of marine resources to the various economic sectors based on the ecosystem services they provide is better understood. For example, fish sales (local and export markets) amount to approximately US$34.3 million per year, a value equivalent to 0.3% of Jamaica's annual GDP.

In terms of general approach, the NEA first compared the contribution of fisheries and tourism to Jamaica's GDP with direct and indirect impacts of the most recent marine invasion in Jamaica (i.e. the lionfish). This resulting value was subsequently compared to the cost of implementation of the BWM Convention in Jamaica for year one plus following years.[26] The report from Jamaica also included survey to determine the non-use value of the country's coral reefs, using the Willingness To Pay (WTP) method. Overall, it was estimated that the potential cost of the direct biological impacts of the lionfish invasion is US$28.9 million and the total WTP for protecting the marine biodiversity of the reef habitats in Jamaica is US$9.9 million. Based on these calculations, the total impact of the lionfish invasion in Jamaica totalled US$38.8 million. The main conclusion from the calculation generated for the lionfish invasion in Jamaica is that if its population growth remains unchecked, the losses to the Jamaican economy in the fisheries sector will exceed total contribution of this sector to national GDP.

Table 4: Estimated economic impact on GDP of the lionfish invasion in Jamaica

ISSUE	AMOUNT IN US$
Potential cost of direct biological impacts of the Lionfish invasion	28,935,000
Total willingness to pay (WTP) for protecting the marine biodiversity of the reef habitats in Jamaica	9,888,000
Total costs of the impacts identified for the Lionfish invasion in Jamaica	38,824,000

For the BWM Convention implementation costs, the national economic assessment introduces two different cost groups (beyond the GloBallast Monograph No. 19): costs incurred in Year 1 and recurring annual costs. It further specifies that recurring annual costs should be made available and sustained indefinitely for the BWM Convention to be implemented effectively. Year 1 costs tend to be higher than

26 Perpetuity is not further explained in this report, however refer to the example of Chile above, which also uses this term in its report (footnote 20).

recurring annual costs and are estimated at US$278,000. Recurring annual costs amount to US$149,000 per year.

Overall, the report comes to the conclusion that although ballast water is not the only cause of IAS introduction, it is the main vector. It is expected that managing ballast water release in Jamaica will result in significant reduction in IAS introduction cases. It also acknowledges the importance of allocating financial resources necessary to implement the BWM Convention and of ensuring their availability also in the longer term.

3.9 JORDAN

The national report for BWM in Jordan was published in January 2011. Jordan is almost entirely land-locked and is only connected to the Red Sea via a short (27 km) stretch of coast. It has a single port – Aqaba, through which nearly all marine activities in Jordan are conducted. Currently about 2,300 ships call at the port of Aqaba and shipping traffic is projected to double during the next decade due to economic growth and increases in Jordanian population. This will also mean increased environmental pressure on coral reefs and other resources. At the time of the report's publication, 3 alien species of fish native to the Mediterranean Sea were recorded in the coral reef ecosystem along the Jordanian coast, while other biota still needed further scientific research.

The NEA was prepared using statistical information available from competent national authorities. The implementation costs of the BWM Convention were estimated based on costs of similar work packages of National BWM Project of Jordan. Methodologically, the report uses two basic economical assessment methods – market price analysis and travel cost.

Pictures 10 and 11: Training activities conducted in Jordan. (Source: *GloBallast*)

The report contains a general description of key economic sectors most susceptible to the effects of a potential IAS introduction (fisheries, aquaculture, coastal tourism and coastal infrastructure). It also highlights the importance of indirect and non-use values provided by key ecosystems in Jordan (e.g. coral reefs). No quantitative estimates assessing the value of resources at risk are available. The report stipulates however that such values are likely to be considerable. It further contains some quantitative estimates of potential economic implications of IAS introduction according to key sectors. The total possible economical loss in case of a worst-case scenario has been calculated at US$118.5 million. The implementation costs of the BWM Convention were estimated to be approximately US$811,000.

The assessment comes to the conclusion that the implementation costs of BWM are definitely lower than potential negative economic impacts of an IAS introduction. The difference between them would become even more pronounced if also indirect and non-use values are included in the calculation of potential costs from IAS introduction. The report therefore concludes that it is feasible to implement BWM measures under the BWM Convention.

3.10 NIGERIA

The national economic assessment of Nigeria is from 2011. Introduction of IAS from other ecosystems into Nigerian waters through the discharge of ballast water has been known to damage the stock of commercial fisheries and to affect some industrial activities. One example is the introduction of the European zebra mussels *(Dreissena polymorhpa)*, which clog the water systems of cities, factories, and power plants. They also foul the hull of ships and boats, and maritime offshore structures such as oil rigs, and cause the sinking of navigation buoys. The North Pacific seastar *(Asterias amurensis)* also has been introduced into Nigeria's fishing fields around the Niger Delta via ballast water and has decimated the shellfish population (Peters, 2011).

The Nigerian report assesses economic values of resources at risk from IAS impacts, potential costs from IAS introduction and contains an estimate of the BWM Convention implementation costs. The assessment applies elements of the TEV-framework, as well as the market price analysis and travel cost methods. The report contains some values for key sectors such as fisheries, aquaculture and coastal tourism. It further provides estimates of possible economic losses to these sectors plus public health. In addition to the data provided in the national report, the Central Bank of Nigeria reported that the contribution of Nigeria's fisheries sector to the country's GDP in 2011[27] was 0.4%, i.e. approximately US$1.7 billion.[28] The economic value of coastal tourism in 2011 was estimated at approximately US$0.638 billion.[29]

The calculation of the BWM Convention implementation costs is also guided by Monograph No. 19 and were estimated at US$235 million.

The assessment arrives at the conclusion that economic losses arising from a potential IAS introduction, clearly outweigh the costs of implementing the BWM Convention. If economic impacts to non-use values were also to be assessed, the potential cost caused by IAS would be higher. The report thus concludes that BWM measures are feasible and support the national decision on the ratification of the BWM Convention.

BOX 13: THE TRIUMPHAL MARCH OF THE NORTHERN PACIFIC SEASTAR

Asterias amurensis, also known as the Northern Pacific seastar and Japanese common starfish, is native to the coasts of northern China, Korea, Russia and Japan. This species has been introduced to the oceanic areas of Tasmania, southern Australia, Alaska, the Aleutian Islands, parts of Europe, and Maine (Shah et al., 2013). Based on the distribution of northern Pacific seastar populations in shipping ports and routes, the most likely mechanism of introduction is the transport of free-swimming larvae in ships' ballast water. Experimental evidence has concluded that the predatory star has a major impact on juvenile bivalves. It will also attach itself to salmon traps, oyster lines and scallop longlines (Chantal, 2013).

Picture 12: North Pacific seastar (Source: *Wikicommons*)

27 Nigeria's GDP in 2011 was US$411.744 billion; see UNCTADstat database at: http://unctadstat.unctad.org/wds/TableViewer/tableView.aspx, accessed February 2017.

28 Central Bank of Nigeria, Statistics database at: http://statistics.cbn.gov.ng/cbn-onlinestats/QueryResultWizard.aspx, accessed February 2017.

29 Since no data for coastal tourism could be found, it was estimated to be approximately 10% of the overall value for travel and tourism; see Travel and Tourism. Economic Impact 2016 Nigeria. WTTC at: https://www.wttc.org/-/media/files/reports/economic-impact-research/countries-2016/nigeria2016.pdf, accessed February 2017.

3.11 PANAMA

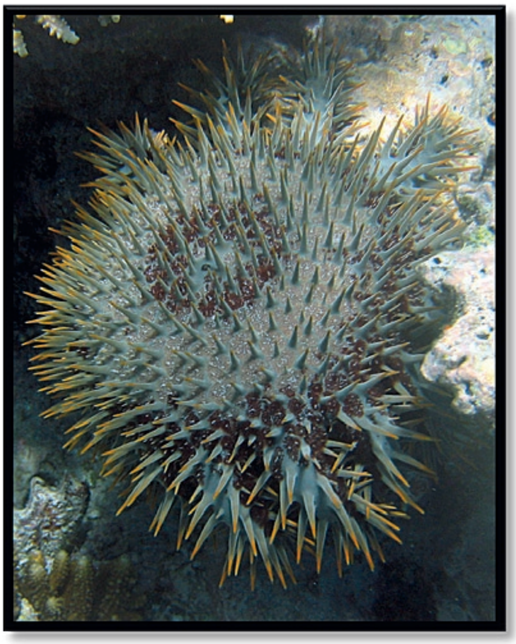
Panama finalized its NEA in 2016. The country's vulnerability to IAS and responsibility in respect of BWM is considered very high, due to several reasons: Panama's coastline is almost 3,000 km long, of which 1,700 km are on the Pacific, and 1,300 km on the Caribbean sides. Additionally, it has the world's largest maritime fleet, and maritime traffic is particularly high due to the Panama Canal.

At the time of publication, there were no baseline studies on native or invasive species in Panama. However, individual case studies do exist and confirm the presence of species introduced through ballast water. The largest economic impact due to IAS happened in 1999, when shrimp farming was affected by the white spot syndrome virus.

BOX 14: IAS IN PANAMA

An impact assessment of 2 Pacific species on Caribbean species has been carried out in Panama: the yellow-bellied sea snake *(Pelamis platarus)* and the crown-of-thorns starfish (*Acanthastar planci)*. While these two species have still not been introduced into the Caribbean Sea, the studies demonstrated the likely effects that an introduction would have. Unlike snappers of the Pacific that share a habitat with the yellow-bellied sea snake, the snappers of the Caribbean as common predators would not recognize the yellow-bellied sea snake as a threat and thus can suffer from its mortal bites. Likewise, an introduction of the crown-of-thorns starfish would have negative effects on the corals of the Caribbean, which do not have a natural defence against this starfish, as the corals of the Pacific do.

Overall, the migration of species from the Caribbean to the Pacific seems to be higher than vice versa, including 8 fish species, 5 bivalves, and 1 ectoproct. Among the species that were introduced through ballast water and through ship's hull fouling are 5 hydrozoan species that have crossed from the Pacific to the Caribbean Sea. However, it is not confirmed that any of these species are reproducing in their new habitat (source: http://www.mma.gov.br/aguadelastro).



Picture 13: Crown of thorns starfish (Source: *Wikicommons*)

Regarding the general approach, the report follows the methodology of GloBallast Monograph No. 19 and provides: (a) economic values of resources at risk from IAS introduction based on the Total Economic Value (TEV) methodology; and (b) an estimate of the BWM Convention enactment costs (no information on the methodology is given).

The TEV of the resources at risk is estimated to be US$5.1 billion. The total costs for enacting the BWM Convention are estimated at around US$55.8 million.

Referring to the comparison of the value of resources at risk on the one hand, and the costs for enacting the BWM Convention on the other, the report concludes that there is no doubt about whether to ratify the

Convention or not. In fact, Panama ratified the BWM Convention in 2016, and the report recommends to develop the National Implementation Plan in the near future.

BOX 15: AQUACULTURE IN PANAMA AND THE WHITE SPOT SYNDROME VIRUS

White spot syndrome virus is the lone virus (and type species) of the genus *Whispovirus* (white spot), which is the only genus in the family *Nimaviridae*. It is responsible for causing the White Spot Syndrome (WSS) in a wide range of crustacean hosts. WSS is a viral infection of penaeid shrimp. The disease is highly lethal and contagious, killing shrimps quickly. Outbreaks of this disease have wiped out within a few days the entire populations of many shrimp farms throughout the world. It was probably introduced from Asia to Panama and to date, it is one of the cases of IAS in Panama that are best studied.

Until 1998, shrimp farming in Panama had been growing by 25% annually, and the growth for the following year was expected to be 30%. However, in February 1999 the impact of the white spot syndrome drastically increased the mortality of shrimp after several weeks of breeding. Survival of shrimp was reduced to less than 15%, resulting in production decline. Since then, shrimp farming has been recovering, but it was not able to reach the levels of production of 1998. Thus, the WSS virus caused dramatic economic damages to the shrimp farming sector (a decline from GBP US$22 million in 1998 to US$5.6 million in 1999), in such a way that direct income of US$39 million was lost for producers in Panama. Production in Colombia has also been severely affected (source: National Economic Assessment for BWM in Panama).

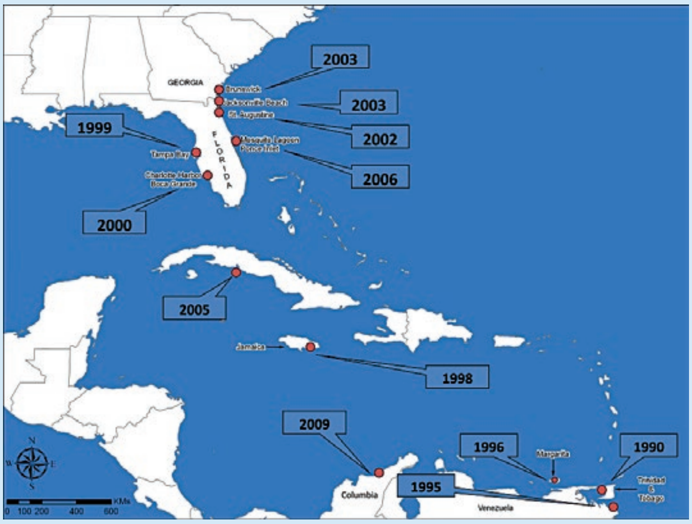
3.12 TRINIDAD AND TOBAGO

The national economic assessment for BWM of Trinidad and Tobago was completed in September 2013. Maritime shipping has been a growing sector in Trinidad and Tobago in the last years to accommodate the country's rapidly expanding energy sector (oil and gas export) and its position as a major hub to facilitate trade between the smaller islands and countries in mainland South America. Also the yachting industry experienced a significant growth over the last 30 years. Trinidad and Tobago has 8 major ports, 2 of which are among the most highly developed in the Caribbean – Point Lisas and Port of Spain.

The demonstration of scale of oil tanker traffic and the growing number of recreational vessels in the report is used by the authors to highlight the point that dealing with marine IAS should be an issue of high priority, since there will be direct impacts on the livelihoods and the GDP of the country. The possibility of IAS introduction is perceived as real and it is deemed critical to understand the severity of negative impacts that a worse-case scenario can have. For example, among documented threats the report mentions the green mussel *(Perna viridis)*, which has invaded the west coast of Trinidad and Tobago causing tremendous economic losses (albeit never quantified) to coastal industries due to clogged pipes, waterways, etc.

Picture 14: Coral reefs (Source: *GloBallast*).

BOX 16: THE GREEN MUSSEL *(PERNA VIRIDIS)* CASE STUDY



The native range of the green mussel *(Perna viridis)* is along the Indian coast and throughout the Indo-Pacific (Siddall, 1980). It was first noticed in 1990 at the Port of Point Lisas, Trinidad (Agard et al., 1992). The green mussel is considered a very successful invading species because of its rapid dispersal, recruitment, growth, its ability to detach and re-attach its byssus and to quickly migrate to vacant spaces thrown open by natural forces. One of the main reasons for the extraordinary invasive ability of the species is its tolerance to a wide range of environmental conditions (Nishida et al., 2003; Rajagopal et al., 2006). Since its introduction into Trinidad, the green mussel has spread throughout the Atlantic Ocean to Venezuela, Margarita Is., Jamaica, Cuba, and Florida and Georgia states in the US (Agard et al., 1992; Buddo et al., 2003; Power et al., 2004; Baker et al., 2007) and Columbia. All of them are trading partners with Trinidad and Tobago, which supports the assumption that vectors for introduction are ship hull fouling and ballast water (Agard et al., 1992). The picture on the left illustrates Introduction of *Perna viridis* into the Atlantic Ocean showing dates of first sightings.

Since its introduction, there has been no published information on its impact on natural ecosystems. Observations by researchers noted that in the early 1990s there were heavy infestations of the green mussels on mangrove prop roots and pier pilings in the intertidal zone, out-competing local intertidal organisms from settling. The biggest impact of the green mussel has been as a fouling organism of sea water cooling systems of industrial plants on the west coast of Trinidad. Although costs of potential IAS introduction could not be estimated at this point, the report mentions the example of extremely high financial losses incurred for a number of industrial plants in the Point Lisas Industrial Estate in 1990. The total cost of fouling organisms including the marine invasive *Perna viridis* was US$1.13 million per annum, while the historical average cost of the green mussel during its peak years of fouling in 1990-2003 was US$240,000 (Chase, 2012).

In Trinidad, the only management methods employed since the introduction of the green mussel have been those by the industrial firms whose water-cooling system has been affected. Originally these control methods were manual scrapings by divers. Later they evolved to the use of chemicals (biocides and chlorination). A more detailed investigation of the economics of the management methods for the control of *Perna viridis* as a fouling organism is currently being investigated.

The report contains quite a detailed qualitative description of key sectors and ecosystem services directly threatened by IAS, such as fisheries, coral reefs and mangrove forests and all associated ecotourism activities. With regard to coral reefs and associated ecosystem values, the report specifically mentions some quantitative values (refer to Box 17 below for more information).

In terms of methodology, market price analysis method was employed for valuing the resources potentially at risk from IAS introduction. The main reason for this choice was the lacking availability of data for other valuation types. The total value of the three key sectors represented in the report (marine fisheries, coral reefs and coastal tourism) is estimated at approximately US$28.4 million annually. Also approximate costs from a potential IAS introduction were calculated for the same three key sectors, comprising up to US$134.2 million per year.

The implementation costs of the BWM Convention were estimated at approximately US$2.9 million and include various important categories and subcategories based on GloBallast Monograph No. 19. Costs from flag State and industry obligations in the category of compliance-related costs could not be estimated at the time of report publication.

BOX 17: IMPORTANCE OF CORAL REEFS AND ASSOCIATED ECOSYSTEM VALUES TO TRINIDAD AND TOBAGO'S ECONOMY AND WELFARE

The island of Tobago has approximately 70% of its surrounding waters comprised of fringing and platform reefs. The amenity value of the Tobago coral reefs contributes significantly to the island's income. This was confirmed by the World Resources Institute (WRI) in an economic valuation report which estimated the value of coral reefs to Tobago's economy (in 2006) at a range between US$100 – 130 million. Based on the same report, coral reef fisheries and tourism are believed to have an annual value between US$830,000 and 1.37 million. Furthermore, the annual value of shoreline protection services provided by coral reefs is estimated to be between US$18 million and 33 million (for Tobago) (Burke et. al., WRI, 2008).

The main findings of the report suggest that it is financially sensible to implement the BWM national strategy and the BWM Convention given that the costs to do so are rather small (US$2.9 million) compared with the much greater anticipated losses to a valuable ecosystem (US$134.2 million per year), if the Convention was not implemented.

3.13 TURKEY

Turkey completed its national economic assessment for BWM in 2010. The report highlights major negative economic impacts of IAS, specifically mentioning the case of the Black Sea and its invasion by the North American comb jelly *(Mnemiopsis leidyi),* introduced in the early 1980s via ships' ballast water.

The assessment follows the GloBallast Monograph No. 19 in terms of approach and applied methodology. For quantitative estimates in the report, two basic economic assessment methods were used – market price analysis and travel cost methods.

The report contains some total value estimates of key economic sectors such as fisheries, aquaculture and coastal tourism. These have been calculated at US$1 billion,[30] US$323 million[31] and US$18 billion,[32] respectively. Total value estimates of shipping, coastal infrastructure and public health sectors were not available at the time of publishing the report. The assessment also estimated potential costs from IAS introduction for fisheries, aquaculture, coastal tourism and public health. These costs depict monetary losses if a worst-case scenario were to be triggered. Total potential costs from IAS introduction in Turkey are calculated at US$8.16 billion.

BOX 18:EFFECTS OF THE NORTH AMERICAN COMB JELLY *(MNEMIOPSIS LEIDYI)* INVASION ON BLACK SEA FISHERIES AND ECOSYSTEM

The comb jelly *(Mnemiopsis leidyi)* is endemic to estuaries along the North and South American Atlantic coast. The species was first recorded in the Black Sea in 1982 and became well established, occurring in massive numbers. *Mnemiopsis* competes for food with commercial fish species and has had a devastating impact on fisheries (Shiganova et al., 2004; Costello et al., 2012; GloBallast, 2014). The national economic assessment of Turkey concludes that assuming a cost of about US$1 per 1 kg of fish, the minimum economic loss for Turkey alone exceeds US$1 billion. The decrease in zooplankton caused by *Mnemiopsis* also had impacts on the food web, causing an increase in phytoplankton, and a decline in predatory fish species and seals. More recently, the accidental introduction into the Black Sea of another comb jelly *(Beroe ovata),* a predator of *Mnemiopsis*, has resulted in its major decline and some recovery of the Black Sea ecosystem

The report further contains a detailed calculation of BWM Convention implementation costs, guided by the categories presented in GloBallast Monograph No. 19. The total estimated costs of BWM Convention implementation amount to approximately US$822 million.

The report concludes that costs of implementing the Convention are definitely lower than economic effects of possible IAS introduction and that the results of the report support the national decision on the ratification of the BWM Convention.

30 Equals TRY (Turkish Lira) 1.6 billion, converted at currency rate from 30.06.2010.
31 Equals TRY (Turkish Lira) 512 million, converted at currency rate from 30.06.2010
32 Value is already provided in US$.

Picture 15: Comb Jelly (Author: By Steven G. Johnson, Own work, CC BY-SA 3.0, Source: *https://commons.wikimedia.org/w/index.php?curid=4573384*)

3.14 YEMEN

The NEA of Yemen was completed in November 2010. The report explains that, despite efforts developed by the government, there is still no database with information about the IAS and their spreading magnitude in Yemeni waters. Likewise, no adequate information on the type, numbers, status and structure of IAS (if present) is available in Yemen.

The estimate of the economic value of resources at risk and potential costs from IAS introduction were prepared using the formal (actual and estimated) available statistical data provided by competent authorities of Yemen (Statistical Yearbooks for 2008 and 2009, Fishery Statistics Reports, etc.). Estimates of implementation costs of the BWM Convention were based on values from similar training activities or work packages already conducted by the GloBallast Project in Yemen in the past. In terms of general approach, the report is based on the GloBallast Monograph No. 19. Of the basic economic assessment methods, presented in the Monograph, the report applied two – market price analysis method and travel cost method.

The NEA contains quantitative estimates of the value of fisheries, other harvested living resources and coastal tourism, and a qualitative description for other sectors (aquaculture, coral reefs, etc.). The potential costs from IAS introduction have been estimated by Yemen based on the conceptual framework of GloBallast Monograph No. 19, either in quantitative or qualitative terms or both. For example, regarding the worst-case scenario for coastal aquaculture, the report states that 80% can be lost if the ecosystem is changed at or near shrimp farms. The total BWM Convention implementation costs in Yemen are estimated at US$1.3 million. Table 5 below provides an example of cost calculation for conducting PBBS in Yemen. The calculation was prepared with taking into account it would be conducted in five high risk areas off the Yemeni coast and that the study would be conducted twice:

Table 5: Estimation of Port Biological Baseline Survey (PBBS) costs in Yemen

COST ITEMS	CALCULATION	TOTAL AMOUNTS (US$)
Accommodation	6x2days x 5 areas x US$100	6,000
Travel expenses	5,000 US$	5,000
Taxonomist	2 days x 5 areas x US$2,000	20,000
Divers	2 days x 2 divers x 5 areas x US$1,500	30,000
Diving equipment	US$5,000	5,000
Laboratory equipment	US$5,000	1,500
Total	**US$71,000 x 2**	**142,000**

The costs of the BWM Convention implementation of US$1.3 million are compared with a total of US$655.2 million (worst-case scenario) for the impact cost of a potential IAS introduction in Yemen. The report arrives at the conclusion that the anticipated benefits of implementing the BWM Convention would significantly outweigh potential costs from IAS introduction. This evidence would become even stronger if also non-marketed ecosystem services, non-marketable environmental and cultural values and mitigative measures were expressed in monetary terms. The national economic assessment therefore concludes that BWM measures under the BWM Convention are feasible to implement.

4

Comparative analysis of the national economic assessments

4.1 COMPILATION OF NATIONAL ECONOMIC ASSESSMENT OUTCOMES

The key outcomes of all the national economic assessments are compiled in two tables. Table 6 below contains a synthesis of the main findings reached by each economic assessment, expressed in qualitative terms.

Table 6: Main conclusions extracted from national economic assessments per country

COUNTRIES	MAIN CONCLUSIONS REACHED BY THE NATIONAL ECONOMIC ASSESSMENT
Argentina	Importance of ratifying the BWM Convention, despite the lack of exact figures and difficulty to put a value on technologies that were still in development at the time the report was drafted. The value of the resources at risk and the disruption to infrastructure, make it not a cost but an investment.
Bahamas	Based on the compiled values, it is clear that the economic value of resources at risk from IAS introduction by far exceed the costs of implementing the BWM Convention. It is therefore in the best interest of the Bahamas to strongly consider implementing the BWM Convention and funding the development of an effective BWM National Strategy.
Chile	Even if ecosystem goods and services are only affected by IAS to a low degree, the economic loss would still outweigh the costs of implementing the BWM Convention. Therefore, the economic assessment recommends ratification and implementation of the BWM Convention by Chile as an important mechanism to control the introduction of IAS.
Colombia	The economic, social and cultural impacts of IAS would negatively affect the sustainable development of the country. The report therefore recommends the ratification of the BWM Convention.
Croatia	Overall costs of the implementing of BWM Convention in Croatia are significantly smaller than negative economic impacts due to a potential introduction of IAS.
Egypt	Costs of enacting the BWM Convention are definitely lower than the costs incurred through possible damage from IAS introduction. The factual values of resources at risk and associated potential costs are likely to be significantly higher, as only the economic loss from IAS introduction was calculated in this national economic assessment. Inclusion of further factors will lead to a proportional decrease of the BWM Convention enactment costs in relation to the costs of IAS introduction. Hence it is feasible to implement BWM activities.
Ghana	BWM Convention enactment costs are definitely smaller than potential costs of an IAS introduction. Also, economic impacts on cultural and social values as well as costs of IAS removal must be considered, which could not be assessed due to methodological difficulties at the time the national report was drafted. Based on this, the national assessment concludes that BWM activities are economically feasible compared to the high costs that the country may incur if it does not put in place the necessary mechanisms to halt further spread of the marine IAS.
Jamaica	Although ballast water is not the only cause of IAS introduction, it is the main cause. It is expected that preventing IAS introduction by managing ballast water release in Jamaica will result in significant reduction in invasion by marine NIS. In order to effectively implement the BWM Convention, it is important to allocate sufficient financial resources and also ensure their long-term availability.

COUNTRIES	MAIN CONCLUSIONS REACHED BY THE NATIONAL ECONOMIC ASSESSMENT
Jordan	The operational costs of a BWM system are definitely lower than potential negative economic impacts of IAS. The difference between them will become even more pronounced if also non-marketed ecological services and non-marketable environmental values are included in the calculation of potential costs from IAS introduction. The national economic assessment therefore concludes that it is feasible to implement BWM activities.
Nigeria	The costs of implementing the BWM Convention and operating the BWM systems are definitely smaller than potential costs incurred as a result of an IAS introduction. Negative economic impacts on cultural and social values as well as costs of IAS removal were outside the scope of this report due to methodological difficulties. Their consideration will further increase the difference between these two cost items. Based on this, the report arrives at the conclusion that BWM activities are economically feasible and that the results of the study support the national decision on ratification of the BWM Convention.
Panama	Referring to the comparison of the value of resources at risk on the one hand, and the costs for implementing the BWM Convention on the other, the report concludes that there is no doubt about whether to ratify the Convention or not. In fact, Panama ratified the BWM Convention recently and the report recommends to develop the National Implementation Plan in the near future.
Trinidad and Tobago	The possibility of invasion by NIS is quite realistic, given that Trinidad and Tobago is a large maritime industry and also a trans-shipment hub in the Caribbean. It is thus critically important to understand the severity of negative impacts that a worse-case scenario can have. It is financially sensible to enact the BWM Strategy, as costs to do so are small compared with the much greater anticipated losses to a valuable ecosystem, if the Convention is not implemented. Furthermore, the implementation of the BWM Strategy will result in much reduced losses to both the overall economy and ecosystems of Trinidad and Tobago and hence sustain the very resources on which the country depends.
Turkey	Costs of BWM Convention implementation in Turkey are significantly lower than anticipated negative economic impacts from IAS introduction. Consideration of further factors, such as negative economic effects on cultural values and costs of possible mitigation measures, would lead to an even bigger difference between Convention costs and IAS costs. BWM activities are feasible to implement and the results of the report support the national decision on the ratification of the BWM Convention.
Yemen	Anticipated benefits of BWM Convention implementation significantly outweigh potential costs from IAS introduction. This evidence would become even stronger if also non-marketed ecological services, non-marketable environmental and cultural values and mitigative measures in case of an occurred IAS introduction were expressed in monetary terms. The national economic assessment thus concludes that BWM activities under the BWM Convention are feasible to implement.

More detailed information is included in the table in Annex I, which contains the main quantitative outcomes from the NEAS of the 14 LPCs, based on the top-level categories and subcategories outlined by the GloBallast Monograph No. 19. The figures included in this table principally reflect the figures as provided by the countries in their NEAs. In cases where values have been calculated at a later stage from using updated sources, this has been explicitly indicated in a footnote. This approach allowed displaying the outcomes and conclusions of the countries in a representative way, without making assumptions beyond the information provided in the reports. The information in Table 6 and Annex I, together with national report summaries in chapter 3 above, form the basis for comparison and analysis of the outcomes of the NEAs.

4.2 COMPARISON OF NATIONAL ECONOMIC ASSESSMENTS: VALUES OF RESOURCES AT RISK AND POTENTIAL COSTS FROM IAS INTRODUCTION

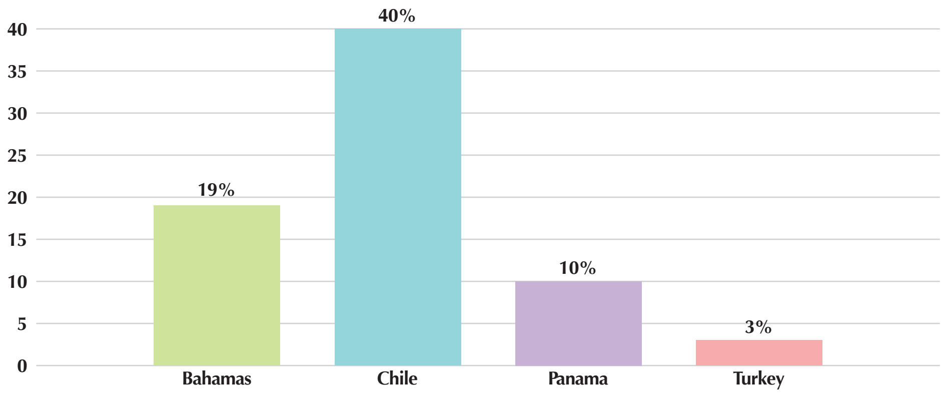
All 14 LPCs that prepared NEAs followed the recommendations in GloBallast Monograph No. 19. This permitted the use of a unified terminology, categories and subcategories, as proposed by the Monograph. However, due to methodological difficulties such as lack of available statistical data and limited research results, it was not possible to estimate all values in some cases. More specifically, of the analytical techniques for valuating ecosystem goods and services presented in Monograph 19, the countries predominantly applied two methods for their estimates: the market price analysis and the travel cost methods (see Box 4 in chapter 2).

4.2.1 OUTCOMES REGARDING VALUES OF RESOURCES AT RISK FROM IAS INTRODUCTION

The information on total economic values of resources at risk from IAS introduction provided by the LPCs is limited. The main reasons can be found in the different methodologies that were used to calculate the values and the lack of underlying research data in some countries. Overall, there is a clear distribution of analysed LPCs into countries with a high percentage share in tourism and fisheries, and countries with a high percentage share in indirect use values. However, such distribution is also likely to be due to methodological reasons and limited availability of data.

To enable comparison between countries according to their economic activity, their GDP was chosen as a reference value (refer to Annex II). Figure 2 below shows how TEVs of resources at risk relate to the overall GDP in each country.

Figure 2: GDP share of TEV of resources at risk from IAS introduction (Bahamas, Chile, Panama and Turkey)

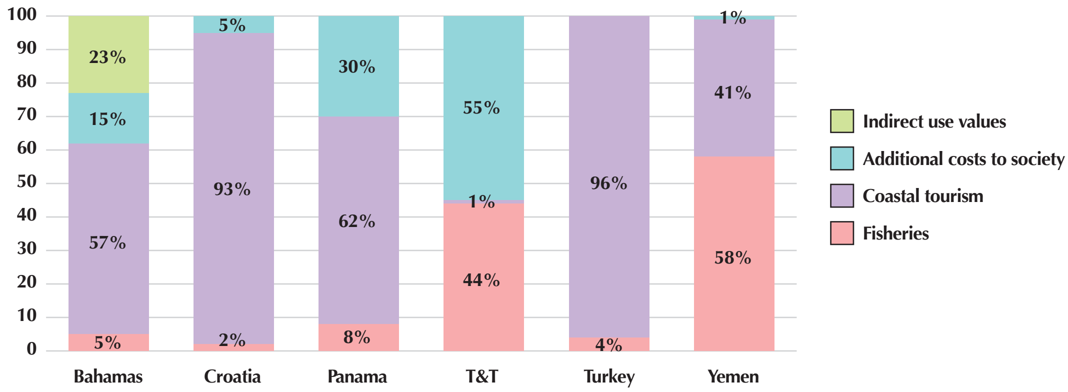


	BAHAMAS	CHILE	PANAMA	TURKEY
TEV of resources at risk (in US$ million 2016)	1,616	94,886	5,137	20,626
GDP 2015 (in US$ million)	8,522	239,727	52,072	719,217
Percentage	19%	40%	10%	3%

According to these estimates, TEVs of resources at risk from IAS introduction for the Bahamas, Chile and Panama constitute 19%, 40% and 10% of their respective GDPs, while the impact on the GDP of Turkey is much smaller at 3%. Possible reasons for such significant differences could be that the countries sometimes provided information on different subcategories and the difficulty to estimate economic values of some resources due to lack of reliable statistical data and national case studies. Other reasons could also be the volume of their GDP or the varying dependence in the four countries on the key sectors conceptualized in the framework of GloBallast Monograph No. 19. In the case of the four countries shown in Figure 2, the difference may be explained by the fact that Bahamas, Chile and Panama did take into consideration an estimation of indirect use and/or non-use values. However, the fact that the TEV was provided only by a few countries and the methodological bias described above make it impossible to make a reliable statement. In any case, Bahamas, Chile and Panama are good examples of countries where the TEV of resources at risk from IAS introduction constitutes a significant proportion of the overall GDP.

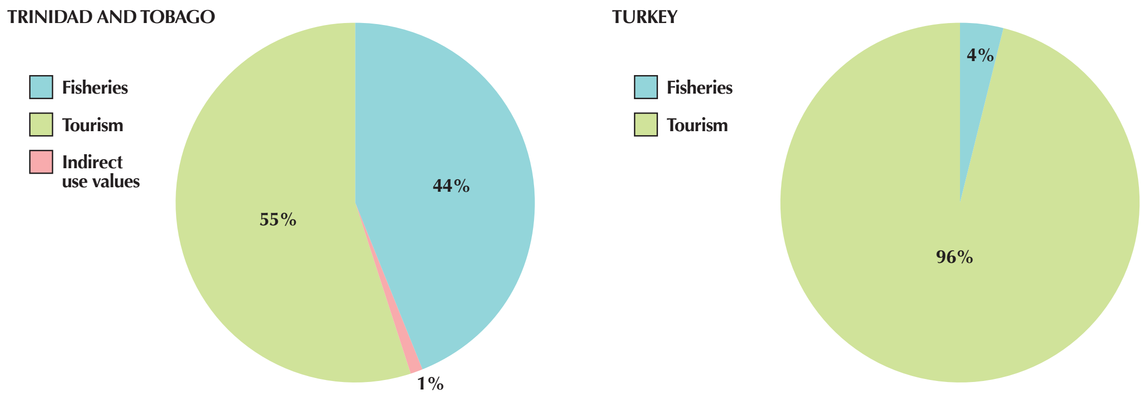
The fact that the TEV of resources at risk has been only provided by a few countries may seem to limit the comparability of the outcomes. However, several other countries included estimates for individual subcategories, with the following conclusions: most quantitative figures are available for direct use values, which include key sectors such as fisheries, aquaculture and coastal tourism. Other subcategories are either more rarely calculated (e.g. indirect use values) or no estimates could be made (e.g. for non-use values, only the Bahamas provided an estimation). Figure 3 shows these subcategories in a diagram for selected countries and gives a first impression regarding their relative importance in those countries.

Figure 3: Share of resources at risk as provided by individual countries



Regarding the shares of individual sectors in the TEV of resources at risk, three main groups of countries can be distinguished. In the first group of countries, coastal tourism is the sector with highest economic value. Examples of such are Croatia and Turkey with a share of over 90%, but also Panama (62%), Bahamas (57%) and Yemen (41%). In the second group of countries, the fisheries sector seems to play a very important economic role (e.g. it accounts for 58% of the known TEV for Yemen and 44% for Trinidad and Tobago).

Figure 4: Distribution of values of resources at risk for individual sectors in two LPCs

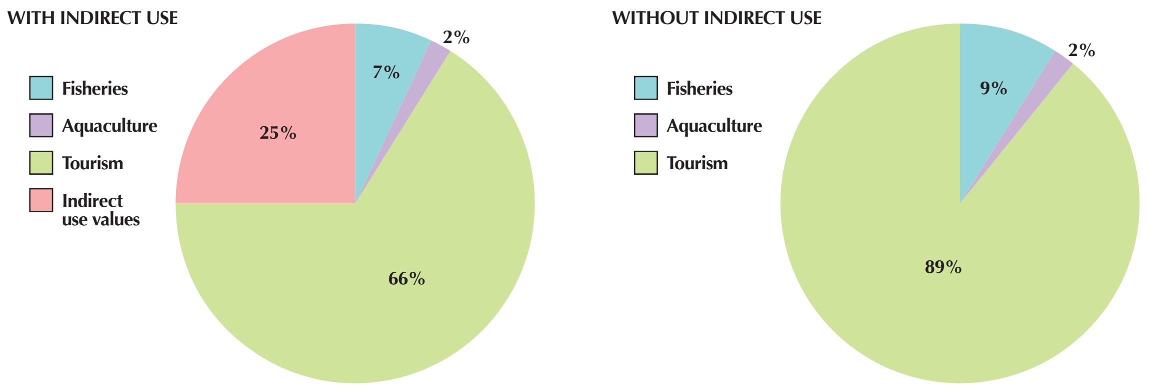


Trinidad and Tobago also belongs to a third group of countries, with high shares of estimated indirect use values (together with Chile, Panama and the Bahamas). Indirect use values provided by countries in their NEAs are mostly partial values either for some regions of the country or limited to specific ecosystems such as coral reefs and protected areas. They were taken from research and case studies that were already available for the country. For example, in the Bahamas, the number of US$347 million in indirect use values was derived from at least three case studies of ecosystem services, conducted between 2010 and 2013 (Hargreaves-Allen, 2011 and 2010; Clavelle and Jylkka, 2013). While the NEA of the Bahamas points out that these studies have focused on specific ecosystem services on some islands and that there is currently no valuation of ecosystem services available at a national scale, they still provide an indication of the high economic value associated with ecosystem services. For Trinidad and Tobago, the annual value of shoreline protection services provided by coral reefs was estimated at US$18-33 million. This estimate is based on an economic valuation report prepared by the World Resources Institute (WRI) in 2008, and therefore it is also incomplete, i.e. it is only for the island of Tobago, but it is used as an indicator to give an idea of the economic importance of investing in coral reef protection.

The Bahamas, Chile, Panama and Trinidad and Tobago are the only four countries which have estimated indirect use values. In other words, countries with a high percentage share of tourism and fisheries did not calculate indirect use values. If estimated, indirect use values are likely to be considerable also in those countries, therefore changing the proportional relation between the individual sectors. As an example,

Figure 5 shows the proportional distribution of economic values of resources at risk in Panama, including and excluding indirect use values. By doing so, it illustrates the potential influence of indirect use values.

Figure 5: Distribution of resource values at risk for individual sectors in Panama (with and without indirect use values)



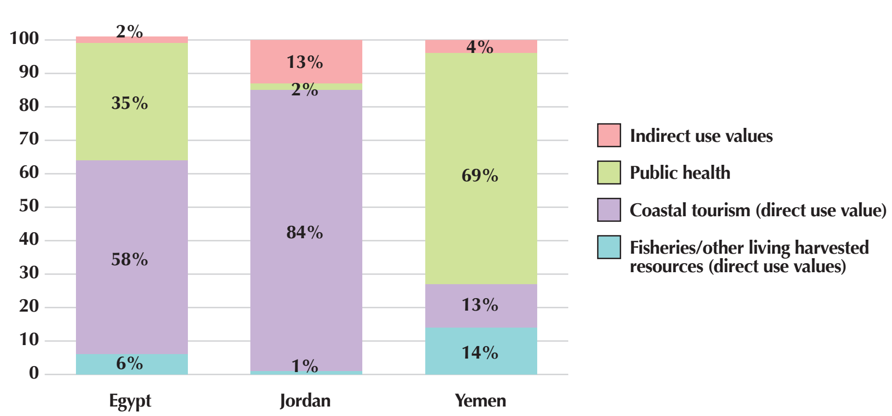
With regards to non-use values, the only country that provided this calculation was the Bahamas, which presented an estimate of US$31 million in existence, altruistic and bequest values, based on a 2010 case study. This case study, conducted with visitors to New Providence, Grand Bahama and Abaco, found out that 95% of respondents were open to paying a minimum of US$5 to protect the natural and cultural environment of the country. The NEA extrapolated this study by multiplying US$5 by the total number of visitors to the Bahamas annually (which were approximately 6.3 million visitors in 1998-2014) and obtained an estimate of US$31million for existence, altruistic and bequest values. According to this calculation, non-use values contribute a 2% share to the overall TEV of resources at risk from IAS introduction in the Bahamas.

4.2.2 OUTCOMES REGARDING POTENTIAL COSTS FROM IAS INTRODUCTION

Seven of the participating LPCs estimated total potential costs from IAS introduction.[33] After breaking down these figures into individual subcategories, it can be concluded that the highest anticipated damages are expected to occur either in the coastal tourism sector (see e.g. Jordan), public health sector (see e.g. Yemen) or both (see e.g. Egypt).

Overall, there are considerable country-based differences in the share of damages inflicted through IAS introduction to key sectors and the ecosystems' ability to provide indirect uses. The reasons for these discrepancies could be methodological difficulties of estimating potential economic impacts on indirect uses provided by coastal ecosystems and lack of research available in this field, particularly at a national scale.

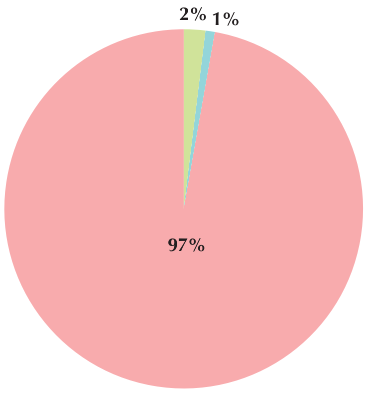
Figure 6: Distribution of potential costs from IAS introduction in Egypt, Jordan and Yemen



33 Croatia did not indicate a total sum, however based on individual values it is possible to estimate an approximate total economic impact from IAS introduction.

Section 4.2.1 above demonstrates, based on the example of Trinidad and Tobago, the significance of indirect use values in the TEV of resources at risk from IAS introduction. Their proportional share in the TEV was estimated to be about 43%. Also the damage to indirect use values can be considerable. For example, in the case of Trinidad and Tobago, the estimated economic loss to the indirect use value is higher than the indirect use value itself. Available qualitative information on the economic importance of indirect uses supported by ecosystems and the considerable damage that can occur to these ecosystems through IAS introduction further supports this statement.

Figure 7: Indirect use values and potential costs from IAS introduction in Trinidad and Tobago



Estimated indirect use value of resources at risk from IAS introduction	Between US$18-33 million annually
Estimated economic damage to indirect use values from IAS introduction	US$133 million annually

The total estimated potential costs of IAS introduction provided in the national assessments range from a rather "small" figure of about US$38.8 million for the estimated impact of lionfish in Jamaica to much higher values, such as US$2.78 billion in Egypt and US$8.97 billion in Turkey. Furthermore, some other countries that were not able to provide any quantitative estimates of potential costs from IAS introduction, nevertheless have evaluated the likely economic damage from IAS introduction as highly significant.

The analysis of NEAs allows the conclusion that coastal tourism, fisheries and diverse indirect uses provided by coastal ecosystems are strategically important resources of a considerable economic value for the LPCs. Potential IAS introduction poses serious threats to these resources. Their protection from such threats is essential both for the economic development of the countries as well as to preserve their environment for future generations. This can be illustrated by comparing estimated economic values of the fisheries and tourism sectors with the estimated costs from an IAS introduction.

Table 7: Fisheries and coastal tourism: estimated economic value and damage from IAS introduction

COUNTRIES	ECONOMIC VALUE OF FISHERIES	COSTS TO FISHERIES FROM IAS INTRODUCTION	ECONOMIC VALUE OF COASTAL TOURISM	COSTS TO COASTAL TOURISM FROM IAS INTRODUCTION
Croatia	214,240	113,300	9,270,000	2,781,000
Turkey	548,358	1,100,000	19,800,000	5,940,000
Yemen	677,395	102,190	478,780	95,700

The numbers in Table 7 above show that there are significant differences in the proportional value-to-damage relation within country and sector. Nevertheless, in all three cases the costs incurred from IAS introduction are likely to pose a significant burden on the fisheries and tourism sectors in all countries.

4.3 COMPARISON OF OUTCOMES ON BWM CONVENTION IMPLEMENTATION COSTS

All 14 NEAs have estimated costs of implementing the BWM Convention. In comparison to economic values of resources at risk and potential costs from IAS introduction, more subcategories were assessed, most likely for methodological reasons, as at least part of the cost items relevant for the implementation of the BWM Convention, such as capacity building and legislative reform costs, are easier to calculate (with the current state of knowledge) than e.g. potential damages to coastal ecosystems.

It can be further observed that the percentual distribution of costs from different implementation phases (i.e. preparatory phase costs, compliance-related costs, etc.) varies considerably from one country to another. These differences in distribution can be partially explained by methodological differences between countries. For example, some countries did not calculate costs for the installation of ballast water treatment systems on board of ships (refer to section 4.2.3.4 of GloBallast Monograph No. 19), which has resulted in a relatively low percentual share of costs from industry obligations in these countries. At the same time, countries that estimated costs for ballast water treatment systems, indicated them to be quite high. This in turn changed the proportional cost distribution in favour of increased industry obligations. However, it must be stated that all estimations for ballast water treatment systems chose to use the middle path from the range presented in GloBallast Monograph No. 19 (US$100 thousand to US$1 million per vessel). Therefore, the estimations are only a guidance and real prices for ballast water treatment systems should be determined based on recent information provided by manufacturers of treatment systems.

As already described in chapter 2, the implementation of the BWM Convention at a national scale includes, broadly speaking, two phases: the preparatory phase and the compliance phase. In the next two sections, some of the costs incurred by countries when implementing the BWM Convention were compared to each other using the most comprehensive and comparable datasets.

4.3.1 PREPARATORY PHASE COSTS

13 LPCs provided values for the subcategory of capacity building costs (see Table 8 below). When comparing the figures provided by different countries with each other, Ghana and Nigeria stand out with particularly high values. This can be attributed to the fact that in their estimates these two countries decided to invest more resources in capacity building than the others, i.e. by conducting more trainings for a higher number of participants.

Table 8: Capacity building costs per country

COUNTRY	CAPACITY BUILDING COSTS (IN US$, 2016)
Bahamas	20,000
Chile	447,615
Colombia	128,400
Croatia	33,372
Egypt	77,671
Ghana	1,005,995
Jamaica	25,000
Jordan	72,257
Nigeria	1,011,627
Panama	28,000
Trinidad &Tobago	145,356
Turkey	148,583
Yemen	80,685

Table 9 below presents a comparison of Legislative, Policy and Institutional Reform (LPIR) costs, which may arise from the development of a national ballast water status assessment or a national BWM strategy. These are also considered as preparatory phase costs. There are no significant differences between countries in this category.

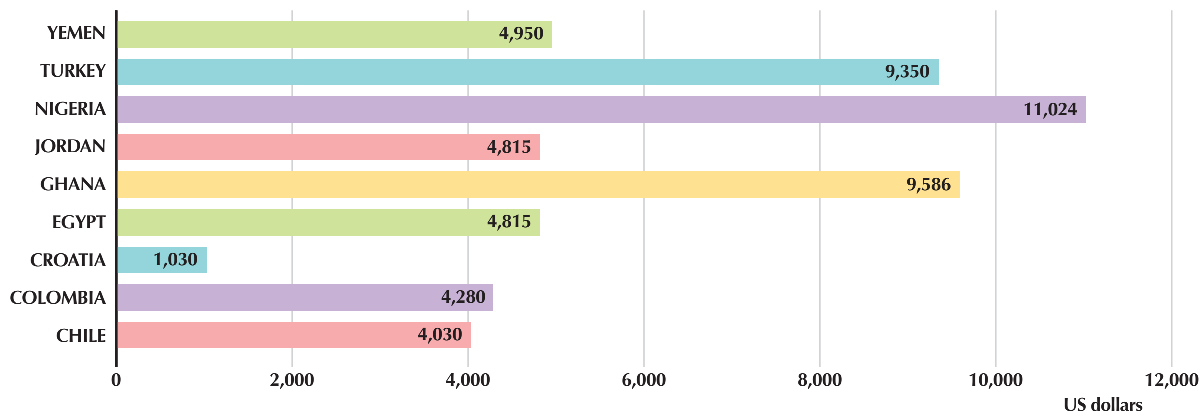
Table 9: Legislative, policy and institutional reform (LPIR) costs per country

COUNTRY	LPIR COSTS (IN US$, 2016)
Bahamas	21,000
Chile	172,767
Colombia	109,140
Croatia	43,878
Egypt	72,439
Ghana	261,113
Jamaica	20,000
Jordan	61,958
Nigeria	219,349
Panama	67,000
Trinidad &Tobago	57,556
Turkey	176,825
Yemen	72,820

4.3.2 COMPLIANCE-RELATED COSTS

Activities that need to be carried out by the countries in their capacity of flag States include, among others: approval of ships' BWM Plans by competent maritime administrations, approval of exemption applications, type approval of ballast water treatment facilities, regular surveys of BWM systems on ships (initial, renewal, intermediate, annual), etc. Figure 8 below compares the estimated costs per ship for conducting surveys of BWM systems in some LPCs. The values were calculated based on the number of registered ships indicated by each country in their national economic assessments (refer to Annex III) and show no significant differences beyond a slightly higher cost estimated by Turkey, Nigeria and Ghana.

Figure 8: Costs for conducting flag Sate surveys per ship (in US$, 2016)



Obligations of port States under the BWM Convention include Compliance Monitoring and Enforcement (CME), inspection of ships, sampling to ensure compliance with either D-1 or D-2 standards, etc. (refer to sections 4.2.2.1 – 4.2.2.7 of GloBallast Monograph No. 19). Table 10 compares the costs incurred by different port States when conducting their CME obligations in relation to their Container port throughput (Twenty foot equivalent unit – TEU) and determines costs per unit in US$. This way, the CME costs from different countries become comparable. Container port throughput (CPT) was selected as reference value, as no better suited data was available illustrating the relative importance of individual port States on a global scale. It must be indicated that the higher costs for Nigeria, Chile and Ghana were based on the assumption that inspections would be conducted on a very high number of ships (22,000, 1,050 and 2,760 per year, respectively).

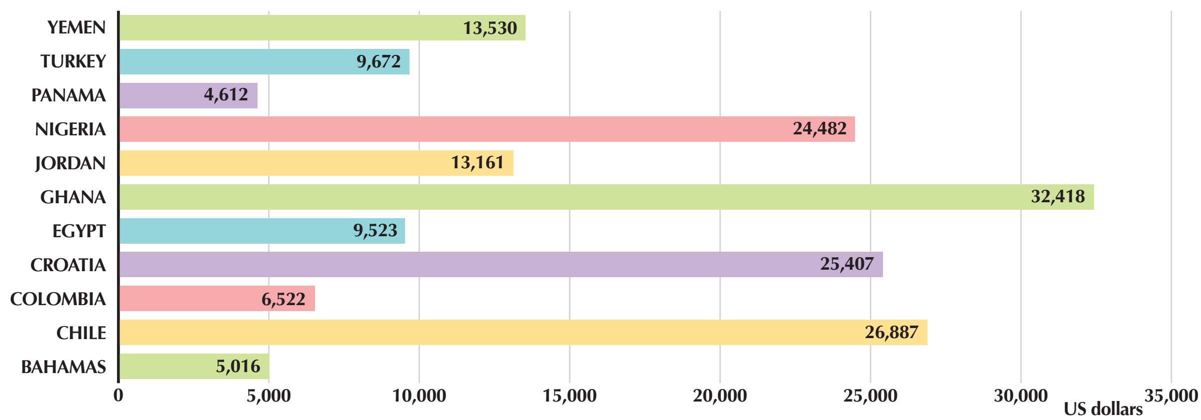
Table 10: CME costs per country in relation to Container port throughput/TEU

COUNTRY	CME COSTS (IN US$, 2016)	CONTAINER PORT THROUGHPUT/TWENTY FOOT EQUIVALENT UNIT (TEU), 2014[34]	COSTS PER UNIT IN US$
Argentina	727,519	1,775,574	0.4
Bahamas	157,000	1,399,300	0.11
Chile	2,079,945	3,742,520	0.55
Croatia	425,287	176,596	2.4
Egypt	200,625	8,810,990	0.22
Ghana	611,594	833,771	0.73
Jordan	118,505	797,624	0.14
Nigeria	3,392,154	1,062,389	3.19
Panama	450,900	7,942,291	0.05
Trinidad &Tobago	89,734	738,630	0.12
Turkey	638,550	7,622,559	0.08
Yemen	106,590	862,079	0.12

As mentioned in Monograph No. 19, successful implementation of the BWM Convention requires input from all stakeholders, including the shipping industry itself. Costs incurred by the industry in the process of implementation covers the following aspects: training of crew members, development of ships' BWM plans, ballast water exchange and installation of ballast water treatment systems.

Figure 9 compares costs for the industry per ship for different countries, excluding ballast water treatment systems. For this purpose, available costs from industry obligations were compiled and divided by the total number of ships as indicated in each NEA. The main reason for the exclusion of ballast water treatment systems is that the market is still at an early stage of development and no reliable information on actual cost of systems was available at the time when national reports were drafted – mostly due to confidentiality issue on the systems costs by most technology providers. However, it is generally acknowledged that ballast water treatment systems will be a significant cost item in the overall implementation of the BWM Convention. For example, according to GloBallast Monograph No. 19, the cost of treatment systems may range from US$100,000 to US$1 million per ship, depending on ship type and size. For this reason, the cost for purchasing and installing a ballast water treatment system should be taken into account when conducting future calculations.

Figure 9: Industry costs (excluding ballast water treatment systems) per ship (in US$, 2016)

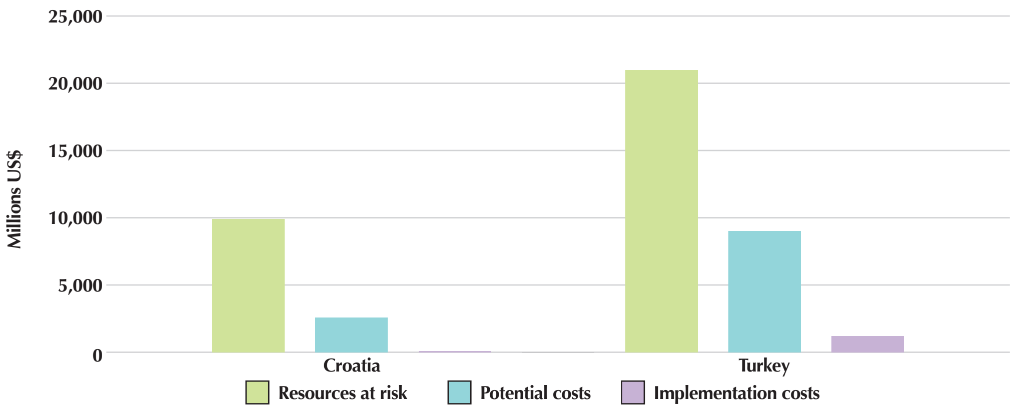


34 2014 is used as reference year, as it is the most recent year with information available both on CPT per country and worldwide; compare http://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=13321, accessed January 2017.

It can be concluded that most LPCs indicated preparatory phase costs as the category with lowest costs. They also represent but a small fraction of their countries' respective GDP. Compliance costs arising from flag and port State obligations are higher than preparatory phase costs in the majority of the analysed LPCs. A look at the respective cost subcategories in the table in Annex I (flag State vs. port State obligations) further shows the differences between countries. Thus, some countries expect their port State-related compliance costs to be higher than the flag State-related compliance costs and vice versa. These country-based variations depend on factors such as number of ports, ship calls and registered ships. In addition, the methodological specifics applied by each country while preparing their NEAs are also of significance.

Finally, TEV of resources at risk and potential costs from IAS introduction (as available) were compared with total BWM Convention implementation costs on country basis. Figure 10 below presents these costs for two LPCs that have conducted estimates on most cost items in these categories.

Figure 10: Comparison of TEV of resources at risk and/or potential costs from IAS introduction vs. BWM Convention implementation costs for Croatia and Turkey (in US$, 2016)



The above comparison clearly shows (a) that the TEV of resources at risk and potential costs from IAS introduction are indeed considerable and (b) that BWM Convention implementation costs (which in this case even include the cost for technologies on board ships as estimated in the national reports) are in all cases significantly lower than costs from IAS introduction. This evidence is further supported by quantitative and qualitative information provided by the other 12 LPCs.

5

Conclusions and the way forward

The comparative analysis of the NEAs demonstrates that most participating LPCs focused on calculating the expected implementation costs of the BWM Convention. However, the economic value of resources at risk and potential costs from IAS introduction were also estimated by a number of countries, albeit with some limitations. The underlying reasons are manifold and include the complexity of methodologies for conducting such economic assessments and the lack of available research and information on these topics.

Most countries have provided figures for direct use values such as fisheries and coastal tourism. Some of them also estimated values for diverse indirect uses supported by coastal ecosystems. These sectors play a crucial role for the economies of the countries in question, their relative importance varying from country to country. The economic value and vulnerability to IAS introduction of resources at stake was often rated as high,[35] even where no quantitative calculations were done due to methodological limitations and lack of available research data.

About half of all analysed LPCs made some estimates regarding potential costs from IAS introduction. It can be concluded that the highest anticipated damages (in absolute numbers) are expected to occur either in coastal tourism, public health or in both sectors. The values provided by the LPCs also indicate that fisheries, aquaculture, coastal infrastructure and diverse environmental services of coastal ecosystems may suffer considerable economic losses in the event of an IAS introduction. Overall, all 14 countries concluded that the likely economic damages from IAS introduction would be significant. Coastal tourism, fisheries and diverse indirect uses provided by coastal ecosystems are strategically important resources of a considerable economic value for the LPCs. Their protection from such threats is essential both for the economic development of the countries as well as to preserve their environment for future generations.

As mentioned in chapter 4, seven of the participating LPCs estimated total potential costs from IAS introduction. The comparison of these costs to BWM Convention enactment costs shows that in all analysed cases, implementation costs are significantly smaller than expected economic damages in case of an IAS introduction. In reality, this ratio is likely to be even higher, considering current methodological limitations and knowledge gaps related with the comprehensive estimation of IAS costs. This conclusion is also supported by countries that were not able to assess potential IAS impacts in quantitative terms at the time the reports were prepared. They nevertheless rated anticipated negative economic impacts from an IAS introduction as high and expected losses to valuable ecosystems as significant. Most reports advocate ratification and implementation of the BWM Convention and associated measures.

Finally, the additional literature evaluated in chapter 1 strongly supports the assessment that the economic impacts from IAS tend to be very significant and that application of the preventive approach will be beneficial both in terms of cost and effectiveness.

The outcomes of NEAs also show that causes and consequences of an IAS introduction may be multidimensional and interconnected. Multiple links that may exist between IAS introduction on the one hand and the fisheries and marine tourism sectors on the other are a good example. For example, overfishing can reduce resilience of the marine ecosystem and make it more susceptible to invasion by NIS. This in turn can affect the tourism industry, further impairing local livelihoods, which can also be affected by damage to infrastructure. Such potential interconnectivity and cumulative impacts must be taken into account when developing a sustainable blue economy, working on the achievement of the SDGs[36] and considering cumulative impacts of human activities at sea.

35 Compare e.g. NEA for Turkey, p. 22; NEA for Croatia, p. 5; etc.
36 And in particular the Goal Targets 14.2 and 9.4, which contain links to the IAS issue.

The outcomes of the reports highlight that economic assessments are important yet challenging undertakings. Through them, the 14 LPCs have taken an important step towards a better understanding of values at stake and the risks of not taking preventive actions. They also obtained a clear picture of the costs that can be expected when implementing the BWM Convention, which can be of great help to national decision-makers in enhancing their planning to prevent and reduce the risks from IAS introduction.

However, knowledge gaps remain and further efforts are necessary to improve the quantification of the socio-economic impacts of IAS introduction on national, regional and global scales. In this regard, three aspects require particular attention and should be addressed with high priority: first, methodologies on economic assessment of potential losses from IAS introduction should be further developed and simplified. Second, more applied research/case studies should be conducted based on these methodologies, especially in currently underrepresented regions of the world (refer to chapter 1.3). Third, more emphasis should be put on addressing the difficulty of valuation of indirect and non-use values of resources at stake.

Systematically addressing these knowledge gaps can improve the understanding of economic benefits of prevention of IAS introduction both nationally and globally and has the potential of supporting decision-makers in establishing BWM measures and regulations. It is therefore important that economic assessments of potential IAS impacts and other BWM issues continue to be considered in future policy processes regarding promotion and implementation of BWM regulations. Notwithstanding currently existing data limitations and knowledge gaps, they present important elements in the decision-making process, while further efforts should focus on improving the methodologies for estimating economic impacts from IAS introduction and on conducting comprehensive case studies and assessments based on them.

The results reached by the reports can serve as an important basis for decision-making in this field when it comes to the development of national BWM strategies and ratification and implementation of the BWM Convention.

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Annex I. Compilation of national economic assessment outcomes[37] per country

(values converted to 000's US$ and updated to 2016)

Outcomes per country	Argentina	Bahamas	Chile	Colombia	Croatia	Egypt	Ghana	Jamaica	Jordan	Nigeria	Panama	Trinidad & Tobago	Turkey	Yemen
1. Value of resources at risk and potential costs from IAS introduction														
1.1 VALUE OF RESOURCES AT RISK (TOTAL SUM)	**N/A**	**1.613.720[a]**	**94.886.400**	**N/A**	**N/A[b]**	**N/A**	**N/A**	**9.888**	**N/A**	**N/A**	**1.628.370**	**N/A**	**N/A**	**N/A**
1.1.1 Direct use value/key sectors (SUBTOTAL SUM 1)	N/A	994,509[c]	5,996,340[d]	201,160[d]	9,485,476[d]	N/A	N/A	9,888 (An,)[e]	N/A	N/A	418,591[d]	28,685 - 29,241	20,626,346[d]	1,156,905[d]
Fisheries	1,207,500	79,191[f]	3,854,550[g]	128,400	214,240[d]	-	-	-	-	-	338,391	27,274+(854-1,411)[h]	548,358[i]	677,395[j] (An,)
Aquaculture	-	-	-	72,760	-	-	-	-	-	-	77,000	-	277,988[k]	-
Other living harvested resources	-	-	-	-	1,236	-	-	-	-	-	-	-	-	730 (An,)[l]
Coastal tourism	-	915,318[m]	2,141,790	-	9,270,000	-	-	-	-	-	3,200	556	19,800,000	478,780[d]
1.1.2 Add. costs society: *Shipping, infrastructure etc.* (SUBTOTAL SUM 2)	N/A	243,224[n]	N/A	N/A	479,980[d]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	16,985[d]
1.1.3 Public health: *Resource/seafood users etc.* (SUBTOTAL SUM 3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.1.4 Indirect Use values: *Shoreline protection etc.* (SUBTOTAL SUM 4)	N/A	347,000	88,890,060[d]	N/A	N/A	N/A[o]	N/A	N/A	N/A	N/A	1,209,779	18,540-33,990 (An,)	N/A	N/A
1.1.5 Non-use values: *Cultural/spiritual etc.* (SUBTOTAL SUM 5)	N/A	31,271[p]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

[37] The figures included in this table principally reflect the values as provided by the countries in their national economic assessments. In cases, where figures have been calculated by the authors of this publication based on numbers provided in national reports for individual subcategories, this is specifically indicated.

Outcomes per country	Argentina	Bahamas	Chile	Colombia	Croatia	Egypt	Ghana	Jamaica	Jordan	Nigeria	Panama	Trinidad & Tobago	Turkey	Yemen
1.2 POTENTIAL COSTS FROM IAS INTRODUCTION (TOTAL SUM)	**N/A**	**N/A**	**N/A**	**N/A**	**N/A[q]**	**2,788,420**	**N/A**	**38,828 (An,)[r]**	**126,795**	**N/A**	**N/A**	**138,236 (An,)**	**8,976,000**	**720,720**
1.2.1 Direct use value/key sectors (SUBTOTAL SUM 1)	N/A	N/A	N/A	N/A	2,913,458[d]	1,771,920[d]	N/A	N/A	108,605[d]	N/A	N/A	3,306 (An,)[s]	7,489,900[d]	198,550[d]
Fisheries	-	-	-	-	113,300	160,500	-	-	1,070	-	-	-	1,100,000	102,190
Aquaculture	-	-	-	-	18,540	-	-	-	-	-	-	-	449,900	-
Other living harvested resources	-	-	-	-	618	6,420	-	-	535	-	-	-		660
Coastal tourism	-	-	-	-	2,781,000	1,605,000	-	-	107,000	-	-	-	5,940,000	95,700
1.2.2 Add. costs society: *Shipping, infrastructure etc.* (SUBTOTAL SUM 2)	N/A	N/A	N/A	N/A	11,330[d]	N/A	N/A	N/A	N/A	N/A	N/A	1,030 (An,)	N/A	N/A
1.2.3 Public health: *Resource/seafood users etc.* (SUBTOTAL SUM 3)	N/A	N/A	N/A	N/A	6,695	963,000	-	N/A	2,140	-	N/A	N/A	1,540,000	495,000
1.2.4 Indirect Use values: *Shoreline protection etc.* (SUBTOTAL SUM 4)	N/A	N/A	N/A	N/A	N/A	53,500	N/A	N/A	16,050	N/A	N/A	133,900 (An,)	N/A	27,170
1.2.5 Non-use values: *Cultural/spiritual etc.* (SUBTOTAL SUM 5)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2. COSTS OF ENACTING THE BWM CONVENTION (TOTAL SUM)	**N/A**	**1,718[t]+ 110[u] + 4-2,983[v]**	**5,871,495**	**87,119**	**N/A[w]**	**4,882**	**196,190**	**278[x] + 149[y,z]**	**868**	**252,315**	**55,880**	**3,052+515 (add, cost)[aa]**	**904,135**	**1,444**
2.1 Preparatory phase costs (SUBTOTAL SUM 1)	39[d]	1,577[bb] + 20[cc]	1,471	4,656	362[d]	737[d]	1,594[d]	N/A	228[d]	1,411[d]	685	2,915[d]	682[d]	338[d]
2.2 Compliance-related costs (SUBTOTAL SUM 2)	717 (An,)[d] + 1,155[dd]	N/A	5,869,605[d]	81,125,260	66,860[d]	4,081[d]	194,827[d]	N/A	630[d]	253,176[d]	55,196[d]	127+515 (add, cost)[ee]	903,453[d]	1,007[d]
2.2.1 Costs from flag state obligations	-	44[ff, d]	1,365	1,755	552[d]	2,569	9,956[d]	-	218[d]	13,196[d]	1,645	-	43,615	585
2.2.2 Costs from port state obligations	-	81[gg, d]	7,875	29,703	568[d]	226	1,114[d]	-	131[d]	5,032[d]	15,950	127[d]	1,008	132
2.2.3 Costs from industry obligations	-	5-2,983[hh]	5,860,365	49,666	65,739[d]	1,286	183,756	-	280[d]	234,946[d]	37,600	-	858,830	288
2.3 Other costs from issues not covered by the Convention (SUBTOTAL SUM 3)	N/A	14[ii] + 89[jj]	420	1,337	226[d]	96	162[d]	N/A	9[d]	349[d]	N/A	9	4,065[d]	99

a Equals B$ (Bahamian Dollar) 1.625.500, converted at currency rate from 15.06.2016.

b Equals US$ 9.965.456 when summing up individual provided values.

c No figure provided in the report; equals B$ (Bahamian Dollar) 1.002.000, converted at currency rate from 15.06.2016.

d No figure provided; value based on summing up individual provided values.

e Estimated value of marine biodiversity to tourism and fisheries, not broken down further.

f Equals B$ (Bahamian Dollar) 80.000, converted at currency rate from 15.06.2016.

g Value also includes aquaculture.

h According to the report, this is a cumulative value from coral reef fisheries and reef tourism.

i Equals TRY (Turkish Lira) 1.590.270, converted at currency rate from 30.06.2016.

j Equals YER (Yemeni Rial) 169.382.714, converted at currency rate from 30.06.2016.

k Equals TRY (Turkish Lira) 806.180, converted at currency rate from 30.06.2016.

l The value stands for incomes from wetlands & salt ponds, however is indicated under this category; equals YER (Yemeni Rial) 182.622, converted at currency rate from 30.06.2016.

m Equals B$ (Bahamian Dollar) 922.000, converted at currency rate from 15.06.2016.

n Equals B$ (Bahamian Dollar) 245.000, converted at currency rate from 15.06.2016.

o However, a value of US$ 219.885 – 1.926.000 is provided as exemplary reference for coral reefs.

p Equals B$ (Bahamian Dollar) 31.500, converted at currency rate from 15.06.2016.

q The report mentions individual values, the total sum of which is US$ 2.931.483.

r Value of estimated impact of Lionfish, not broken down further.

s Comprised of costs to the key sectors fisheries and coastal tourism and is not broken down further.

t One-time costs for the state; equals B$ (Bahamian Dollar) 1.731, converted at currency rate from 15.06.2016.

u Ongoing annual costs for the state; equals B$ (Bahamian Dollar) 111, converted at currency rate from 15.06.2016.

v Costs for ship owners, per vessel; equal B$ (Bahamian Dollar) 5- 3.005, converted at currency rate from 15.06.2016.

w The report contains individual BWM Convention cost items, the total sum of which is US$ 67.449, including industry obligations.

x Year 1 costs.

y Recurring annual costs.

z The national economic assessment does not provide enough numbers to fill in the subcategories 2.1-2.4 properly, see section 5.4 on p. 95-96.

aa See national economic assessment of Trinidad and Tobago, pp. 26-27 and Appendix 1 on pp. 31-32 for details.

bb One-time costs for the state, equal B$ (Bahamian Dollar) 1.589, converted at currency rate from 15.06.2016.

cc Ongoing annual costs for the state; equal B$ (Bahamian Dollar) 21, converted at currency rate from 15.06.2016; *Supra note 4*.

dd The costs items for flag and port state obligations are presented jointly without distinguishing which item belongs to which category.

ee See national economic assessment of Trinidad and Tobago, pp. 26-27 and Appendix 1 on pp. 31-32 for details.

ff One-time costs, equal B$ (Bahamian Dollar) 45, converted at currency rate from 15.06.2016.

gg One-time costs; equal B$ (Bahamian Dollar) 82, converted at currency rate from 15.06.2016.

hh Costs for ship owners, per vessel; equal B$ (Bahamian Dollar) 5 – 3.005, converted at currency rate from 15.06.2016.

ii One-time costs for the state; equal B$ (Bahamian Dollar) 15, converted at currency rate from 15.06.2016.

jj Ongoing annual costs for the state; equal B$ (Bahamian Dollar) 90, converted at currency rate from 15.06.2016.

Annex II

GDP per country for 2015

(values converted to 000's US$)[38]

COUNTRY	GDP (IN 000'S US$, 2015)	WORLD SHARE (IN %, 2015)
Argentina	615,914,000	0.82
Bahamas	8,522,000	0.01
Chile	239,727,000	0.32
Colombia	298,515,000	0.4
Croatia	48,448,000	0.06
Egypt	296,123,000	0.4
Ghana	35,284,000	0.05
Jamaica	13,812,000	0.02
Jordan	36,367,000	0.05
Nigeria	525,220,000	0.7
Panama	52,072,000	0.07
Trinidad &Tobago	29,511,000	0.04
Turkey	719,217,000	0.96
Yemen	39,379,000	0.05

38 Compare UNCTADstat database at: http://unctadstat.unctad.org/EN/, accessed January 2017. The year 2015 is used as reference year, as it is the most recent year with information available on GDP per country

Annex III

Number of registered ships per country[39]

COUNTRY	NUMBER OF SHIPS
Argentina	not mentioned in NEA
Bahamas	1,450
Chile	82
Colombia	52
Croatia	150
Egypt	125
Ghana	300
Jamaica	not mentioned in NEA
Jordan	25
Nigeria	400
Panama	8,153
Trinidad &Tobago	not mentioned in NEA
Turkey	1,525
Yemen	25

39 As indicated in NEAs.

Annex IV

Container Port Throughput/Twenty foot equivalent unit (TEU) per country for 2014[40]

COUNTRY	CONTAINER PORT THROUGHPUT/TWENTY FOOT EQUIVALENT UNIT (TEU), 2014
Argentina	1,775,574
Bahamas	1,399,300
Chile	3,742,520
Colombia	3,127,994
Croatia	176,596
Egypt	8,810,990
Ghana	833,771
Jamaica	1,638,100
Jordan	797,624
Nigeria	1,062,389
Panama	7,942,291
Trinidad &Tobago	738,630
Turkey	7,622,559
Yemen	862,079

40 Compare UNCTADstat database at: http://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=13321, accessed January 2017. The year 2014 is used as reference year, as it is the most recent year with information available on CPT per country.

More Information?

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