ASEAN Journal on Science & Technology for Development
Vol. 35, No. 1-2, 2018, 5-10
DOI 10.29037/ajstd.466
POLICY

Ballast Water Control and Management in Brunei Darussalam

Hjh Zuliza Hj Jolkifli[1,*] and Ranimah H.A. Wahab[1]

[1]Capture Fisheries Development Division, Department of Fisheries, Ministry of Industry and Primary Resources, Brunei Darussalam
*Corresponding author: zuliza.jol@gmail.com

KEYWORDS
Alien
Ballast
Biodiversity
Biological invasion
Fouling
Invasive species

ABSTRACT The ongoing transfer of non-indigenous organisms through shipping, especially via ballast water transport, is placing marine and coastal resources under increased threat. The transport of Invasive Alien Species (IAS) is a critical issue which may cause irreversible consequences to receiving environments and economies needing particular attention. The main objective of this paper is to highlight the importance for implementation of ballast water management measures in Brunei Darussalam. This paper recognised IAS intrusion via ballast water has high probability to have direct effects on the economic value of fisheries sector, thus the need for an effective ballast water management strategy. Management of ballast water is a complex issue and horizontal policy is the appropriate approach for building this management framework in addition to valid baseline and efficient monitoring. Further studies such as development risk assessment model and assessment of different management measures are critical for an effective prevention, eradication and control strategy.

1. INTRODUCTION

The oceans cover approximately 70% of the earth's surface, forming the largest habitat on earth which host multiple diverse ecosystems with highest marine biodiversity in the benthic system (Gray 1997). Naturally, the spatial distribution of aquatic organisms in the oceans is determined by both behavioural capabilities and physical oceanographic structures such as landmasses, temperature and salinity that effectively control ecological balance (McManus & Woodson 2011). However, humans have intervened in the natural dispersal mechanism, agitating balance in ecosystems through maritime activity. Today, 90% of the world trade is dependent on the maritime transport, which by far offers the most energy efficient mode of long distance transportation for goods and raw materials (Kaluza et al. 2010).

The worldwide maritime network also acts as marine invasion pathways for the introduction of thousands of invasive species, ranging from viruses to fishes (Minchin et al. 2009) through two major pathways: discharged water from ships' ballast tanks (Ruiz et al. 2000) and hull fouling (Drake & Lodge 2007). Scientists and policy makers turned their focus on ballast water transport as the major pathway of marine introductions. Currently, about 10 billion tonnes of ballast water are being carried across the ocean surfaces annually and is likely to transport entire assemblages of microscopic species inclusive bacteria, protozoans, phytoplankton and zooplankton (Carlton & Geller 1993).

Realizing ballast water is an invasion vector, this paper highlights the importance of facilitating ballast water management (BWM) in Brunei Darussalam when the IMO BWM Convention comes into force. It provides an outline for a systematic approach to determine biosecurity risk to Brunei's marine environment to meet the expected outcomes of ballast water management.

2. BRUNEI DARUSSALAM

Brunei Darussalam is located at the equator and experiences a generally warm, tropical climate characterized by nearly uniform temperature and rainfall. Being under the influence of seasonal fluctuation of the inter-tropical convergence, Brunei is subject to the Northeast monsoon, which prevails from December to March, and the Southwest monsoon that occurs from June to October. The country's coastal waters, typical of tropical areas, are relatively warm (29.5°C) with low salinity (31 ppt) and relatively lack of nutrient (Silvestre & Jaafar 1992).

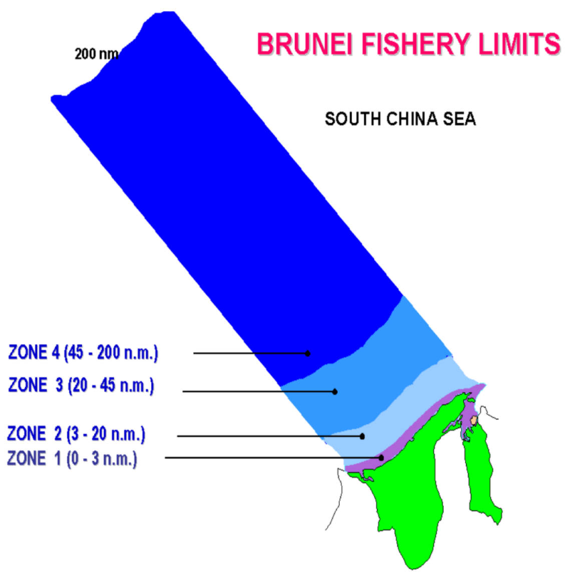

Figure 1. Fishing zonation in Brunei waters.

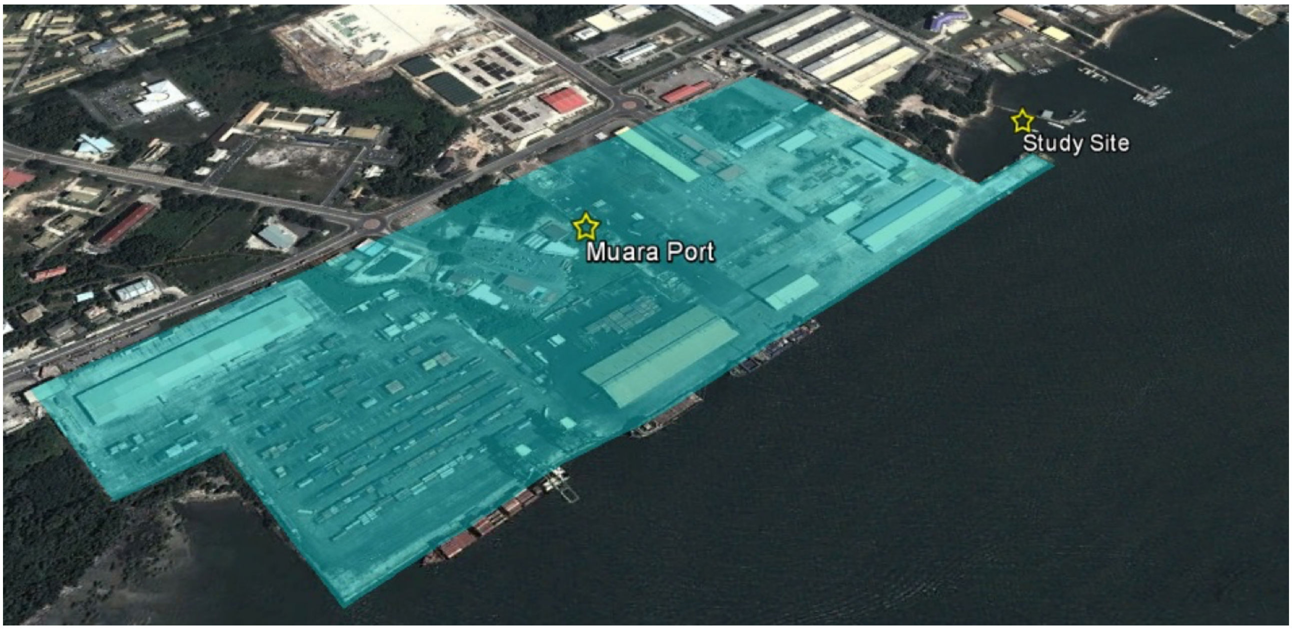

Figure 2. Muara Port, the main port of Brunei Darussalam.

In an effort to diversify the economy of Brunei Darussalam, sustainable development of the fisheries sector is actively being pursued. Although fisheries in Brunei are still at the developmental phase, this sector is estimated to be worth B$400 million. In an effort to implement an 'ecological approach', the allowed exploitation of capture fisheries is limited to the "maximum economic yield" (MEY). Fishing areas are divided into four zones namely Zone 1, 2, 3 and 4 (see Figure 1). Zone 1 is exclusive to small-scale fishers whereas zones 2, 3 and 4 are for commercial operators. The near shore or coastal fisheries are almost utilized to its sustainable capacity and the next areas of development will be towards the deeper areas of zones 3 and 4 (SEAFDEC 2007).

Aquaculture is another fast growing sector in this industry with an estimated valuation of B$200 million annually. By 2011, 86 ha were gazetted for the development of cage culture. Seabass, grouper, trevally, mangrove snapper and hybrid tilapia are among the species being cultured in floating cages.

2.1 Muara Port

Muara port (Figure 2), the main port of Brunei Darussalam, is directly under the jurisdiction of the Ports Department, Ministry of Communications. Positioned at the inner part of Brunei Bay, which is the largest estuary present in Brunei Darussalam, the only approach to this port is through the main channel of Tanjong Pelompong.

From April, 2012 until April, 2013, Muara Port received 788 vessels calls (see Appendix A) with Malaysia being the most common port of embarkation followed by Singapore, China and Japan Figure 3). Bulk and tanker vessels accounted for over 90 percent of the vessels arriving at Brunei port.

Currently, there are no data describing the patterns of ballast water exchange among vessels entering Muara

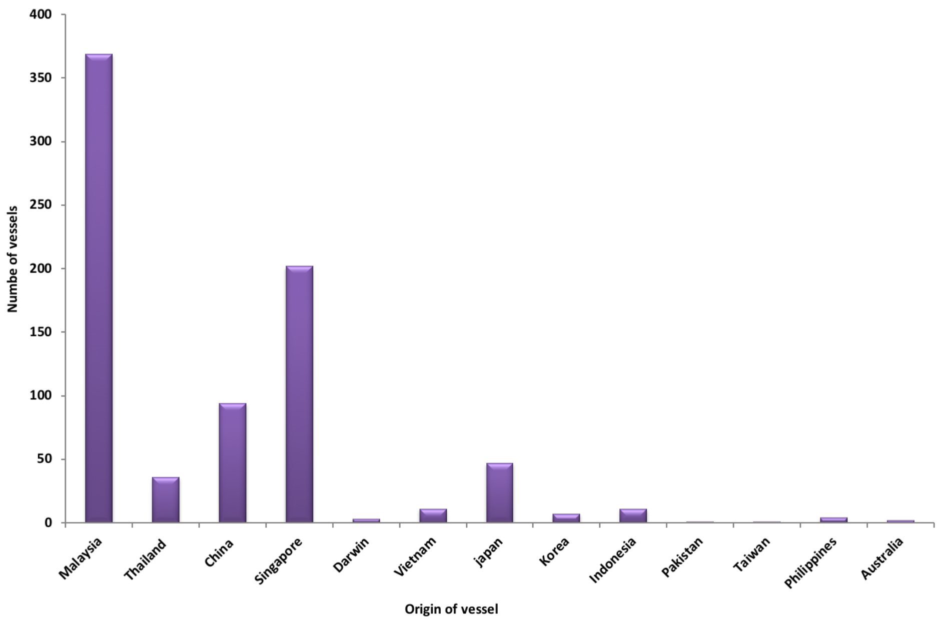

Figure 3. Number of vessels calling at Muara Port for the period April 2012 to April 2013 (see also Appendix A).

Table 1. A basic framework for assessing economic risk pertaining to fisheries sector in Brunei based on data record for 2011 (Department of Fisheries 2011).

Key sectors	Total yield (mt)	Total value (B$ million)	Number employed/ dependent	Vulnerability
Fisheries	5,896	38.05	2,370	Direct
Aquaculture	124	1.43	n/a	Direct
Overall	6,020	39.48	2,370	Direct

Table 2. Frequency of occurrence of harmful algal blooms in Brunei from 2005 to 2013.

Year	Frequency of Occurrence	Duration	Causative Species
2005	2	3 months	*Pyrodinium bahamense var compressum*
		4 months	*Cochlodinium polykrikoides*
2006	2	3 months	*Pyrodinium bahamense var compressum*
		2 months	*Cochlodinium polykrikoides*
2007	2	2 months	*Cochlodinium polykrikoides*
		2 months	*Cochlodinium polykrikoides*
2012	1	4 months	*Cochlodinium polykrikoides*
2013	1	7 months	*Pyrodinium bahamense var compressum*

port. There is no port policy or governed body for the exchange of ballast water. So far, no efforts have been made to collect ballast water exchange data for vessels that are engaged in coastwise voyages.

2.2 Economic value at risk

In this paper, we provide a basic framework needed to analyze the economic value of fisheries and aquaculture sector and potential cost as a result of IAS introduction cause by uncontrolled ballast water exchange. We then review the potential for invasions of harmful microalgae that required mitigation measures.

As mentioned earlier, Muara port is located in an estuarine environment and Brunei Bay is considered the most vulnerable areas to such intrusion. Carlton (1979) discovered there is a striking difference in the number of IAS species with more IAS species invaded San Francisco Bay (212 species) comparing the <10 IAS from the adjacent outer coast. A majority these organisms originate from estuarine environment, thus invasive species introduced via ballast water is likely to survive and colonize Brunei Bay, an estuarine habitat (Ruiz et al. 1997).

While there are numerous sectors, stakeholders and processes that may be impacted by untreated ballast water, the fisheries sector is classified to be directly affected and/or are more vulnerable. Brunei Bay (estuary) is a highly productive ecosystem that harbour mangroves with high nutrient runoff that influence about 75% of commercially harvested fish and shellfish. This estuary plays a vital role both as nursery grounds for juveniles and as migration routes to or from spawning and feeding habitats (Kennedy et al. 2002). Thus, reduction in fisheries production and closure/reduction in aquaculture are of particular importance when considering the economic impacts associated with fisheries sector (Table 1).

The direct economic cost of untreated ballast water for the fisheries sector has been estimated at about B$40 million (approximately US$32 million) which reflects the high productivity and economic value of Brunei Bay ecosystem to the fisheries sector. This estimated value only covers the fisheries and aquaculture sector situated in close proximity to the Muara port. It excludes maintenance, damage and repair costs to fisheries, aquaculture equipments and water supply. Further rapid economic assessments covering other sectors, such as coastal tourism, shipping, coastal infrastructure and other indirect values (e.g., shoreline protection, sediment and nutrient control), would provide accurate quantification on the impact of unmanaged ballast water (GEF-UNDP-IMO GloBallast Partnerships Programme and IUCN, 2010).

2.3 Harmful algal blooms (HAB)–Threats of ballast water

In March 1976, Brunei Darussalam recorded its first occurrence of Pyrodinium red tide. Since then, major red tide have recurred in 1980 and 1988. Brunei Darussalam shared the same worldwide pattern on the increasing frequency and intensity of Harmful Algal Bloom (HAB) occurrences (Table 2). Since 2005, observations of HAB are being reported in increasing frequency. From year 2005 until 2007, HAB occurred twice and a significant increase in duration is being recorded for 2012 and 2013.

The frequent occurrence of HABs is an indication that the theory on ballast water dispersal – HAB paradigm should not be ignored completely. Ballast water assisted expatriations impact the global occurrence of HABs through the direct transfer of previously absent species or introduction of genetic strains from the donor habitat that are ecologically favored over resident strains. Of considerable concern was the detection in 16 ships of cysts of the toxic dinoflagellates *Alexandrium catenella*, *A. tamarense* and *Gymnodinium catenatum* all of which were successfully germinated. Diatom and dinoflagellate species that are not endemic to a region can be inadvertently introduced when their resistant resting stages are discharged with the ballast-tank waters and sediments of bulk cargo vessels (Hallegraeff & Bolch 1992). With the detection of host containing PSP (Paralytic Shellfish Poisoning) in samples of commercial ships' ballast water and increased occurrence of HABs, ballast water management is an effective preventative measure that should be undertaken.

3. WHAT NEEDS TO BE DONE

3.1 Risk assessment

With the increasing effort being invested in field surveys to detect biological invasion, studies have demonstrated that every corner of the globe involved in shipping activity is susceptible to the harmful effects of ballast water introduction (Raaymakers 2002). The global extent on the impact of marine invasion, ballast water issue should be managed with similar resolve dedicated to overexploitation, pollution, and climate change.

Ballast water management is a new focus in Brunei Darussalam. Current knowledge is quite poor and derived in an ad hoc manner, harvesting information from published literature and anecdotal evidence. This paper rectifies the lack of knowledge and understanding of the identity of marine invaders in Brunei's coastal waters, while requesting for further quantitative assessment of risk.

Probability of successful establishment of species and its probability causing harm to the "donor" are expected to be derived from risk assessment (Williams & Grosholz 2008). With reference to Figure 3, majority of ballast water exchange process occur within bioregion where there is possibility of natural genetic exchange. Species – specific risk assessment is applicable for such scenario by estimating the potential of targeted species to survive in the recipient environment through two approaches: utilising its distributional information from the native range or using its life history or physiological tolerance as reference (Barry et al. 2008).

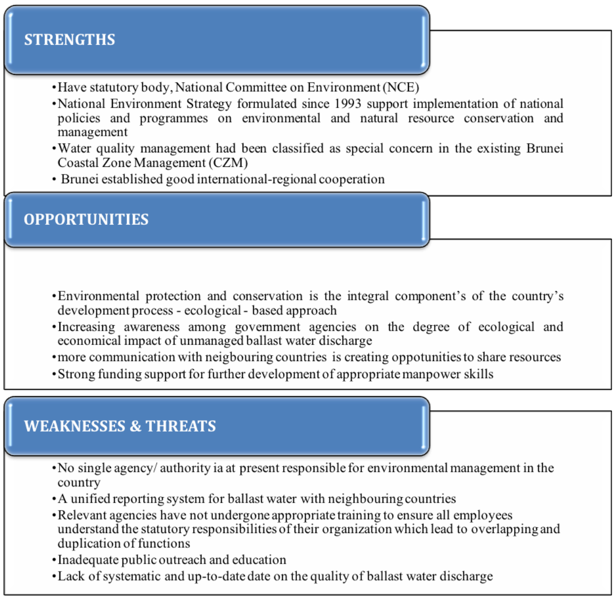

Figure 4. Analysis of strengths, opportunities, weaknesses and threats (SWOT) for implementation of Brunei's ballast water regulations.

Muara port is expected to be visited by an increased number of vessels with trans-biogeographic journeys, thus environmental risk assessment approach is appropriate for ballast water management. This approach predicated that the possibility of survival and establishment of any species that is repeatedly transferred between locations can be determined by the degree of physical similarity between these locations (Hilliard and Raaymakers 1997). Smith et al. (1999) recognised the feasibility of this assessment approach with their findings on the dearth of invasion in the upper reaches of Chesapeake Bay despite the high release of ballast water within the area. Such low risk of invasive intrusion is attributed to the difference in physical conditions between the donor and receiver regions.

Through further risk assessment, comprehensive information on taxonomy and ecology of marine organisms, including databases on species distribution data about the extent of invasive threats faced by Brunei, could be acquired. Scientific information is crucial for decision makers to facilitate the building of detailed regulatory controls and procedures for effective ballast water management. With adequate background information, a regional-level risk assessment could be used to identify the priority ports for detailed risk assessments.

3.2 Legal Framework

The degree of ecological and economic impacts of invasive species contained within ballast water demands an effective, policy environment underpinned by scientific and technical baseline information. Although several countries have made significant progress in developing baseline information, proactive horizontal policy development - beginning with high level strategic policy and planning at the international level, ultimately cascading through national to local ordinances that target prevention - is recognised as the most effective strategy to deal with this problem. In Brunei, this approach does not currently exist (Creative Resource Strategies 2010). Figure 4 shows an analysis of Brunei's strength, weaknesses, opportunities and threats relative to effective ballast water policy implementation.

While ballast water management is a complex undertaking. it coincides with the government's shift to promote ecosystem-based planning and management. An effective legislative framework requires the merging of recommended international agreements with national policies and legislation that take into account the varying local needs and priorities of different jurisdictions and sectors. The new legislation needs to focus on prevention through vector management and complying requirements of the IMO's Ballast Water Management Convention (Intergovernmental Oceanographic Commission 2007). Newly developed mandatory instruments should serve as references on requirements for the control and management of ballast water, biofouling on hulls, sea chests, piping, etc. and address technical cooperation and collaboration for research and monitoring (Roberts and Tsamenyi 2008).

3.3 National Ballast Water Management Strategy

While international policies and laws pertaining to ballast water are available for reference, these are often by their nature generic. They need to be further operationalized taking into account local, national and regional issues from environmental, legal and institutional viewpoints. Shine (2008) recognised that a National Ballast Water Management Strategy (NBWMS) is an integral component of the national regulatory framework.

The first step to enable the development of a stronger national legal and institutional framework relies upon the awareness and cooperation among stakeholders; not just in government but also including commodity industries (see Table 3). Developing a NBWM is a complex undertaking that involves a wide range of stakeholders. Brunei share similar key issue with other nations: selection of the most suitable agency in the country in establishing a structure which will facilitate co-operation between the Lead Agency and the Task Force (Tamelander et al. 2010).

Once a Task Force has been formed and a Lead Agency identified, a detailed timeline for delegation of tasks and responsibilities to relevant agencies, expert committees or consultants will help to ensure a timely and efficient process. Tackling issues pertaining to ballast water has been raised at international level and should be reflected in the newly drafted national policies. Key instruments to initiate information gathered through reference on international

Figure 5. Steps in the development of a national strategic framework for ballast water management as proposed in the GloBallast Programme (see Shine 2008).

Table 3. Suggested stakeholders to be involved in the development of National Ballast Water Management Strategy (NBWMS; adapted from Tamelander et al. 2010).

Institution	Responsibility
Maritime authority	Coordination and control of shipping including maritime safety and environmental aspects. Flag and Port state control. Implementation of shipping-related convention and legislation
Environment authority	Overall coordination and management of invasive species problems, including monitoring and response plans. Implementation of biodiversity and environmental conventions and facilities
Port authority	Responsible for the elaboration and implementation of port ballast water management plans (consistent with national strategy) and provision of relevant infrastructure eg. Port reception facilities.
Fisheries administration	Regulates and oversees fisheries and aquaculture, both of which mayprovide pathways for species introductions. NBWMS may have implications for fisheries.
Quarantine authority	Where present, makes and enforces regulations to prevent introduction and transmission of disease and pathogens.
Universities and Research Institutes	Where there are specialists in taxonomy (used to correctly identify species), marine ecology and adequate monitoring method.
Oil & Gas Industry	Activities of the oil, gas and mining industry may provide vectors for species introduction. NBWMS has implications for the industry

agreements and voluntary instruments that have an explicit focus on IAS include the following: Convention on Biological Diversity (CBD 1993); International Maritime Organization (IMO); United Nations Convention on the Law of the Seas (UNCLOS); Food and Agriculture Organization of the United Nations (FAO); and International Union for the Conservation of Nature (IUCN) (Secretariat of the Convention on Biological Diversity 2011). Identification of gaps and consideration for amendments on the existing policies would resolve conflicts between regulations or control activities related to invasive species and the provisions for movement of goods in international trade agreements.

4. CONCLUSIONS

Devastating impact on ecology and economy of unmanaged ballast water discharged can be reduced through coordinated and coherent responses. Implementation of national ballast water management for national level coupled with international collaboration and coordination will strengthen their efficiency to reduce the risk of spreading IAS through ballast water. The Ballast Water Convention provides the set of internationally consistent practices, standards and guidelines ensuring effective control of ballast management, which emphasizes the need for regional and global solutions. Ratifying IMO Ballast Water Convention is a necessary consideration for effective management actions.

REFERENCES

Barry SC, Hayes KR, Hewitt CL, Behrens CL, Dragsund E, Bakke SM. 2008. Ballast water risk assessment: principles, processes, and methods. ICES Journal of Marine Science 65:121–131.

Carlton JT. 1979. History, biogeography, and ecology of the introduced species marine and estuarine invertebrates of the Pacific Coast of North America [dissertation]. Davis: University of California, Davis.

Carlton JT, Geller JB. 1993. Ecological roulette: the global transport of non-indigenous marine organisms. Science 261:78–82.

Creative Resource Strategies. 2010. A state-wide management assessment of invasive species in Oregon. Oregon Invasive Species Council; [accessed 2013 May 18]. http://www.oregon.gov/oisc/pages/statewidemngtassessment2010.aspx.

Department of Fisheries. 2011. Brunei Darussalam Fisheries Statistics in Brief. Brunei Darussalam: Department of Fisheries.

Drake JM, Lodge DM. 2007. Hull fouling is a risk factor for intercontinental species exchange in aquatic ecosystems. Aquatic Invasions 2:121–131.

Gray JS. 1997. Marine Biodiversity: patterns, threats and conservation needs. Biodiversity and Conservation 6:53–175.

GEF-UNDP-IMO GloBallast Partnerships Programme and IUCN. 2010. Economic assessments for ballast water management: a guideline. GloBallast Monographs No. 19. London and Gland: GEF-UNDP-IMO GloBallast Partnerships and IUCN.

Hallegraeff GM, Bolch CJ. 1992. Transport of diatom and dinoflagellate resting spores in ships' ballast water: implications for plankton biogeography and aquaculture. Journal of Plankton Research 14:1067–1084.

Hilliard RW, Raaymakers S. 1997. Ballast water risk assessment for twelve Queensland ports - Stage 5: Executive summary and synthesis of stage 1–4. Ecoports Monograph Series vol 34.

Intergovernmental Oceanographic Commission - National Ocean Policy. 2007. The basic texts from: Australia, Brazil, Canada, China, Colombia, Japan, Norway, Portugal, Russian Federation, United States of America. IOC Technical Series 75: Law of the Sea Dossier 1. Paris: UNESCO.

Kaluza P, Kölzsch A, Gastner MT, Blasius B. 2010. The complex network of global cargo ship movements. Journal of the Royal Society Interface 7:093–1103.

Kennedy VS, Twilley RR, Kleypas JA, Junior JHC, Hare SR. 2002. Coastal Marine Ecosystems and Global Climate Change. Washington DC: Pew Center.

McManus MA, Woodson CB. 2011. Plankton distribution and ocean dispersal. Journal of Experimental Biology 215:108–116.

Minchin D, Gollasch S, Cohen AN, Hewitt CL, Olenin S. 2009. Characterizing vectors of marine invasion. Biological Invasions in Marine Ecosystems 204:109–116.

Raaymakers S. 2002. The ballast water problem: global ecological, economic and human health impacts. RECSO/IMO Joint Seminar on Tanker Ballast Water Management & Technologies; Dubai, UAE.

Roberts J, Tsamenyi M. 2008. International legal options for the control of biofouling on international vessels. Marine Policy 32:559–569.

Ruiz GM, Carlton JT, Grosholz ED, Hines AH. 1997. Global invasions of marine and estuarine habitats by non-indigenous species: mechanisms, extent, and consequences. American Zoologist 37:621–632.

Ruiz GM, Rawlings TK, Dobbs FC, Drake LA, Mullady T, Huq A, Colwell RR. 2000. Global spread of microorganisms by ships. Nature 408:49–50.

SEAFDEC. 2007. Marine Fishing in Brunei Darussalam: Annual production. SEAFDEC; [accessed 2013 Aug 6]. http://map.seafdec.org/Monograph/Monograph_brunei/marine.php.

Secretariat of the Convention on Biological Diversity. 2011. Considerations for implementing international standards and codes of conduct in national invasive species strategies and plans. Canada: United Nations

Environment Programme.
Silvestre GT, Jaafar HMH. 1992. Brunei Darussalam capture fisheries: a review of resources, exploitation and management'. In: Silvestre G, Jaafar HMH, Yusof PSPH, Silva, Chua TE, editors. The coastal resources of Brunei Darussalam: status, utilization and management. Brunei Darussalam: Department of Fisheries.
Shine C. 2008. A toolkit for developing legal and institutional frameworks for invasive alien species. Nairobi: Global Invasive Species Programme.
Smith LD, Wonham MJ, McCann LD, Ruiz GM, Hines AH, Carlton JT. 1999. Invasion pressure to a ballast–flooded estuary and an assessment of inoculants survival. Biological Invasions 1:67–87.
Tamelander J, Riddering L, Haag F, Matheickal J. 2010. Guidelines for development of national ballast water management strategies. GloBallast Monographs No. 18. London and Gland: GEF-UNDP-IMO GloBallast and IUCN.
Williams SL, Grosholz ED. 2008. The invasive species challenge in estuarine and coastal environments: marrying management and science. Estuaries and Coasts: J CERF 31:3–20.

Appendix A. Number of vessels arriving at Muara port (April 2012 to April 2013).

Port of Embarkation	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13
Malaysia	23	44	25	25	26	27	28	33	27	27	20	32	32
Thailand	4	2	4	3	3	3	2	2	2	2	2	4	3
China	10	13	12	5	7	7	7	5	6	6	7	3	6
Singapore	15	14	13	14	13	17	14	19	17	16	16	15	19
Darwin	1	0	0	1	0	1	0	0	0	0	0	0	0
Vietnam	2	2	0	0	0	1	1	0	1	0	3	1	0
Japan	5	5	5	4	5	2	4	3	4	4	3	2	1
Korea	2	0	0	1	1	1	0	2	0	0	0	0	0
Indonesia	1	1	0	1	0	1	1	1	0	0	1	2	2
Pakistan	0	0	0	0	1	0	0	0	0	0	0	0	0
Taiwan	0	0	0	0	0	1	0	0	0	0	0	0	0
Philippines	0	0	0	0	0	0	1	0	1	0	0	1	1
Australia	0	0	0	0	0	0	0	0	0	0	1	1	0