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Coastal and Port Environments:

International Legal and Policy Responses to Reduce Ballast Water Introductions of Potentially Invasive Species

*by Jeremy Firestone & James J. Corbett**

Introduction

Ships take on water by gravity or through pumping and store that water in onboard tanks to control trim and draft, provide stability, and enhance voyage safety — an action known as ballasting. Although any heavy solid or liquid can serve as ballasting material, ships almost exclusively employ ballast water for operational convenience. Ships often store ballast water as compensation for those times in which they are less than fully loaded. The term ballast water is a bit of a misnomer, however, as the "water" contains organisms and pathogens that were present in the aquatic environment from which the ballast originated; while other organisms and pathogens that have been entrained in ballast water tanks are found in a sediment layer, which separates out from the liquid phase in the tanks.[1] When ships reach destination ports, they discharge ballast (both water and the surviving organisms and pathogens) into those new port environments. Ballast is discharged for many reasons, including to lighten loads to aid navigation or to take on additional cargo. In new aquatic environments, some introduced organisms reproduce, live more than one life cycle, and become established. These organisms — referred to as exotic, non-native, non-indigenous, alien, nuisance, marine pests, or invasive — may, for example, out-compete native aquatic species, transmit diseases to native species, or contaminate the genome of native species through inter-breeding. Pathogens such as *E. Coli* also may be present in ballast water (for example, where local discharge of untreated sewage to coastal waters occurs), thus providing a vector for disease transmission to human populations from one port to the next.

The use of ballast to stabilize ships has been employed since the Phoenicians began to trade by sea, however two changes during the industrial era have greatly increased the rate of species transfer from one aquatic environment to another: first, a technological shift from solid to liquid ballast; and second, globalization of trade and the concomitant increase in the number, size, and speed of ships engaged in waterborne commerce. Because the marine transportation system presently moves the vast majority of international trade,[2] vessels have become the primary vector for the introduction of non-indigenous species.[3] Indeed, each day some three thousand species are transported in ship ballast or on ships' hulls.[4]

Each day some three thousand species are transported in ship ballast or on ships' hulls.

Although the impact of species introduction is in one sense ecological, those ecological impacts have potentially grave socio-economic consequences,[5] as witnessed by the infestation of zebra mussels in the North American Great Lakes.[6] In response, there have been efforts at local, national, and global levels to control species introductions from ships' ballast. A number of countries have adopted rules and regulations related to the handling of ballast water, including Argentina, Australia, Canada, Chile, Israel, United Kingdom, New Zealand, and the United States.[7] Significant achievements have been realized at the global scale — the arena that is the focus of this paper. Of particular relevance is a recently adopted convention by the International Maritime Organization ("IMO") regarding ballast water, the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 ("Ballast Water Convention" or "BWC").[8]

The Ballast Water Convention

Each Party to the Ballast Water Convention is required, "with due regard to its particular conditions and capabilities," to develop national ballast water management policies and "promote the attainment" of the Convention objectives.[9] Each Party also "shall require" ships flying its flag to comply with the Convention, including taking "effective measures" to ensure such compliance.[10] The Convention applies to all ships with a few practical exceptions,[11] although States may exempt certain vessels from the ballast water discharge standards that follow specified routes based on a risk assessment undertaken in accordance with guidelines to be developed by the IMO.[12] The Ballast Water Convention is to be applied by Parties as a condition for port entry for non-parties; thus ships of non-parties receive "no more favorable treatment."[13]

The Parties to the Convention have a number of obligations,

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including: to provide technical assistance "as appropriate;" "to cooperate actively" in technology transfer "subject to their national laws;" and to enhance regional cooperation, particularly in enclosed and semi-enclosed seas.[14] The Parties also have obligations regarding monitoring, data gathering and sharing,[15] inspection[16] and enforcement,[17] and are required to inform the IMO and other Parties of domestic ballast water management requirements, procedures, and reception facilities for ballast water and related sediments.[18]

Article 9 provides that when a ship is flying the flag of one Party to the Convention in a "port or offshore terminal of another Party," the ship is subject to inspection for the "purpose of determining whether the ship is in compliance with this Convention."[19] A port State also may inspect a ship if a request is received from another Party, "together with sufficient evidence that a ship is operating or has operated in violation of a provision" of the Convention.[20] In general, inspections are limited to verifying that the ship has a valid International Ballast Water Management Certificate, inspecting the Ballast Water record book, and sampling the ballast water in accordance with guidelines to be developed by IMO.[21] By authorizing port States to sample ballast water to determine compliance with ballast water discharge standards in the absence of "clear grounds" for believing that the ship does not conform substantially to the Certificate, the Ballast Water Convention, like the 2001 International Convention on the Control of Harmful Anti-Fouling Systems on Ships,[22] represents a significant departure from prior international practice.[23] Authorizing compliance sampling rather than merely a paper examination is a major step that should enhance compliance with the Ballast Water Convention. The Convention requires flag, coastal, and port States to establish sanctions for violations.[24] Importantly, port and coastal States have authority under the Convention to not only furnish the flag State with information regarding a violation, but, in the alternative, can themselves institute enforcement proceedings.[25] This grant of authority to port and coastal States, while not unusual on its face,[26] takes on added significance given the ability of port States to engage in compliance sampling. In contrast, the two most prominent examples of international instruments providing for enhanced port and coastal State control and/or jurisdiction, the United Nations Convention on the Law of the Sea ("UNCLOS")[27] and the United Nations Fish Stocks Agreement,[28] are structured in such a manner that enforcement under those regimes ultimately can devolve to the flag State if that State so wishes.[29] The Ballast Water Convention thus encompasses an expanded vision of port State control.

Perhaps the most important aspect of the Ballast Water Convention is its establishment of concentration-based ballast water performance standards.

Application of the Convention

The Ballast Water Convention applies to discharges of "harmful aquatic organisms and pathogens" and to "sediments" that settle out of ballast water from ships that fly the flag of, or are otherwise under the administration of, a Party to the Convention. The Convention defines the term "harmful aquatic organisms and pathogens" as organisms and pathogens, "which, if introduced into the sea including estuaries, or into fresh water courses, may create hazards to the environment, human health, property or resources, impair biological diversity, or interfere with other legitimate uses of such areas."[30] By reference to "biological diversity" and the use of the permissive "may," this definition is less anthropocentric than other definitions of "pollution" under international law, such as found in UNCLOS or as crafted by the Joint Group of Experts on the Scientific Assessment of Marine Environmental Protection ("GESAMP").[31] Moreover, in the preamble of the Ballast Water Convention there is explicit acknowledgement of the threat that ballast water poses to the conservation and sustainable use of biological diversity and of the actions taken by the Convention on Biological Diversity Conference of Parties to protect marine biodiversity from invasive species.[32] These developments suggest an expanded regulatory horizon for the IMO; in addition, the definition moves beyond pollution prevention to biodiversity protection.

While no mention of the precautionary approach is found in the substantive text of the Convention, the Parties were at least "mindful" of it.[33] Rather than explicitly relying on the precautionary approach, the Convention establishes specific requirements in a number of areas, including: ballast water management planning and reporting,[34] ship surveying and certification,[35] ballast water exchange,[36] sediment management,[37] ballast water treatment,[38] and additional measures for certain areas in order to prevent, minimize, and ultimately eliminate the threat posed by aquatic organisms and pathogens contained in ballast water.[39]

When in force, the Ballast Water Convention will require each ship from a signatory Party to have an approved ship-specific Ballast Water Management Plan ("BWMP").[40] A ship also must have on board a ballast water record book in which to enter and maintain a record of its ballast activities and explain the circumstances behind, and the reasons for, any non-standard ballasting activities (*e.g.*, due to an exemption, for safety, or as a result of an accident).[41]

Each ship of 400 gross tonnage or more will be required to undertake a series of surveys to ensure that its BWMP "and any associated structure, equipment, systems, fitting, arrangements, and material or processes comply fully" and "have been maintained in accordance with" the Convention and "remain satisfactory for the service for which the ship was intended."[42] These surveys must be conducted after each significant ship repair and at other specified intervals. After passing the surveys the ship receives certification. This certificate is valid for a period of not greater than five years, but it ceases to be valid if the ship changes its flag registry to a different State.[43]

The Convention requires ships to engage in ballast water exchange with "at least 95 percent volumetric exchange" or to pump through three times the volume of each ballast water tank.[44] Each Party to the Convention must ensure that "adequate" sediment reception facilities are provided "where cleaning or repair of ballast water tanks occurs."[45]

Perhaps the most important aspect of the Ballast Water Convention is its establishment of concentration-based ballast water performance standards, which ships that fly the flag of a State Party must meet. Assuming timely entry into force of the Convention, these standards will come into effect between 2009 and 2016 depending on vessel class, size, and construction date.[46] Vessels can gain an additional five years by participating in a technology demonstration project.[47] Two performance standards (limits) are set for "viable organisms" and three performance standards are set for "indicator microbes" in order to protect human health from pathogens.[48] These standards must be achieved unless the vessel undertakes alternative methods that ensure an equivalent level of protection.[49]

Policy-makers could construct a ballast water management regime that applies selectively to those vessel voyages posing the greatest risk or, alternatively, could apply more stringent measures to those vessels that pose the greatest risk.

The Ballast Water Convention also explicitly acknowledges the right of individual States to establish "more stringent measures . . . consistent with international law."[50] While States enjoy broad authority to condition entry into their ports on compliance with environmental and other mandates — for example, the U.S. Oil Pollution Act of 1990 requires oil tankers to be double hulled[51] — it is unusual, although not unprecedented, for an international treaty to explicitly acknowledge the right of States to establish more stringent standards.[52]

Implementation Challenges

Given the aquatic organism and pathogen performance standards and the lack of off-the-shelf technology to necessarily meet them, it is expected that substantial thought and effort will be directed in the near-term toward developing treatment technologies that will reduce or eliminate the introduction of species from ballast water as cheaply as possible. However, as noted above, individual States may regulate ballast water discharges more stringently, and the global standards established by the Ballast Water Convention are not inviolate. Indeed, the Convention performance standards are subject to review by the Marine Environment Protection Committee ("MEPC") "no later than three years before" their "earliest effective date."[53] To assist the MEPC in its review of ballast water standards, Resolution Two of the Conference Final Act,[54] calls for the application of "suitable" decision-making tools. Fundamental, interdisciplinary research is thus needed not only to facilitate implementation of the specified standards, but to design and develop these decision and risk assessment tools as well.

In light of the existing performance standards, the mandated-review of the standards, and the ability of States to implement more stringent measures on a State-by-State basis, what is needed is: (a) an enhanced understanding of which trade routes and vessel types present the greatest risk of introducing non-indigenous species; (b) information on which treatment technology or suite of technologies will need to be employed on a particular vessel that follows a specific route to reduce the concentration of viable organisms and pathogens prior to discharge to levels that are below the standards specified in the Convention; (c) exploration of the least-cost solution for that vessel to come into compliance with the standards; and (d) an evaluation of the cost-effectiveness of meeting the present standards and/or alternative standards. Attention also may be directed toward whether an administratively feasible and enforceable alternative market-based standard that would allow for trading among vessels can provide equal protection at lower cost.

Decisions such as how to implement the BWC can be difficult for several reasons.[55] To begin with, a decision may simply be complicated, with a number of factors to consider. In addition, some considerations that bear on a decision may be uncertain. In the present context, ecosystem risk factors, vector characteristics, and treatment technology efficacy and costs are all uncertain to at least a limited degree. Frequently, a decision also poses tradeoffs among desirable attributes or objectives. Moreover, because differently-situated actors often approach a question from their own unique perspectives, they in turn weigh decision criteria differently. While port States may place a priority on protecting sensitive ecosystems from species introductions, the major maritime nations may be more interested in meeting the economic goals of shippers that fly their flags.

Proposed Model To Facilitate BWC Implementation

With the above discussion as a backdrop, what is proposed is a Ballast Water Discharge Compliance and Policy Support Model ("BWDCPSM")[56] that is premised on five primary objectives:

- Minimizing the number of viable organisms discharged (or, alternatively achieving a specified standard);
- Reducing the time needed to achieve reductions;
- Minimizing total cost (public and private);
- Protecting particularly sensitive ecosystems; and
- Maximizing technology adoption by vessels according to their relative risk of introducing organisms.

By evaluating how alternative policy scenarios fare under these five objectives, such a model could shed light on points of agreement, identify other considerations in need of more scientific research or policy development, and generally assist policymakers in the implementation of the Ballast Water Convention and other applicable policies.

The BWDCPSM extends a recent model that Winebrake, Corbett, and others developed to generate optimal passenger ferry air pollution reductions.[57] In laymen's terms, it is an optimization model that allows determination of the minimum cost required for a given ship (or ships) that takes a particular voyage to meet a specified ballast water discharge performance standard given the cost and efficacy of the suite of available treatment technologies. The BWDCPSM can generate results in a disaggregated fashion that will: 1) permit analysis of the relative risk posed by a given vessel (*e.g.*, by type, tonnage, ballast tank capacity) undertaking a particular voyage;[58] 2) support implementation of the Ballast Water Convention; and 3) assist policymakers in their consideration of the relative merits of alternative policy goals.

The model can be run under various policy scenarios, including the Ballast Water Convention's concentration-based standards. Alternatively, the BWDCPSM permits a user to model either more stringent or more lenient concentration-based standards to facilitate the Convention-mandated review of standards established therein. It also assists States that may wish to set more stringent standards. Indeed, a legislative proposal before the U.S. Senate would, if adopted, set ballast water organism discharge standards for U.S. waters at 1/100 of those established by the Ballast Water Convention.[59] Moreover, recent testimony before the U.S. Congress recommended establishing a standard of zero live organisms above 50 microns to simplify enforcement.[60]

The BWDCPSM can facilitate the analysis of other policy scenarios as well. For example, concentration-based standards could vary by port (*e.g.*, some ports may have sensitive ecosystems while others may have ecosystems that have only a slight chance of being invaded) or be even more finely-tuned standards that vary by source-destination port pair. Furthermore, the model is flexible enough that, at a given port, a concentration-based standard could be set at the average concentration of viable organisms in the ballast water across all discharges. Finally, in addition to, or in place of a concentration-based standard, other constraints could be specified such as one on the total number of organisms that could be discharged into a port ecosystem over a given period of time. In sum, inclusion of policy variables in the BWDCPSM permits decision-makers to model the technical feasibility of achieving various policy objectives, alternative means of achieving those objectives, and the comparative compliance costs associated with those means. And for any given policy scenario, the model will generate the least-cost solution. More specifically, the objective function for the model, assuming a policy that places limits on both the concentration and the total number of viable organisms that may be discharged, is:

$$\text{(1)} \quad \min\left(\sum_{v}^{V}\sum_{k}^{K} BINK_{v,k} \cdot KTE_{v,k}\right) \text{ subject to:}$$

$$\text{(1a)} \quad C_v < P_v$$

$$\text{(1b)} \quad \sum_{v}^{V} C_v \cdot V_v \leq \sum_{v}^{V} Q_v$$

The binary variable $BINK_{v,k}$ takes on a value of "1" if a given treatment technology (k) (*e.g.*, filtration) is incorporated on a specific vessel (v) and a value of "0" otherwise. The variable $KTE_{v,k}$ is the total annual expense (the capital cost annualized over its lifetime at a given discount rate plus operation and maintenance costs) of incorporating technology k on vessel v. Those two variables are multiplied together in equation (1) and the resulting product is summed over all vessels and treatment technologies, with the objective of minimizing total costs. C_v is the concentration of viable organisms (*e.g.*, the number per cubic meter) in the ballast water discharge of vessel v. It is a function of the initial organism/pathogen concentration by size and a number of factors that affect survivability, including: donor and recipient attributes such as water temperature and salinity; voyage duration; ballast water tank size; volume exchanged at sea; and treatment efficacy. P_v is the maximum concentration of viable organisms permitted by regulatory authorities to be discharged by vessel v. Under equation (1a), the concentration discharged must be less than that permitted. Finally, V_v is the volume of ballast water discharged by vessel v and Q_v is the maximum quantity of organisms permitted by regulatory authorities to be discharged by vessel v.

The use of limits on the concentration and quantity of organisms discharged (the risk of introduction) in the model rather than the risk of harm/invasion[61] has parallels in the surface water quality discharge regulatory context where regulators can choose to focus on end of pipe discharge limits rather than water quality parameters. The choice of risk of introduction also is sensible given a similar focus in the Ballast Water Convention. Moreover, at this point in time, we believe it prudent to avoid modeling individual species or quantifying species invasive potential given the fact that the majority of species that move in international waterborne commerce have yet to be identified, let alone analyzed for their invasive potential.[62] In any event, predicting invasiveness continues to confound experts.[63]

Conclusion

The Ballast Water Convention has ushered in a new era: it suggests that the international community has come to recognize that near-exclusive flag State control is outmoded and that flag State prerogatives must be complemented by, and in some circumstances give way to, coastal and port State jurisdiction. In this modern era, crew safety remains paramount and a reasonable flag-State interest, but it has been joined by biodiversity protection, which is primarily a port or coastal State interest. The BWC also provides evidence that the international community has begun to take seriously the threat posed by organisms and pathogens contained in ballast water.

In regard to the last point, the Ballast Water Discharge Compliance and Policy Support Model can help decision-makers evaluate regulatory standards and market-based policies to enable innovation of environmental technologies to meet performance-based targets. Policy-makers could construct a ballast water management regime that applies selectively to those vessel voyages posing the greatest risk or, alternatively, could apply more stringent measures to those vessels that pose the greatest risk. The model also will assist ship operators in complying with the Ballast Water Convention's concentration-based standards and at the same time minimize costs. Third, the model will allow interested ports to gather and input the necessary data to determine costs associated with protecting individual port ecosystems. And finally, because the model includes treatment technologies and policy options, policy-makers can use the model to assist with their consideration of the relative merits of differing policy and treatment combinations.

Endnotes: Coastal and Port Environments

1 *See*, *e.g.*, Gregory M. Ruiz & James T. Carlton, *Invasion Vectors: A Conceptual Framework for Management*, *in* Invasive Species: Vectors and Management Strategies 459, 468 (G.M. Ruiz & J.T. Carlton eds., 2003). The International Convention for the Control and Management of Ships' Ballast Water and Sediments defines "ballast water" as "water with its suspended matter taken on board a ship to control trim, list, draught, stability or stress of the ship" and "sediments" as "matter settled out of Ballast Water within a ship." The International Convention for the Control and Management of Ships' Ballast Water and Sediments art. 1.11, 1.2, Feb. 13, 2004, BWM/Conf/36, *available at* http://www.bsh.de/de/Meeresdaten/Umweltschutz/ Ballastwasser/Konvention_en.pdf#search=%22International%20Convention% 20for%20the%20Control %20and%20Management%20of%20Ships'%20Ballast%20Water%20and%20 Sediments%22 (last visited October 15, 2006) [hereinafter BWC].

2 Marine Transportation Task Force, U.S. Department of Transportation, An Assessment of the U.S. Marine Transportation System: A Report to Congress 19 (1999), *available at* http://www.dot.gov/mts/report/mtsfinal.pdf (last visited Oct. 15, 2006).

3 Paul W. Fofnoff et al., *In Ships or on Ships? Mechanisms of Transfer and Invasion for Nonnative Species to the Coasts of North America*, *in* Species: Vectors and Management Strategies, at 152; *see also* National Research Council, Committee on Ships' Ballast Operations, Stemming the Tide: Controlling Introductions of Nonindigenous Species by Ships' Ballast Water 1 (1996). *Cf.* Z. Yang & A. N. Perakis, *Multiattribute Decision Analysis of Mandatory Ballast Water Treatment Measures in the US Great Lakes*, 9D *Transportation Research Part D* 81 (Jan. 2004); Andrew N. Cohen & James T. Carlton, *Accelerating Invasion Rate in a Highly Invaded Estuary*, 279 Science 555, 556 (1998).

4 Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection ("GESAMP"), A Sea of Troubles UNEP, at 13 (2001), *available at* http://gesamp.imo.org/no70/report.pdf#search=%22(GESAMP)%2C% 20% E2%80%9CA%20Sea%20of%20Troubles%22 (last visited Oct. 15, 2006) [hereinafter A Sea of Troubles].

5 European Commission, Life III Programme, et al., Alien Species and Nature Conservation in the EU: The role of the LIFE program 14 (2004), *available at* http://ec.europa.eu/environment/life/infoproducts/alienspecies_en.pdf#search= %22Alien%20Species%20and%20Nature%20Conservation%20in%20the%20E U%3A%20The%20role%20of%20the%20LIFE%20program%22 (last visited Oct. 15, 2006); *see also* Meinhard Doelle, *The Quiet Invasion: Legal and Policy Responses to Aquatic Invasive Species in North America*,18 Int'l J. of Marine & Coastal L., 261, 263 (2003); A Sea of Troubles, *supra* note 4, at 13; Duncan Knowler & Edward B. Barbier, *The Economics of an Invading Species: A Theoretical Model and Case Study Application*, *in* The Economics of Biological Invasions 70, 71 (Charles Perrings et al. eds., 2000).

6 *See* National Research Council, *supra* note 3, at 11, 18.

7 *See* Intertanko, Ballast Water Requirements, http://www.intertanko.com/ tankerfacts/environmental/ballast/ballastreq.htm (last visited Oct. 15, 2006); Moira McConnell, Global Ballast Water Management Programme, Globallast Legislative Review, Final Report (2002), *available at* http://globallast.imo.org/ monograph1%20legislative%20review.pdf (last visited Oct. 15, 2006). *But see* David Mckie, Ballast Water 'Minefield' Could Explode on Owners, Elbornes.com & Lloyd's List, Mar. 28, 2001, http://www.elbornes.com/articles/ shipping/shi_0006.htm (last visited Oct. 15, 2006). *See generally*, Mark L. Miller & R. M. Fabian, eds., Harmful Invasive Species: Legal Responses (2004). Nevertheless, for the most part, state laws implement the Guidelines adopted by the IMO and emphasize ballast water exchange outside of coastal waters. IMO Res. A.774(18), Guidelines for Preventing the Introduction of Unwanted Organisms and Pathogens from Ships' Ballast Water and Sediment Discharges (Nov. 4, 1993); IMO Res. A.868(20), Guidelines for the Control and Management of Ships' Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens (Nov. 27, 1997).

8 BWC, *supra* note 1.

9 BWC, *supra* note 1, at art. 4.2.

10 BWC, *supra* note 1, at art. 4.1.

11 *See* BWC, *supra* note 1, art. 3.2 (excluding, *inter alia*, ships where the ship: does not carry or discharge ballast water, operates solely within the territorial waters and the high seas of a single party, and military vessels). The exceptions are qualified, however, with the proviso that they are subject to the concept that the state parties may not allow a flag to damage the environmental resources of another state.

12 BWC, *supra* note 1, at reg. A-4.

13 BWC, *supra* note 1, at art. 3.3.

14 BWC, *supra* note 1, at art. 13-14.

15 BWC, *supra* note 1, at art. 6.

16 BWC, *supra* note 1, at art. 9.

17 BWC, *supra* note 1, at art. 10.

18 BWC, *supra* note 1, at art. 14

19 BWC, *supra* note 1, at art. 9.1.

20 BWC, *supra* note 1, at art. 10.4

21 BWC, *supra* note 1, at art. 9.1.

Endnotes: Coastal and Port Environments *continued on page 83*

Endnotes: Coastal and Port Environments

continued from page 49

22 BWC *supra* note 1 at art. 9.1, 9.2; International Convention on the Control of Harmful Anti-Fouling Systems on Ships art. 11(1)(b), Oct. 18, 2001, 12 I.L.M. 1319 [hereinafter Anti-Fouling Convention], *available at* http://www.uscg.mil/hq/g-m/mso/images/AFS-CONF-26%20Antifouling.pdf#search=%22 AFS% 2FCONF% 2F26%22 (last visited Oct. 15, 2006); *see generally* International Maritime Organization, http://www.imo.org/ (last visited Oct. 15, 2006).

23 *Compare* BWC, *supra* note 1, at art. 9.1(c) and Anti-Fouling Convention, *supra* note 22, Article 11(1)(b) with International Convention for the Prevention of Pollution from Ships art. 5.2, Nov. 2, 1973, 12 I.L.M. 1319 *available at* http://sedac.ciesin.columbia.edu/entri/texts/pollution.from.ships.1973.html (last visited Oct. 15, 2006) [hereinafter MARPOL]. In a nod toward flag State prerogatives, the BWC does, however, provide that "the time required to analyze the samples shall not be used as a basis for unduly delaying the operation, movement or departure of the ship." BWC, *supra* note 1, at art. 9.1(c).

24 BWC, *supra* note 1, at art. 8.

25 BWC, *supra* note 1 at art. 8.2.

26 *See* MARPOL, *supra* note 23, at art. 4.2.

27 United Nations Convention on the Law of the Sea, Dec. 10, 1982, 21 I.L.M. 1261 art. 218, 220, 226, *available at* http://www.un.org/Depts/los/convention_agreements/texts/unclos/UNCLOS-TOC.htm (last visited Oct. 15, 2006) [hereinafter UNCLOS].

28 United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks art. 21-23, Dec. 4, 1995, 34 I.L.M. 1542.

29 Jeremy Firestone & James Corbett, *Maritime Transportation: A Third Way for Port and Environmental Security*, 9 Widener L. Symposium J. 419, 428-431 (2002–03). In any event, port States may in practice have other enforcement tools at their disposal. For example, in 1999, the Royal Caribbean Cruises, Ltd. agreed to plea guilty to twenty-one felonies and pay a $18 million fine. Press Release, U.S. Dept. of Justice, Royal Caribbean to Pay Record $18 Million Criminal Fine for Dumping Oil and Hazardous Chemicals, Making False Statements: Cruise Line Faces 21 Felony Counts in 6 Different U.S. Courts (July 21, 1999), *available at* http://www.usdoj.gov/opa/pr/1999/July/316enr.htm (last visited Sept. 22, 2006).

30 BWC, *supra* note 1, at art. 1.8.

31 M. Tomczak, Jr., *Defining Marine Pollution: A Comparison of Definitions used by International Conventions*, 8 Marine Pol'y 311, 317-18 (1984) .

32 BWC, *supra* note 1, at pmbl.

33 BWC, *supra* note 1, at pmbl.

34 BWC, *supra* note 1, at arts. 2.5, 4.2.

35 BWC, *supra* note 1, at art. 7.

36 BWC, *supra* note 1, at reg. B-4.

37 BWC, *supra* note 1, at reg. B-5.

38 BWC, *supra* note 1, at reg. D-4.

39 BWC, *supra* note 1, at reg. E-1(6), E-1(9).

40 BWC, *supra* note 1, at reg. B-2.

41 BWC, *supra* note 1, at reg. B-2, app. II.

42 BWC, *supra* note 1, at regs. E-1.1(.1), E-1.1(.4).

43 BWC, *supra* note 1, at reg. E-5.

44 BWC, *supra* note 1, at reg. D-1.

45 BWC, *supra* note 1, at art. 5.

46 BWC, *supra* note 1, at regs. A-5, B-3.

47 BWC, *supra* note 1, at reg. D-4.

48 BWC, *supra* note 1, at reg. D-2.

49 BWC, *supra* note 1, at reg. B-3.7

50 BWC, *supra* note 1, at art. 2.3.

51 46 U.S.C. §3703 a(a).

52 *See e.g.*, 1996 Protocol to the London Dumping Convention of 1972 art. 3.4, 36 I.L.M. 1 (1997); UNCLOS, *supra* note 28, at art. 210(6).

53 UNCLOS, *supra* note 27 at reg. D-5.1.

54 IMO, Final Act of the International Conference on Ballast Water Management for Ships (2004).

55 *See generally* Robert T. Clemen, Making Hard Decisions with Decision Tools (1996).

56 This model is presently being tested by the authors at two U.S. ports.

57 James J. Winebrake et al., *Optimal Fleet-wide Emissions Reductions for Pas-*

senger Ferries: An Application of a Mixed-Integer Non-Linear Programming Model for the New York-New Jersey Harbor, 55 J. AIR & WASTE MGMT. ASS'N., 458 (2005).

[58] DARREN OEMCKE, PORTS CORPORATION OF QUEENSLAND, THE TREATMENT OF SHIP'S BALLAST WATER 42-43 (1999), *available at* http://www.optimarin.com/PDF_Files/oemcke.pdf#search=%22%22The%20Treatment%20of%20Ship's%20Ballast%20Water%22%20Oemcke%22 (last visited Oct. 31, 2006).

[59] S.363, 109th Cong. (2005).

[60] Allegra Cangelosi, Ballast Water Management Hearing: Testimony of Allegra Cangelosi, Senior Policy Analyst, Northeast-Midwest Institute before the United States House of Representatives Committee on Transportation and Infrastructure Subcommittee on Coast Guard and Maritime Transportation Subcommittee on Water Resources and Environment (2004).

[61] Stephen Gollasch, *Hazard Analysis of Aquatic Species Invasions*, *in* INVASIVE AQUATIC SPECIES OF EUROPE, DISTRIBUTION, IMPACTS AND MANAGEMENT, 447-455 (Erkki Leppäkoski et al. eds., 2002).

[62] *Cf.* Anne M. Perrault & William Carroll Muffett, *Turning off the Tap: A Strategy to Address International Aspects of Invasive Alien Species*, 11 RECIEL 211, 212, 214 (2002).

[63] Perrault & Muffet, *id.* at 2.