SUSTAINABLE DEVELOPMENT IN THE MARITIME INDUSTRY:

A MULTI-CASE STUDY OF SEAPORTS

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Abstract

Seaports are historic and commercial infrastructures and significant nodes in the logistics and transport chains that form the backbone of national and regional economies. However, ports are also sites of environmental pollution originating from land-based activities, ship movements and ports' own activities that impact the ecology. It is, therefore, increasingly recognized that economic growth in ports must be balanced with environmental protection and social progress. This has led to enhanced appreciation of the need for sustainable development in ports. While much has been written about port environmental practices in European and American ports, there is limited synthesis of sustainable port practices from different parts of the world. Furthermore, in-depth case analysis and critical examination of the challenges of sustainable port development is limited.

Given this gap, this paper presents findings from a qualitative multi-case study research that aimed to analyse sustainable port policies and practices from a range of perspectives as well as to understand the dilemmas, challenges and opportunities faced in attaining SD in ports. This paper reports findings pertaining to the following research questions from a larger study:

1. What specific sustainable practices do ports utilise to manage environmental aspects such as air pollution, water quality, ballast water, dredging and disposal of dredged materials, and hazardous substances?
2. What are the driving and constraining forces in achieving sustainable development in ports?

Four port authorities were studied by reviewing documents and secondary data – the Port of Long Beach (USA), Port of Rotterdam Authority (The Netherlands), Sydney Ports Corporation (Australia), and Transnet Ltd. that owns and manages South African ports. Findings of the study demonstrate that the SD paradigm has gained momentum, albeit to differing degrees, in the functioning, organisation and the very ethos of case study ports. An important theme from all four case studies is that, while there is definite progress towards SD, practices deemed to be sustainable must be critically examined from the perspectives of different stakeholders including shippers, port-related businesses, and the local and global community. Reconciling differences between stakeholders; capitalising on economic opportunities, operational efficiencies and cost-savings offered by environmental-friendliness; public-private partnerships; and policies negotiated by involving all stakeholders were found to foster port sustainability. Furthermore, this study found that globalisation necessitates a more holistic and global analysis of port operations and environment practices in order to be truly sustainable.

Key words: sustainable development; seaports; port environmental management; port environmental practices; globalisation.

Introduction:
With the acceleration of global integration, many countries have a growing dependence on water transportation (UNCTAD, 2007; World Bank, 2001). Seaports are an essential part of the maritime transport industry and have a key role within integrated transport chains (Cullinane, 2002; UNCTAD, 1996). Seaports have served as international trade gateways and crucial economic lifeline of nations by bringing goods and services to people around the world for hundreds of years (Haarmeyer & Yorke, 1993; Nagle, 2009). In the era of globalisation and the rapid expansion of world trade, ports are crucial links in contemporary supply chains and logistics processes, serving as transport hubs with their intermodal transport networks (sea, road, rail and inland shipping) (Bryan, et al., 2006; Pettit & Beresford, 2009; Tovar, et al., 2007; World Bank, 2001). Given their ability to handle and store bulky industrial raw materials such as oil, coal and iron ore, seaports are industrial zones with several industries, such as chemicals and steel (ESPO, 2009a; de Langen, 2004). Thus, the ports industry constitutes the greatest single business complex leading to corresponding impacts on coastal, marine and atmospheric environments (Allen, 1996; Button, 2005; Hinds, 2007; Juhel, 2001; Project GRACE, 2007).

With increasing international and regional regulations to control port pollution and intensified public debates, port communities can no longer avoid environment concerns (AIVP, 2008; Oliver, 2007). Concurrently, ports are also confronted with enhanced competition and pressure to increase services, modernize development, and enhance economic efficiency (AAPA, 1998; GreenPort, 2009a). In order to balance these competing needs, it has become imperative for port authorities to manage port operations in a sustainable manner. The concept of 'sustainable development,' therefore, has been gaining ground in the maritime transport sector in recent years.

While literature on sustainable port development practices in American and European ports has grown (eg. Gilman, 2003; Houston, 2007; MWGI, 2006; Peris-Mora, et al., 2005), there is limited synthesis of sustainable port environmental practices from different parts of the world. Notably, Comtois & Slack's (2007) study of 800 port authorities and 120 shipping lines provides a global overview of SD practices and environmental management systems in maritime transport; however, in-depth case analysis and critical examination of the challenges of sustainable port development are lacking. Given this gap, the present paper presents findings from a larger qualitative research that undertook case studies of ports in four continents to understand and analyse their sustainability policy frameworks and practices and investigate factors that promote or constrain successful implementation. The findings described in this paper pertain to two research questions from the larger study:

1. What specific sustainable practices do ports utilise to manage environmental aspects such as air pollution, water quality, ballast water, dredging and disposal of dredged materials, solid waste, hazardous substances, and land/resource use?
2. What are the driving and constraining forces in achieving sustainable development in ports?

The next section summarises existing literature pertaining to sustainable development in seaports. The subsequent section elaborates the multi-case study research design, qualitative research methodology of document review, and qualitative content analysis that was employed in this study. Research findings for each of the four selected port authorities –Long Beach, Rotterdam, Sydney and Transnet Ltd that manages South African ports are presented and discussed next. The paper concludes with identifying future research directions.

Literature Review

The Conceptual Framework of Sustainable Development:

As early as 1970s, the term 'sustainability' was employed to describe an economy in equilibrium with basic ecosystems (Stivers, 1976). In 1980s, the term 'sustainable development' was widely publicised by the World Commission on the Environment and Development (known as the Brundtland Commission), convened by the United Nations and led by Norway's former Prime Minister Gro Harlem Brundtland. The Commission adopted the following definition: "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (UN, 1987, p. 43). Sustainable development (SD) has since become central to the thinking on environment and development due to its holistic nature that embraces economic, environmental and social dimensions (Koppenjan & Enserink, 2009; Strong, 2009). Sustainability is also increasingly recognised as an essential part of long-term business strategies and corporate social responsibility (Baker, 2009).

Applying the Sustainable Development Framework to Seaports:

The pressures to integrate with the global supply chain, the demand for greater port expansion, the urgent requirement to conserve natural resources, and increasingly stringent international regulations necessitate that ports not just declare their intentions for environmental sustainability but also concretize and demonstrate innovative and sustainable practices (AIVP, 2008; MISL, 2009a; Tillman, 2008).

The literature review demonstrates that the concept of sustainability is gaining awareness in the port industry, requiring them to attain new expertise and apply new practices (e.g. Balbaa, et al., 2009; Comtois & Slack, 2007; Darbra, et al., 2009; Oliver, 2007; Port Strategy, 2008; Sletmo, 2002). 'Port sustainable development' is defined as the situation in which the port is able to meet its needs without endangering its own future (Abbott, 2008). Thus, for ports, sustainability implies business strategies and activities that meet the current and future needs of the enterprise and its stakeholders, while protecting human and natural resources. This means ports must balance their roles as coastal stewards, facilitators of commerce and transportation, and members of their respective communities (Goulielmos, 2000).

Most existing literature, however, has focussed on the impacts of port and shipping operations on the environment (e.g. Paipai, et al., 2000; Carballo & Naranjo, 2002; Pieters, et al., 2002), while some articles evaluate and emphasize the need for SD in maritime transport (e.g. Callaghan, 1998; Giaoutzi & Nijkamp, 1993; Hilling, 2001; IMO, 2001; Saldanha & Gray, 2002). Although these studies have enabled better appreciation of implementing appropriate legislation, they do not elaborate on the implementation and critical evaluation of sustainable practices and associated challenges and opportunities. Thus, there is a significant gap in terms of systematic studies that critically scrutinise the processes and practices of SD (Comtois & Slack, 2007); as such the present study seeks to fill the aforementioned gap. While the importance of different environmental aspects clearly depends on the characteristics of each port, ports face several common environmental issues such as air pollution,[1] water quality,[2] ballast water,[3] dredging and disposal of dredge materials,[4] and storage, transport and management of hazardous substances.[5] Since national and regional legislation usually draw from international agreements (GPA, 2009), literature on international environmental regulations affecting ports was reviewed for this study and is summarized in the Appendix.

3. Methodology

Research Design:

As the purpose of this study was not to achieve causal explanations or predictions, but rather to explore, identify and critically analyse SD practices, a qualitative research approach with a multiple-case study design was employed. Case study designs do not claim generalisability; rather, case studies allow researchers to compare and contrast research findings from each of the cases, thereby promoting theoretical reflections on the findings (Bryman & Bell, 2007; Yin, 2003).

Selecting case study ports:

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[1] Vessels berthed at ports use their auxiliary engines and sometimes their main engines to provide heating, cooling, and electricity, and for loading and unloading cargo, thereby generating significant emissions (Friedrich, et al., 2007). Similarly, road and rail transport and industrial activities in port areas generate emissions of carbon dioxide (CO2), nitrogen oxides (NOx), sulphur oxides (SOx) and particulate matter (PM) (Bailey, 2004; ESPO, 2009a).

[2] Sources of water pollution in ports include wash water of oil tankers, cabin water, gas stations on shore, repair and moving machinery; runoff water from storm drains and coal storage, wash water from terminal surfaces; port region and ship sewage and industrial wastewater; Ship discharge (bilge water) which can contain water, oil, dispersants, detergents, solvents, chemicals, particles and more (EcoPorts Foundation, 2006a; IAPH 1999).

[3] Ballast water is used by ships for maintaining stability when navigating with little or no cargo. Seawater is widely used as ballast material, and it is usual practice to get seawater from near the ship or the port of discharge. Local water, however, contains aquatic organisms and bacteria, which get transported with ballast water. When the ship reaches the next port for loading or discharging cargo, it ejects this ballast water into the local harbour, thereby introducing foreign organisms. The alien species released can survive and reproduce, often preying on native species or competing with them for food and/or space, and threatening local ecosystems (Reynolds, 2004).

[4] Dredging consists of periodic removal of sediments from seabeds in port approach channels to maintain water widths and depths to ensure safe access for ships. The disposal of dredge materials can have adverse effects on biophysical health of lagoons and water quality due to acute chemical toxicity, increased suspended sediments and release of contaminants (Bolam, et al., 2006; EcoPorts Foundation, 2006b).

[5] In an increasingly globalised world, where goods are transported by sea in ever-increasing quantities, dangers of permitting hazardous substances to cross borders is escalating. Hazardous wastes (hazwaste) constitute the biggest component: yearly trade in hazwaste is estimated at $10-12 billion (D'Monte, 2009). While hazwaste and handling of hazardous goods are of concern, there is increasing trepidation about marine oil pollution and oil spills particularly after the grounding of *Exxon Valdez* that spilled 30,000 tons of oil in Alaska in March 1989 (Farthing & Brownrigg, 1997).

Keeping in view time and resource constraints, four cases were selected to enable a broad overview of the issues, yet allow their in-depth examination. To identify cases, academic literature, press reports and leading shipping journals were consulted. However, because most articles pertain to European or American ports, the selection of cases presented considerable challenge since the study was conceptualised as having a global character. Following Bryman & Bell's (2007, p. 68) suggestion, this research is not restricted to high-profile 'success stories' alone. For instance, although the award-winning port of Long Beach (USA) was studied, this research also involved ports that 'have made significant moves' (e.g. South Africa) towards SD. Thus, the following ports were selected:

1. Port Authority of Long Beach, USA;
2. Port Authority of Rotterdam, The Netherlands;
3. Sydney Ports Corporation, Australia; and
4. Transnet National Port Authority that manages South African ports.

Data Collection:

Since the purpose of this research was to critically analyse SD practices undertaken by ports, secondary data from a wide range of documents were deemed to be most appropriate to give a balanced view of port sustainable practices. Document reviews reveal what people/organisations do or did and what they value. This behaviour occurs in a natural setting, so the data has strong validity (Scott, 1990). Documents were retrieved from various print and internet sources, such as port websites, printed and online reports, manuals and handbooks, scientific literature including books and peer-reviewed journal articles, maritime magazines and journals, and news reports. For each of the case study ports, a range of key words was used to search for documents.[6]

Validity of data:

To ensure validity, data obtained in this research were selected carefully. Articles or reports that were outdated were discarded, except when used to indicate an idea that was relatively constant. For internet sources, editable sites (ex. wikipedia), blogs and forums, and non-copyrighted content and sites that accept open contributions were disregarded to ensure data was factual. Data analysis incorporated all relevant evidence and included rival interpretations. Port documents (e.g. annual reports) were not solely relied upon: both corroborating and contesting information from various sources were included.

Data analysis:

Data were analysed thematically (van Manen, 1998), where categories and patterns that contributed to the core theme of SD were identified. Following Strauss & Corbin (1990), each document was read repeatedly and significant statements relating to various aspects of SD in ports were identified and demarcated. Labels (codes) were assigned to these categories and later

[6] Key words included port name and the following terms: sustainable development, environment management, air pollution, air quality, water quality, ballast water, dredging, dredged material disposal, hazardous materials management, hazwaste, port expansion, and port development.

standardised across documents pertaining to each case study port. The goal was to create descriptive, multi-dimensional categories which formed a preliminary framework for analysis. The next stage of analysis involved re-examination of the categories to determine their interrelationships, a process called axial coding (Strauss & Corbin, 1990). Axial coding puts data back together in new ways by making connections between categories. Categories that dovetailed together in meaningful yet distinct ways were then developed into core analytical themes.

Results and Analysis

Case Study 1: Port of Long Beach (POLB):

Background:

The Port of Long Beach (POLB) is a public agency managed and operated by the City of Long Beach Harbour Department. The port lands are owned by the City of Long Beach. POLB is a landlord port: it leases terminals to private shipping and stevedoring companies. POLB is the second busiest seaport in the United States (POLB, 2011). Over the past decade, POLB container traffic has risen 108% (Cannon, 2008). Although POLB has been a trailblazer in environmental stewardship winning several international awards (POLB, 2011b, 2011c), its rapid expansion has significantly impacted the environment and human health (Bailey, et. al., 2004).

POLB operationalizes SD mainly through its Green Port Policy adopted in 2005, which mandates reduction of negative environmental impacts while maintaining economic benefits of international trade (Musser, 2008; POLB, 2011d). The Green Port Policy directs the port to proactively foster an organizational culture of environmental enhancement, fiscal responsibility and community integrity. This culture extends beyond port staff to the port's customers and other stakeholders.

<u>*SD practices:*</u>

Air Pollution:
In 2006, POLB and Port of Los Angeles initiated the San Pedro Bay Ports Clean Air Action Plan (CAAP) – a comprehensive landmark framework to reduce air pollution from port operations by 45% by 2012 whilst accommodating growth in trade (Ellis, 2007; GreenPort, 2009b; IAPH, 2007; POLB, 2011e). CAAP includes:

(i) *Clean Trucks Program (CTP):*

In 2007, POLB launched the CTP that bans diesel trucks built 1998 or earlier from serving the port. Truckers can apply for subsidies to finance truck replacement, for which POLB collects a fee. The fee is waived for privately-financed clean trucks (CCJ, 2009a). However, the CTP faces several controversies. Trucking companies are recouping their investment by charging higher drayage rates; consequently, retailers and other shippers are diverting shipments to other ports to avoid the fee (Mongelluzzo, 2009a). Moreover, while environmental groups support CTP, in July 2008 the American Trucking Association (ATA) filed a lawsuit challenging CTP's plan to require truckers to obtain concessions and licenses to enter port facilities, giving the port authority to regulate truckers' business intricacies including hiring, truck safety, driver credentials, security measures, and financial disclosures (Mongelluzzo & Nall, 2008). These regulations have no connection to the environment (Page, 2009). ATA claims the port's plan, which could add more than a $1billion per year to drayage costs, violates the US Constitution by hindering interstate commerce (Gallagher, 2008). In 2009, the US Court of Appeals for the Ninth Circuit ruled in favour of ATA (CCJ, 2009b).

Meanwhile, POLB has subsidised the purchase of trucks with liquefied natural gas (LNG) engines (Cannon, 2009; Quinn, 2007). While these trucks cost almost twice as clean-diesel trucks (Mongelluzzo, 2009b), an LNG truck can save between $0.35 and $1.73 per gallon (Cox, 2009). However, because 2010-model diesel trucks will be 98% cleaner than pre-1989 diesels, questions remain about the cost-effectiveness of POLB's LNG promotional efforts (Mongelluzzo, 2009b). Moreover, critics emphasize that engine-makers have overstated environmental benefits of LNG engines: although LNG emits less NOx and SOx, it releases more methane - a greenhouse gas (Eason, 2008). There is hope that the methane slip can be solved with further technological developments.

(ii) Green Flag program:

The Green Flag program provides approximately $2 million a year in discounts and environmental recognition for vessel operators who slow their ships to 12 knots (22 km/h) or less within 32 km of the harbour, thereby reducing emissions (POLB, 2011f; Quinn, 2007).

(iii) Shore-side electricity:

POLB has built new infrastructure to provide shore-side electricity (also known as cold-ironing) to container ships (Dibenedetto, 2004; POLB, 2011g). Shore-power allows ships to shut their diesel engines at berth and plug into landside electricity grid to improve air quality.

(iv) Green leases:

POLB has signed 'green leases' with terminal operators, which require cold-ironing, the use of clean fuels at berth, and replacement of cargo-handling equipment to meet tougher standards of the Environment Protection Agency (EPA) (Bonney, 2007; Mongelluzzo, 2006; POLB, 2007).

(v) Cleaner vehicles:

POLB committed $5 million to replace all locomotives with cleaner units by 2008 (Smith, 2006). POLB has also retrofitted diesel-powered maintenance equipment with diesel oxidation catalysts and clean diesel fuel mixed with biofuel/ethanol, and begun replacement of the gasoline-powered fleet with compressed natural gas (CNG)-powered vehicles (Cannon, 2009; POLB, 2011f). POLB is developing a hybrid tugboat, which will reduce air pollution by at least 44% and consume 30% less fuel (Cannon, 2008; POLB, 2007).

However, scientific evidence suggests corn-based ethanol production negatively affects the environment and communities (de Fraiture & Berndes, 2009; Howarth, et al., 2009). Biofuel production increases greenhouse gas emissions relative to fossil fuels, by transforming farming practices and taking away agricultural land earlier used for food crops, besides competing for freshwater that is increasingly in short supply. Hence, sustainability benefits of biofuels have been increasingly questioned.

(vi) Other clean technologies/measures:

POLB requires contractors to use ultra-low-sulphur diesel in construction equipment (Smith, 2006; POLB, 2011f). However, unavailability of low-sulphur fuel, their higher cost, and lack of separate storage tanks to prevent contamination from diesel are major impediments (Eason & Joshi, 2009; POLA, 2005).

Further, POLB has promoted intermodal transport.[7] In 2009, the Middle Harbour Redevelopment Project (MHRP) was approved that will double capacity at two container terminals while halving air pollution by adopting green initiatives (Kanter, no date). MHRP will add 65,000 feet of track to move cargo by train, taking trucks off roads (JoC, 2009; GreenPort, 2009c). In 2001, the Alameda Rail Corridor was designed to move freight to a satellite terminal about 30 km away to reduce traffic congestion and air pollution (GAO, 2005a; Steinberg & Watson, 2001). Unfortunately, the $2.5 billion Corridor continues to operate under-capacity, without alleviating congestion (Bailey, et al., 2004).

Water Quality:

In 1992, POLB adopted the Storm Water Pollution Prevention Program that goes beyond what is required by federal and state law. Contractors and tenants follow best management practices to prevent soil erosion and pollutants from entering storm drains. POLB manages the National Pollution Discharge Elimination System storm-water permits and ensures tenants’ compliance through inspections and training (POLB, 2011h, 2011i).

However, POLB does not treat storm-water and has not addressed the link between toxic pollutants in storm-water runoff and their impact on sediment and water quality. It does gather information on potential pollutants, spills, and control measures from each of the facilities, helping identify areas for improvement.

Ballast Water:

Mid-ocean ballast water exchange (BWE) is currently the only treatment for ballast water for ships in the US.[8] However, scientific studies have questioned mid-ocean BWE efficacy since most emptied vessels contain significant amounts of sediment with invasive species accumulated at the bottom of ballast tanks (Gollasch, 1997; Hallegraeff & Bolch, 1992; Zhang & Dickman, 1999). POLB is testing a new shipboard treatment system to remove oxygen levels of ballast water, thus destroying organisms (POLB, 2007).

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[7] Intermodalism implies moving from road transport to rail, inland and short sea shipping (van Ierland, et al., 2000).

[8] Ballast water exchange consists of flushing coastal water from ballast tanks, replacing it with oceanic waters to reduce the concentration of coastal organisms since oceanic organisms are unlikely to colonize coastal habitats (GAO, 2005b; Reynolds, 2004).

Dredging and disposal of dredged materials:

Long Beach harbour, with draughts ranging from 60 to 80 feet, requires little or no dredging. POLB dredges more to create new terminal area than to enable deep-draught ships to enter (Gibb, 1997). POLB's Green Port Policy emphasizes removing, treating or rendering suitable for beneficial reuse contaminated soils and sediments. Reuse of dredged sediments has occurred when channel dredging coincided with landfill construction for direct disposal from one to the other (Houston & Steinberg, 2008).

In the past 10 years POLB has removed nearly 200,000 tons of contaminated soils and sediments from the environment and disposed them in approved landfills and recycling facilities (POLB, 2011j). Contaminated areas are made productive – a process of beneficial re-use known as 'brownfield redevelopment'. Contaminated dredged sediment has also been used as construction fill material to reduce the cost of imported fill (CCC, 2003; Steinberg & Watson, 2001). Besides, POLB sequesters contaminated sediments in a confined disposal facility (CDF) capped with clean sediment, thereby preventing contact with the sediment surface and water column (CCC, 2003; Lukens, 2000).

Hazardous substances:

California law prohibits discharge of any petroleum product, refuse liquid or solid, and substances deleterious to fish, plant life, or bird life (SWRCB & CEPA, 2003). Hazardous waste rules of EPA require facilities to properly store, label and seal hazardous waste containers (EPA, 2008).

However, US hazardous waste regulations do not cover exports. US Government Accountability Office (GAO) noted that with globalisation, hazardous waste is illegally being increasingly exported through many US ports (Stephenson, 2008). There is inadequate data on hazwaste exported specifically via POLB except for GAO testimony that mentions an illegal shipment of CRT monitors originating from Colorado was intercepted in Hong Kong and returned to POLB in 2008 (Stephenson, 2008).

<u>Driving and Constraining Forces:</u>

Stakeholder relations:

Southern California has the dubious distinction of having the poorest air quality in the US (Avol, 2007; Joshi, 2008; Sharma, 2006). Hence pressures from community and environmental groups have been a driving factor in POLB's environmental efforts. POLB has involved local communities, tenants and other stakeholders, including operators, port workers and regulatory agencies in its sustainable achievements (Houston, 2007; POLB, 2007; POLB, 2011k, 2011l).

However, in an effort to publicise goals and announce deadlines, POLB has heightened expectations with the local community and environmental groups, resulting in failure and criticism (Bailey, et al., 2004). For example, implementation of CTP was originally scheduled for July 2007, but has been rescheduled multiple times. POLB's failure to meet these deadlines also resulted in threats of litigation (McLaurin, 2008; LB Report, 2008).

Economic factors:

The costs of implementing CAAP alone are huge (Cannon, 2008). Shippers are diverting cargo to other ports because of the plethora of fees POLB charges to fund infrastructure and environmental programs (Mongelluzzo, 2009c). Besides, with California facing a $29 billion budget deficit in 2009, there is little money for infrastructure projects to sustain POLB's economic viability (McLaurin, 2008).

Globalisation:

Globalisation has led to increased trade and competition (McLaurin, 2008). POLB predicts the need for 1,100 acres of new container cargo space and 400 acres of other types of terminal space to accommodate cargo volumes projected for 2020, which worries environmentalists (Bailey, et al., 2004; LB Report, 2008).

On the positive side, globalisation has enabled international collaborations to exchange knowledge on sustainable practices. In 2007, POLB and Port of Shenzhen, China, signed a formal agreement to exchange information on their best environmental practices. POLB has also signed similar agreements with ports in Mexico (POLB, 2007).

Legislation/Regulations:

U.S. federal impetus on green initiatives has been a driving factor: port interests are encouraged by federal stimulus programs promoted by the Obama administration, which has linked green initiatives associated with infrastructure development projects as integral to the economic stimulus plan (Mongelluzzo, 2009d). The US and Canada have proposed the world's largest emission control area. California has established its own emission standards to introduce these limits far sooner than the timetable proposed for the North American emission control area (Wallis, 2009a).

Case Study Port # 2: Port of Rotterdam Authority (PoR), The Netherlands

Background:

PoR is as an independent company with a professional Executive and a Non-Executive Board appointed on a commercial basis, as described in the Netherlands Corporate Governance Code. The Municipality of Rotterdam is a shareholder; yet, the city and port collaborate on major issues. Port land belongs to PoR that it leases to businesses (Paipai, 1999; PoR, 2007a).

PoR is the busiest seaport in Europe (PoR, 2008a) with annual throughput of more than 421 million tonnes of goods (de Langen, 2004; PoR, 2008b). Rotterdam is recognized as a European leader for cleaner technologies and efficient port practices (POLB, 2009b).

PoR is guided by its Port Vision 2030 prepared along with clients, government departments, knowledge institutes and societal organisations. Building on Port Vision 2020 that aimed to develop PoR into a 'quality port,' Port Vision 2030 envisages by 2030 Rotterdam will be Europe's most important port and industry complex with a strong combination of the Global Hub (logistics and industrial pillars of the port complex) and Europe's Industrial Cluster (largest, most modern and sustainable petrochemical and energy complex of Europe). Sustainability is envisioned as having the smallest ecological footprint in the world, achieved by sustainable transportation modes, clean fuels and efficient logistics chains (PoR, 2011a). PoR has addressed environmental management through its corporate social responsibility program that is an integral component of its Business Plan 2006-2010, which was refined further in 2007 making sustainability a priority goal. PoR believes that a healthy environment offers competitive advantages (Paipai, 1999). Therefore, it emphasises combining economic objectives with the broad concept of 'liveability' encompassing environment, safety and quality of life aspects (Kolk & van der Veen, 2002). In 2008, the focus was on climate, labour and education, knowledge exchange and anchoring sustainability within the organisation (PoR, 2011b).

SD Practices:

With growing trade volumes, PoR is expanding the port area by a land reclamation project called Maasvlakte 2 to increase port size by 20% (PoR, 2008b; Visser, 2007). Maasvlakte 2 will promote sustainability by clustering businesses, whereby companies that can benefit from each other's residual products and residual heat are all within easy reach, resulting in energy and raw material savings. Secondly, wind turbines will be installed on the solid sea defences. Thirdly, sustainable logistics has set 45% minimum requirement of waterborne transport to achieve intermodal transport to hinterland networks (RPI, no date). Sustainability is also a part of tender procedures at Maasvlakte 2 (DPC, 2009; PoR, 2007b).

Air Pollution:

Port Vision 2020 and 2030 have endorsed numerous strategies to reduce air pollution. PoR is contemplating using natural gas for barges between port and inland destinations. It is also developing a sustainability shipping index to create financial incentives, such as lower fees for clean ships that comply with the index (Cannon, 2009; GreenPort, 2008a).

PoR installed shore-based electricity facilities for inland shipping in 2007 (GreenPort, 2008b; PoR, 2007b). However, European Sea Ports Organisation (ESPO), representing common interests of ports in Europe, maintains technical changes to vessels are far more effective in reducing emissions at sea and in ports, since ships spend only limited time at berth. The average operating hours of engines per year at sea is 6,000 and only 700 at berth. Moreover, shore-side electricity is delivered by land-power grids, which produce considerable CO_2 emissions. Therefore, ESPO believes that shore-side electricity has limited advantage in improving air quality (ESPO, 2008).

PoR's Green Awards program rewards ship owners and managers who demonstrate environmental stewardship (Hoebee, 2009; PoR, 2007b). PoR’s own vessels have switched to low-sulphur fuel (Einemo, 2007; PoR, 2007b). However, as stated earlier, there is limited availability of low-sulphur fuel (Eason & Joshi, 2009).

PoR has replaced hydraulic and truck diesel engines in AGVs (unmanned vehicles for transporting containers) with electric motors and small diesel engines respectively. A feasibility study has been undertaken on using fuel cells in inland vessels (PoR, 2007b).

Rotterdam’s location on the estuary of the rivers Rhine and Mass enables efficient and economic transport by inland vessel deep into the heart of Europe. PoR is investing substantially in intermodal approach including transport by road, rail and inland waters and pipelines to reduce pollution (de Langen & Chouly, 2004). It is also developing a Container Transferium, where container flows are combined and transported by barge between sea terminals and Rotterdam’s immediate hinterland, to reduce congestion and improve air quality (Hill, 2008; PoR, 2008c). In 1995, it was decided to build a new rail link (Betuwe line) to transport goods from Rotterdam to other European places (van Ierland, et al., 2000; van Wee, et al., 2003). However, this has been strongly criticised by environmentalists since the rail link, while having some environmental benefits, will be accompanied by ecosystem fragmentation, visual pollution and noise. Studies show, Betuwe rail link contributes only modestly to reducing environmental problems, and inland shipping is a better alternative (Annema, et al., 2007; van Ierland, et al., 2000).

By the end of 2011, PoR aims to reduce its CO2 footprint by 35% compared to the footprint in 2007. PoR is, therefore, encouraging the use of biomass in coal-fired power stations, use of biofuels, and innovation with regard to the next generations of biofuels. PoR aims to become the European centre for bio-diesel and bio-ethanol fuel production. The supply of raw materials from abroad using the biggest sea vessels is relatively cheap in PoR. The CO2 in the production process will be captured, compressed and transported via pipelines to greenhouses for use in growing plants and vegetables (GreenPort, 2008c; PoR, 2007b).

Water Quality:

Measures dealing with water quality in the Rhine river are among the most rigorous in the world. Under the European Water Framework Directive, the Netherlands is required to set new standards for water quality by assessing ecological risks and developing remediation measures (Heise & Forstner, 2006). Licenses for industry are being modified according to the new requirements of the Water Framework Directive, in which PoR is also involved (PoR, 2007b).

Ballast Water:

PoR is the largest ballast water exporter in the world at some 14 million tonnes discharged in other ports annually (Oliveira, 2008; van Niekerk, 2008). No specific ballast water discharge regulations exist in the Netherlands. Most incoming ships exchange ballast water at high sea. Currently no information is gathered by the Shipping Inspectorate from visiting ships in PoR (van Niekerk & Adnitt, 2004; Veritas, 2005). PoR is currently participating in ballast water testing programmes.

Dredging and disposal of dredged materials:

A major issue in the Rhine delta is the toxin-filled dredge from PoR dumped since the 1970s (UNEP, 2008). Rotterdam requires intensive maintenance dredging yielding 20 million m3 of sludge annually (Alcock, et al., 2003; PoR, 2005). Rotterdam uses sea disposal as a relatively cheap procedure for less contaminated dredged sediments (Forstner & Heise, 2006; GreenPort, 2008d). More contaminated dredge material is stored at De Slufter, a confined isolated disposal site (Allan, et al., 2005; PoR, 2005). Dredged materials disposed off-shore comply with Dutch quality standards. However, studies show dredged materials can have toxic ecological effects such as endangering the survival of oyster larvae (van den Hurk, et al., 1997) and adversely affecting marine benthic resources by physical disturbances that may be caused by dredge disposal (Stronkhorst, et al., 2003). PoR aims to ensure that all dredged material is sufficiently clean by 2015, so that it can be relocated at sea or beneficially re-used (PoR, 2005, 2007b).

Hazardous substances:

PoR has reception facilities for oily and chemical waste. Spills of hazardous materials must be reported immediately and equipment is available to allow for speedy clean-up, with the ‘polluter pays’ principle.[9]

To detect hazwaste as mandated by law, in 1999, a powerful scanner was introduced to detect the contents of containers travelling through PoR.[10] More than 5 million containers pass through PoR annually; about 80 a day are X-rayed. Images obtained are compared with the description of the product on the consignment note. If found suspicious, the container is opened for checking (UNESC, 2000). However, it is impossible to check every container. Dutch Environment Enforcement Agency observed exporting waste through European ports has become common. There is no accurate database on waste shipments, unless such containers are detected and enforcement procedures are launched. In 2003, 51 containers were intercepted at PoR - these contained illegal electronic waste from Ireland en route to Indonesia, India and Singapore (Renout, 2004).

Driving and Constraining Forces:

Stakeholder relations:

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[9] The ‘polluter pays’ principle requires those who are engaged in disposal or incineration at sea bear the cost of meeting the pollution prevention and control requirements for the authorised activities (Salomons & Gandrass, 2001).

[10] Under the Basel Convention, implemented into legally-binding EU law, exports of hazardous waste from the EU to non-OECD countries are prohibited (D'Monte, 2009; Ermacora, 1998).

PoR has emphasised strengthening external and internal communications to garner support for sustainable operations (PoR, 2007b). Recently a 'PortCast' (an internal PodCast) discussed the issue of air quality. Port Infolink, funded by PoR, efficiently exchanges information with operators to improve terminals-hinterland interface for handling inland shipping, trains and trucks (de Langen & Chouly, 2004; PoR, 2008a). Besides, public-private partnerships have played a key role. PoR initiated Quality Rail Rotterdam - a public-private partnership - to optimise rail transport quality.

PoR adopts a consensus-oriented, rather than conflict-oriented approach (Deelstra, et al., 2003). When negotiations for Project Mainport Rotterdam reached an impasse with NGOs, the manager brought together all stakeholders to co-create a shared vision by expanding the project's objective towards a more integrated idea of PoR development. Maasvlakte 2 is an example of an alternative to top-down, 'expert'-driven port planning (Daamen, 2007; Edelenbos, et al., 2008; Kelly, 2005).

Lack of data:

Lack of information on emissions from rail and ship engines running on low-sulphur fuel has hampered PoR's implementation and monitoring efforts (van Wee, et al., 2003). Furthermore, although the fate of dredged materials is based on 'Chemical Toxicity Test' values, assessment of sediment quality is still prone to a number of uncertainties and insufficient information about regulation, analytical methods, risk assessment and management (Forstner & Heise, 2006). Besides, there is need for harmonising data from various testing procedures of dredge materials, systems to measure sand in the sediment, and long-term monitoring system in the Slufter (Alcock, et al., 2003).

Economic factors:
The introduction of shore-side electricity is hampered due to concerns about the high costs required to install or retrofit and expand utility lines, substations and vessels. Lack of international standards for shore-side electricity increases the risks for investments in this measure. Two recent Dutch studies indicate that shore-side electricity at present is not viable for container vessels in Rotterdam due to high costs and the relatively low environmental benefits as well as uncertainty about future cold-ironing standards (Hammingh, 2007).

Globalisation:
Unbridled growth in trade with Asia continued unabated in 2007. This has created considerable pressure on the terminals and hinterland connections (PoR, 2007b). Furthermore, geographical origins of raw materials for bio-fuels (eg. cole seed, grains, palm nuts, soya beans, sugar cane, jatropha nuts) are in Asia, Africa, North and South America, Central Europe, Germany, France and Spain (GreenPort, 2008d, 2008e). This has created major controversies. For instance, jatropha, typically grown in India, is being introduced for cultivation in a large area of Rajasthan without any consultations with local people. Farmers have been encouraged to produce biofuel raw materials. Those who refuse are evicted without issuing notices despite holding valid documents for their land (The Hindu, 2007). A World Bank report shows the shift towards cultivation of biofuel raw materials have forced global food prices up by 75% (Chakraborty, 2008).

However, globalisation has also led to international opportunities. Recently, PoR partnered with Senegal, West Africa to develop sustainable practices (PoR, 2007b).

Legislation/regulations:
Progress in European port environmental activities has been driven by increasing number of legislation. In June 2006, the European Commission released its *Maritime Policy Green Paper*, followed in October 2007 by an official action plan, called the *Integrated Maritime Policy for the European Union*, which creates a roadmap to facilitate continued growth in maritime activities while reducing their ecological footprint (Cannon, 2009).

However, societal pressures and strict EU legislation often result in delays to port expansion projects, putting port authorities under constant pressure to defend their 'licence to operate' (Verhoeven, 2009). Implementation of environmental legislation is also not consistent throughout the EU due to different interpretations by member-states. This results in distortion of competition because certain ports are subject to stricter conditions (ESPO, 2009b; GreenPort, 2008f). To level the playing field, Dutch seaports have undertaken 'self-regulation' and information exchange between European ports (Kolk & van der Veen, 2002). The EU now officially recognises the problem and is developing guidelines to reduce confusion.

Case Study # 3: Sydney Ports Corporation (SPC), Australia:

Background:

Australian ports were converted from departments of the State Maritime Boards to publicly-owned corporations under the Ports Corporatisation and Waterways Management Act to ensure greater commercial and customer focus in port operations (Piyapatroomi, et al., 2006; SPC, 2004a).The Sydney Ports Corporation (SPC) was established in 1995 as a state-owned corporation managing Port of Botany and Sydney Harbour Port that together handle one-third of Australia's containerised trade (SPC, 2011a). As a port corporation, SPC is a government-owned landlord port that leases port terminals and facilities to various companies. SPC views sustainability as fundamental to corporate social responsibility (SPC, 2003a, 2007a, 2011a). SPC has also developed 'Green Port Guidelines' to encourage port operators to adopt sustainable approaches and innovations in design and operations (GreenPort, 2008g; SPC, 2006, 2007b).

SD Practices:

Air Pollution:
Unlike POLB and PoR, the easy availability of low-sulphur fuel has led to much lower SOx emissions in Sydney compared to the national average (NSW Parliament, 2006). SPC uses fuel that contains 10% of the amount of sulphur in ordinary fuel, thereby reducing air pollution (Comtois & Slack, 2007; NSW Parliament, 2006). Dust monitoring and air sampling is conducted prior to and during construction. Various control measures, such as using water sprays, re-vegetating exposed areas and constructing wind breaks, are in place to prevent excessive dust during construction (SPC, 2008a).

SPC supports maximising the use of rail to transport cargo between ports to reduce air pollution from trucks (SPC, 2003b). However, NSW Parliament (2006) observed that although the impact of Port Botany expansion is proposed to be mitigated by moving 40% of freight by diesel freight-trains, using diesel-powered engines without any regulatory framework will only increase emissions. The NSW Government aims to implement a system to regulate diesel emissions from freight trains.

Water Quality:

Past poor industrial practices have extensively contaminated Sydney harbour (Birch, 2000). As part of its Storm Water Management Plan, SPC has installed three storm-water treatment devices to capture sediments, oil, grease and litter. All operators are required to treat storm water prior to discharge. For Botany Bay expansion, SPC has implemented a Soil and Water Management Plan to control erosion of soil and sedimentation, besides ongoing water quality monitoring (Merz, 2005).

Ballast Water:

Ballast water discharges in Sydney's ports do not occur frequently; surveys by SPC show that dead toxic dinoflagellate cysts, which can potentially harm marine fauna and flora, are the only target marine pests found in Sydney ports (SPC, 2003b). However, mid-ocean exchange of ballast water, currently the most common way of handling ballast water, is only partially effective in removing dinoflagellate cysts settled to the bottom of ballast tanks (Hallegraeff & Bolch, 1992).

Dredging and disposal of dredged materials:

Before the twentieth century, dredging was regularly undertaken to accommodate larger ships with deeper draughts, and dredged sediment was used to reclaim mudflats or marshes, thereby creating additional useful waterfront land. Dredging is now intermittent, and carried out largely to facilitate navigation for specific projects or minor maintenance to remove sediment from storm water drains (Ling, 2007; SPC, 2003b).

Dredging required for Botany Bay expansion has led to several environmental measures, including the use of silt curtains to prevent sediment from flowing into the water (Jarrett, 2008; SPC, 2011b). However, environmentalists maintain that consequent environmental damage (e.g. tidal changes and disturbance of fish and bird breeding grounds) will be extensive (Zin, 2008).

Hazardous substances:

SPC takes a proactive approach to prevent oil pollution incidents during refuelling operations and ensuring that an international ship-to-shore safety checklist is completed prior to every bulk oil, gas and chemical transfer (SPC, 2003b). SPC provides 24-hour immediate emergency response unit, with well-equipped response equipment and staff for emergencies.

SPC ensures that dangerous goods are transported in strict accordance with statutory requirements. SPC maintains a database of all dangerous goods imported to, exported from, or transiting Sydney ports, in an internet-based system known as ShIPS (Sydney's Integrated Port System) (SPC, 2004b).

Driving and Constraining Forces:

Stakeholder relations:

SPC is committed to working with all stakeholders and local communities to minimise negative impacts of port operations. A range of initiatives exist, including sponsorship of local events and establishment of consultative committees and liaison groups (SPC, 2008b, 2011c, 2011d).

Although Carew (2002) contends Botany Bay development has been a pioneering exercise in collaborative relationships between different stakeholders, a commission of inquiry set up in 2004 to investigate controversial proposals found strong opposition from local councils, community groups and residents (Tull, 2006). According to this assessment, port planning has been poorly integrated with city development and environmental impact inquiries have not consulted affected city populations.

Lack of data:
The lack of good quality and regionally comparable data in Sydney ports has hindered the development of appropriate management strategies and legislation for the coastal zone (Birch, 2000).

Globalisation:
Strong consumer demand for imported products and a lower competitive Australian dollar have increased global trade in Sydney ports, necessitating port expansion to accommodate this growth with concomitant environmental problems (Martin, 2003).

Legislation/Regulations:
The House of Representatives (2007) in its report noted frequent delays in the government's approvals process on environmental issues, thereby often disrupting capital and maintenance projects. The report points to the lack of agreed mechanisms and coordination in setting standards between and within the Australian government and states/territories regarding dredging and dredge-material disposal approvals. The report further mentions that the government's dredging and disposals review process raises the environmental bar for every subsequent application, leading to increasing costs and little overall benefit.

Case Study # 4: Transnet National Ports Authority (TNPA) and Transnet Port Terminals (TPT), South Africa (SA):

Background:

Transnet Ltd is the state-owned South African transport business conglomerate which controls (i) Transnet National Ports Authority (TNPA) that has monopoly over the landlord function in all ports, (ii) Transnet Port Terminals (TPT) that manages port operations, (iii) Transnet Freight Rail, and (iv) Transnet Pipelines - the national petroleum pipeline network (van Zyl, 2005; Visser, 2007). Transnet, established in 1990, is the successor of South African Transport Services (SATS), formed during the days of apartheid as a highly centralized organization. Transnet Ltd's only shareholder is the State, which controls the core transport infrastructure (Mayer & Onyango, 2005). TPT monopolises handling of most commodities, particularly containers (Thompson, 2009). Private operators under leases handle only bulk commodities serving as niche markets without competing with each other or TPT.

Transnet currently does not have a comprehensive sustainability policy, although its 2008 annual report included a sub-report on sustainability. TPT (2003; 2011a) believes in integrating safety, health, environment and quality (SHEQ) within all activities.

SD Practices:

As ensuing sections suggest, limited information is available on sustainable practices in SA ports:

Air Pollution:
Transnet prohibits ships from producing smoke within port confines, although reasonable amounts (not specified) are tolerated during engine start-up. Dust mitigation measures include conveyor covers; a sprayer system on stockpiles, online moisture analysers, surfactant sprays, paving of loading areas, and using dust monitors (TPT, 2008, 2011b).

The number of containers conveyed by road has increased tremendously in recent years. Inter-modal facilities are generally inadequate – South Africa does not have inland waterway transport (Khumalo, 2003). The quality of rail services to the hinterland differs for bulk and container cargo. Transnet Freight Rail (earlier Spoornet) is the sole provider of train services mainly for handling bulk cargo. Container rail services are hardly developed; hence most containers move by road. Spoornet's monopoly in the rail market has prevented entry of private firms (de Langen & Chouly, 2004). Recently, the government and Transnet promised greater use of South Africa's railways in transporting freight (FinWeek, 2008; Naidoo, 2007).

Besides, Transnet has embarked on internal restructuring programmes, particularly in managing supply chains and procurement processes whereby bookings can be captured and containers released from customers' own desks without their truck drivers waiting in queues in ports to collect containers (MISL, 2009b). This has reduced traffic congestion and air pollution.

Water Quality:

Recent studies in South Africa have shown that anthropogenic activities lead to heavy metal contamination of sediments within ports (de Boer, 2008; Durban Metro, 1999a; Fatoki & Mathabatha, 2001). An integrated harbour water quality management plan has been proposed to manage the sensitive marine ecosystem, particularly in Durban (Durban Metro, 1999b).

Ballast Water:
South Africa, as a signatory to International Maritime Organization's[11] Ballast Water Management Convention, has developed a Ballast Water Management System awaiting approval of its Maritime Safety Authority (PMG, 2007). South Africa has also participated in IMO's Global Ballast Water Management Program (GloBallast) that is developing best-practice guidelines (Naidoo, 2007). Yet, uptake from and discharge of invasive marine species into the harbours continue to be major problems (Le May, 2004).

Dredging and disposal of dredged materials:
By law, marine disposal of dredged material is subject to the approval of the division of Marine and Coastal Management of the Department of Environment Affairs and Tourism. Dredging impact is minimised by ongoing monitoring at critical locations and regulation of the contractor's activities. Dredge material is disposed off in designated marine disposal area (Patel & Holtzhausen, 2008).

Hazardous substances:
Estimates suggest 2.5 million tons of oil enter South Africa's coastal waters annually (DEAT, 2001; Dittke, 2000). TNPA (2009) mentions care will be taken to identify sources, types and quantities of hazardous waste, and to ensure that such waste is disposed off in accordance with this policy; however, specific practices are not mentioned. In the Port of Saldanha, TNPA reached an agreement in 2007 with Oil Pollution Control South Africa to formalise oil spill response procedures, such as upgrading port control vessel tracking equipment, and employing trained staff and well-maintained equipment (Ports & Ships Maritime News, 2008).

Driving and Constraining Forces:

Stakeholder relations:

Communities have opposed for many years the expansion of South Durban industrial zone. Despite the existence of new participatory frameworks of environmental management embodied in the National Environmental Management Act 1998, most government practices lack community involvement (Scott & Barnett, 2009). TPT (2007) maintains Transnet is committed to becoming a customer-centric organisation by providing effective customer service, enhancing customer engagement and input.

Lack of data:
Lack of reliable data regarding health consequences of pollution during the apartheid era hampered development of effective legislation, which allowed companies to keep their data secret from public scrutiny for 'security' reasons (Scott & Barnett, 2009). Consequently, environmental movements' dedicated efforts and journalistic reports on real-life stories of

[11] The International Maritime Organisation (IMO) is a specialized agency of the UN dealing with maritime affairs and devoted to the improvement of maritime safety and the prevention of marine pollution), has a number of provisions aimed toward environmental objectives.

pollution effects, including increased levels of cancer in South Durban, laid the foundations for the Air Quality Management Act of 2004. An air quality monitoring programme was set up to produce and publish credible air quality data for all parties to inspect and verify (Scott & Barnett, 2009).

Globalisation:

Since 1994, global economic integration and export-led growth strategy has led to exponential increase in container cargo throughput by an average rate of about 12% a year over the last five years (Omar, 2000; Rogerson, 1998), thus necessitating port expansion. The size of container vessels calling at South African ports is increasing, with concomitant environmental consequences due to resultant channel deepening and expansion (Naidoo, 2007; Visser, 2007).

On the other hand, globalisation has promoted international collaborations. In 2009, South Africa hosted a conference of the Port Management Association of Eastern and Southern Africa, which is proactive in bringing all African ports together to partner with international actors to foster sustainable practices (Mutonya, 2009).

Legislation:

Past regulations regarding environmental management in South Africa have been fragmented both in implementation and responsibility. Over the past five years, international trends and public pressures have led to changes in environmental legislation in South Africa (van Koppen, et al., 2005). However, some changes (e.g. waste regulations) are more suited to developed country conditions; these regulations have not been matched by adequate resources (Dohrman & Aiello, 1999).

Port governance:

The Legal Succession to the South African Transport Services Act, 1989, that transferred all assets, liabilities, rights and obligations of South African Transport Services to Transnet Ltd, did not provide for the state's regulation of the monopoly inherent in incorporating both port ownership and operations in one company (van Niekirk, 2000). South Africa's port sector is characterised by limited private sector participation (outside of road transport in the ports sector). In addition to market failures arising from this monopolistic structure, Transnet is both player and referee since it controls both the infrastructure (TNPA) and operations (TPT) (Mayer & Onyango, 2005).

There is need for Transnet to promote competition; however, there is resistance to any change in the deeply entrenched state enterprise. Labour unions remain highly critical of increased private participation (Chasomeris, 2003). Although the government does not intend to privatise state transport enterprises, it is willing to enter into public-private partnerships railway and port services (Fourie, 2006).

Discussion:

The findings of this study correspond with Wooldridge and Stojanovic's (2004) and Pinder & Slack's (2004) analyses questioning popular perceptions that ports are averse to environment protection. While Wooldridge and Stojanovic's (2004) study pertained to Western European ports, this study underscores that, at the very least, several ports around the world show considerable concern for sustainable development. Given their diversity, no two ports may follow similar trajectories of sustainable development; however, within their diverse structures, several common frameworks, practices, challenges and opportunities were noted – the deliberation of which can benefit SD in other ports:

Policy framework for SD:

Case study ports employ a range of policy frameworks to promote sustainability: the underlying premise is to promote all three arenas – environmental, economic and social sustainability. POLB's internationally-recognised Green Port Policy mandates protection of environment and communities from negative impacts, while promoting international trade. Both PoR and SPC have integrated sustainability within their CSR philosophy, making environmental protection, in principle, a core component of business plans. Although Transnet has not articulated a sustainability policy, its safety, health, environment and quality (SHEQ) statement demonstrates its orientation towards sustainability. However, the challenge for all case study ports remains that of translating conceptual frameworks into actual practices (Nagle, 2008).

SD practices:

Findings of this study demonstrate that ports utilise a range of sustainable practices:

Air pollution:

Air pollution is the biggest environmental concern in all case study ports (except Sydney where water quality is the greatest concern). Case study ports have implemented or proposed three main strategies to reduce local emissions: alternative fuels (eg. LNG, low-sulphur and biofuels), shore-side electricity, and intermodal transport). However, these strategies are not without controversies. Without further technological developments, greenhouse gas emissions of LNG trucks make them a questionable option (Eason, 2008). While low-sulphur fuel reduces SOx and PM (Friedrich, et al., 2007), its limited availability, high cost, and need for separate storage facilities are drawbacks. The International Bunker Industry Association observes that a complete changeover to low-sulphur distillate would require oil refineries to process an additional 12 million barrels of crude oil a day (Bonney, 2008). Likewise, although biofuels reduce consumption of non-renewable energy sources and are biodegradable, they lead to different, not necessarily less, air pollution. Biofuels' implications of lower speed and larger bunker tanks, their greenhouse gas (GHG) emissions and the relatively new GHG reduction technology need further investigation (GreenPort, 2008h). Furthermore, biofuels have provoked increasing criticism about diverting land in food-insecure countries from food to biofuel feedstock production, with concomitant implications for food security, biodiversity and social justice (Howarth, et al., 2009; GreenPort, 2008c).

While offering shore-side electricity obviously reduces fuel consumption by ships at berth, alternative energy is delivered by the land power grid, which produces considerable CO2 emissions (ESPO, 2008; Friedrich, et al., 2007). Environmental benefits and cost-effectiveness of shore-side electricity need further evaluation. ESPO (2008) maintains adaptation of vessels to reduce emissions both at sea and at berth would be far more cost-effective and environmentally-friendly. Meanwhile, utilizing low-carbon sources for shore-side power (eg. solar and wind generators) and developing cost-effective energy storage technologies to achieve near-zero emissions have been suggested (Friedrich, et al., 2007).

POLB and PoR have invested heavily in developing intermodal transport to combat air pollution. Each mode (rail, inland, short sea) has its economic and ecological trade-offs (Tull, 2006). While SPC aims to use rail transport to move cargo in Port Botany, the use of diesel freight-trains defeats the purpose of using intermodalism to control air pollution. Inland and coastal shipping are cleaner alternatives (Comtois & Slack, 2007; van Ierland, et al., 2000). Moreover, a key characteristic of intermodal transport is the coordination between various components, requiring alliances between multiple actors. PoR plays a pro-active role in the formation of such coalitions. In South Africa, such associations are hardly developed, mainly due to historical reasons. While Rotterdam has a long tradition in cooperation in the port community, in South Africa one public organisation (Transnet) has been dominant (de Langen & Chouly, 2004).

Water quality:

Water quality, sediment and storm-water management plans have been proposed or implemented in all case study ports; however, all ports have yet to achieve sustainable water quality. POLB has yet to mitigate contaminated sediments and clean up toxic hotspots (Bailey, et al., 2004). PoR is working on tackling soil and groundwater pollution (GreenPort, 2008f). Perhaps the history of water pollution in Sydney harbour has propelled SPC to adopt innovative strategies such as treating storm-water, reducing own water consumption, and utilising rainwater tanks.

Ballast water:

All four countries USA, Netherlands, Australia and South Africa are signatories to IMO's 2004 Ballast Water Management Convention. Mid-ocean ballast water exchange (BWE), allowed by IMO convention within 200 nautical miles from the nearest port, is most commonly used by ships visiting case study ports. While Gray, et al. (2007) contend BWE in only freshwater ports exceeds IMO's ballast water performance standards, other studies (ex. Gollasch, 1997; Reynolds, 2004) question BWE since, as stated earlier, emptied tanks can contain invasive species accumulated at the bottom.

Dredging and disposal of dredged materials:

PoR and South African ports dispose off less contaminated dredge materials at sea, the consequences of which are ambiguous. Some studies (ex. Bolam, et al., 2006) suggest that consequences of dredge material disposal depend on site-specific variations (ex. ecological status, hydrographic profile) and variations in disposal activity (ex. quantity, timing, frequency and type of disposed material). Others (ex. Bateman, 1996; van dem Hurk, et al., 1997) maintain sea dumping can lead to declining water quality and biological impacts (e.g. reductions and changes in marine biodiversity).

Disposing dredge materials on land in approved landfills and confined disposal sites, although cheaper and more flexible in their regional application than open water disposal (Heise & Forstner, 2006; Krause & McDonnell, 2000), can also lead to environmental repercussions, such as contamination of groundwater (Bateman, 1996). POLB and SPC have used innovative practices such as recycling and beneficial re-use of dredged materials for 'brownfield developments,' capping deepwater contaminated sediments, and reclaiming mudflats and marshes. Remediation techniques for contaminated sediments are generally limited (Heise & Forstner, 2006) although POLB has successfully used them as construction fill materials (Steinberg & Watson, 2001).

Hazardous substances:

Oil spill responses and storage and transport of hazardous goods are well-developed in all case study ports. However, information on their procedures to manage land-based and operational oil discharge is inadequate. This corroborates with existing literature (ex. Reynolds, 2004) that there is more information about marine pollution from accidental oil spills than from everyday operational oil discharges.[12] Export of hazwaste, discussed below in the subsection on globalisation, is of concern in POLB and PoR.

As is clear, several sustainable port practices are mired in controversies, which call for further research on their pros and cons. Additionally, study findings point to various related challenges and opportunities:

<u>Driving and Constraining Forces:</u>

Stakeholder relations:

As these case studies suggest, enlisting public participation and communication with all stakeholders are cornerstones for sustainable development (Peterlin, et al., 2004; Quinn, 2007). However, community pressure to address environmental impacts has been both a driving and constraining factor in all case study ports. Ports face challenges of reconciling different stances of the industry and public (GreenPort, 2008i). For instance, in POLB, emission reduction measures have been viewed as chaotically quick by industry and agonizingly slow by the public (Avol, 2007). PoR's consensus-based, rather than conflict-oriented approach, which reconciles

[12] While public perceptions of marine oil pollution are associated with tanker groundings and collisions, in reality, accidents are responsible for minor proportions of marine oil pollution. Reynolds (2004) notes that only 20% of ship-generated oil pollution results from accidents; the remainder is discharged during normal ship operations.

differences and offers an alternative to top-down, 'expert'-driven port planning, is imperative for SD (Daamen, 2007; Kelly, 2005); yet it is time-consuming.

Lack of data:

This research shows sustainable port practices have often been marred by lack and uncertainties of data. Data is required for monitoring environmental performance and the effects of ports' activities on the ecosystem. To address data limitations, Wooldridge & Stojanovic (2004) suggest ports can forge links with local, regional, national and international regulatory authorities, NGOs and industry to gain access to their wealth of data. This is being increasingly done: for instance, PoR participated in Eco-Information Project (1997-1999) that compiled significant baseline data from which port industry's environmental responses could be monitored (Paipai, 1999).

Economic factors:

In the current global economic recession (Cannon, 2009), reducing environmental impacts of ports is a costly endeavour. For instance, the cost of low-sulphur fuel is estimated to be twice as much as residual fuel oil (Hammingh, et al., 2007), mainly due to its limited availability. Shore-side electricity is another case in point, with infrastructure costs of about $4 million per container terminal (Mongelluzzo, 2009c).

Nonetheless, as ports look for ways to increase market share or simply to survive (Meerseman & Van de Voorde, 2002), they can capitalise on new sources of profit offered by pollution control and environmental management activities (Soriani, 2004; Wallis, 2009a, 2009b). For instance, POLB and PoR, with their expertise in environmental management, have commercially marketable skills to improve coastal management in other regions (Comtois & Slack, 2007). Environmental stewardship of the port can also become a strong commercial argument (Alderton, 1999). Besides, operating sustainably offers opportunities to implement state-of-the-art practices that enhance operational efficiencies and reduce costs (Tillman, 2008). Thus, economic factors can become a driving force for SD.

Globalisation:

On one hand, globalisation has promoted exchange of information on sustainable practices across borders (GAO, 1999; Comtois & Slack, 2007). On the other, globalisation has created several challenges in case study ports. Growth in global trade has necessitated port expansion, creating major local environmental implications (Cleary & Goh, 2004). Furthermore, in the globalised economy, ports are key interfaces in global logistics chains (Tull, 2006). As the illegal exports of hazwaste, often in the garb of 'recycling', via POLB and PoR demonstrate, inspecting every container is impractical. Substantial amounts of hazwaste end up in countries without adequate disposal practices, thereby harming their workers and environment (Stephenson, 2008). IMO treaties do not cover cross-border harm transported through shipping. It is, therefore, imperative to develop greater monitoring and coordination between port customs officials and international organisations (D'Monte, 2009).

Another globalisation-related challenge revealed in this study is feedstock production for biofuels. PoR aims to become the European leader for producing biofuels. The raw materials for these are imported from developing countries. International organisations such as Oxfam contend 'green policies' in developed countries are contributing to the world's soaring food prices, which have hit the poor hardest. It is estimated EU's emissions reduction targets could multiply carbon emissions 70-fold by 2020 by changing the use of land (BBC News, 2008). Thus, there is need for holistic assessments about the potential impacts of biofuel programs (Howarth, et al., 2009).

Clearly, practices deemed to be sustainable in one part of the world can degrade the environment in another region. Findings of this study, therefore, refute Soriani's (2004) claim that while their role in sustaining global economies is of global importance, environmental impacts of ports still remain largely localised. With globalisation, environmental impacts are no longer local. A broader environmental view is required in which ports are recognized as part of larger global ecosystems, where environmental pressures exerted by ports both locally and globally are addressed.

Legislation/regulations and their implementation:

Regulations and their implementation are both a driving and constraining factor. While American and European legislations have driven sustainable activity in the maritime industry, constraining forces include inconsistencies in interpretation and implementation among European member-states, delays in approvals by Australian regulatory agencies, and South Africa's erstwhile fragmentation of environmental regulations.

Furthermore, the complexity and divergence of international, national and regional/local legislation and frequent changes to these can hinder SD in ports (Roe, 2009). For instance, in the EU, polices are interpreted from a higher international jurisdiction (ex. IMO), and then adapted by EU member-states by national legislation, which is then applied through regional and local regulations. Since the maritime sector operates within internationally competitive environments, this can distort competitiveness of local entities due to stricter regional regulations (de Langen & Nijdam, 2008; Roe, 2009).

Port governance:

Except for South Africa's Transnet, all ports in this study are public-private partnerships in varying proportions. While POLB and SPC are government-owned landlord ports with port operations being managed by private tenants, PoR is an independent company with the Rotterdam Municipality as its shareholder and several private companies as its tenants. Thus, unlike South Africa where port ownership and management is vested in one entity, the USA, Australia, and Netherlands have avoided monopolisation by public or private corporations. While conclusive evidence about causal relationships between port governance structures and port SD cannot be claimed from this research, the case studies point to a possible correlation between public-private partnerships and high degree of sustainability.

Overall, despite several challenges, POLB, PoR and SPC have moved from regulatory compliance to proactive environmental stewardship. South African ports too have embarked on the sustainable journey, which refutes, in part at least, the claim about the environmental 'priority gap' in developing countries (ex. Pinder & Slack, 2004). As Cleary & Goh (2004) note, although developing countries prioritise economic development, the environment is on their agenda: pollution dangers have prompted a range of initiatives in these countries.

Suggestions for future research:

This study is based on secondary data. Further research can include interactions with port authorities, government agencies, international organisations, environmental groups, port operators and businesses to provide a more complete picture on port SD as well as dilemmas that need resolution. Particularly, more research is needed on various controversial aspects identified in this study, such as biofuels and shipment of hazwaste in a globalised era.

Concluding Remarks

This study has demonstrated that sustainable development has gained momentum, albeit to differing degrees, in the functioning, organisation and the very ethos of case study ports. Sustainability requires an integrated and holistic approach. Award-winning ports incorporate activities that go beyond regulation requirements and rely on input from multiple stakeholders.

A key theme from all four case studies is that, while there is definite progress towards SD in ports, practices that are deemed sustainable must be critically examined from the perspectives of different stakeholders including shippers, port-related businesses, and the local and global community. Reconciling differences between various stakeholders, capitalising on opportunities offered by environmental-friendliness, public-private partnerships, and policies negotiated by consensus can foster port sustainability. Furthermore, this study found that globalisation necessitates more holistic analysis of port practices. The essence of sustainable development, after all, demands environmental stewardship both locally and globally.

APPENDIX:

International Conventions and Regulations Pertaining to Environmental Concerns in Seaports

Environmental Issue	Relevant international regulations and their brief descriptions
Generic/overlapping conventions	*(i) UNCLOS: The United Nations Convention on the Law of the Sea:* UNCLOS is the globally recognized regime dealing with all matters relating to the law of the sea. The Convention comprises 320 articles and nine annexes, governing all aspects of ocean space, such as delimitation, environmental control, marine scientific research, economic and commercial activities, transfer of technology and the settlement of disputes relating to ocean matters (Friedrich, et al., 2007; Project Grace, 2006). The definition of pollution in UNCLOS is limited to the marine environment—that is, the world's seas, oceans, estuaries, etc. UNCLOS attempts to prevent or limit pollution from reaching the marine environment through six different sources: (1) from land based sources, (2) from seabed sources subject to national jurisdiction, (3) from activities in the area, (4) by dumping, (5) from vessels, (6) from and through the atmosphere (Article 4) (Friedrich, et al., 2007). *(ii) SOLAS: International Convention for the Safety of Life at Sea:* SOLAS was adopted on 1 November, 1974 and entered into force on 25 May, 1980. The SOLAS Convention in its successive forms is generally regarded as the most important of all international treaties concerning the safety of merchant ships. Its main objective is to specify minimum standards for the construction, equipment and operation of ships, compatible with their safety. Flag States are responsible for ensuring that ships under their flag comply with its requirements, and a number of certificates are prescribed in the Convention as proof that this has been done. Control provisions also allow Contracting Governments to inspect ships of other Contracting States if there are clear grounds for believing that the ship and its equipment do not substantially comply with the requirements of the Convention (Mitroussi, 2004; World Bank, 2009). *(iii) MEPC:* The IMO's Marine Environmental Protection Committee (MEPC) is responsible for regulating emissions from ocean-going ships. Starting in the 1950s and 1960s, the IMO initially focused on marine safety (i.e. the SOLAS agreement), oil tanker accidents, storage tank cleaning, and ballast water. In the 1990s, the MEPC widened its scope to address concerns about air pollution. As mentioned below, the underlying international agreement for this work is MARPOL 73/78 Annex VI (Friedrich, et al., 2007).

	(iv) MARPOL (International Convention for the Prevention of Pollution from Ships): The MARPOL of the International Maritime Organisation (IMO) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. MARPOL was codified in 1973 and modified by the Protocol of 1978 (MARPOL, 1978; Reynolds, 2004). MARPOL includes regulations aimed at preventing and minimizing pollution from ships - both accidental pollution and that from routine operations – and currently includes six technical Annexes as follows: Annex I: Prevention of pollution by oil Annex II: Control of pollution by noxious liquid substances Annex III: Prevention of pollution by harmful substances in packaged form Annex IV: Prevention of pollution by sewage from ships Annex V: Prevention of pollution by garbage from ships Annex VI: Prevention of air pollution from ships (IMO, 2002). The country where a ship is registered (that is, the 'flag state') is obligated to certify the ship's compliance with pollution prevention standards, although many nations delegate this task to classification societies, which perform pollution prevention compliance and other inspections under contract. The country that the ship visits (that is, the 'port state') can conduct its own examinations in order to ascertain the ship's compliance with international standards and can detain the ship if significant non-compliance is determined (GAO, 2000).
Air Pollution	*(i) UNCLOS: The United Nations Convention on the Law of the Sea:* The primary mechanism for regulating pollution from ocean-going vessels under UNCLOS is mainly through international rules and standards set by the IMO, or in some cases, through other international treaties. States have been given the authority to subject foreign-flagged vessels to air pollution standards that go above and beyond international minimum requirements so long as certain conditions are met. Those conditions include allowing innocent passage to foreign vessels in territorial waters and refraining from imposing any rules that would require additional hardware or staffing obligations that 'travel with the ship' into the high seas. In many cases, the legality of state action is tied to the practical effect of a regulatory policy. Although air pollution is explicitly mentioned in Article 212 of UNCLOS, it is only in relation to the deposition of pollution "from" or "through" the air into the marine environment: "States shall adopt laws […] to control pollution of the marine environment from or through the atmosphere" (Friedrich, et al., 2007, p. 40). UNCLOS clearly envisions additional unilateral national level regulatory actions by individual states or by groups of states (Molenaar 1998).

	(ii) MARPOL 73/78 Annex VI: Annex VI of MARPOL, titled Regulations for the Prevention of Air Pollution from Ships was adopted on November 31, 2004 and came into force on May 19, 2005. It was ratified by 19 countries accounting for 59.9% of the world maritime fleet (Comtois & Slack, 2007). Under Annex VI, parties have the right to impose limits on the SO_x and NO_x emissions in ship exhaust gas systems and to prohibit the emissions of ozone-depleting substances. Annex VI of MARPOL sets limits for NO_x emissions that vary with engine speed. The IMO characterized the NO_x standards as a 30% reduction from current levels; however the United States Environment Protection Agency more recently determined that the standards would reduce NO_x levels by 20%, rather than 30 percent. Annex VI also prohibits on-board incineration of certain items such as contaminated packing materials and polychlorinated biphenyls (PCBs); however, there are no set standards for particulate matter, hydrocarbon, or carbon monoxide emissions. Annex VI sets a global cap on fuel sulphur at 4.5%. It also establishes the first SO_x Emission Control Area (SECA) in the Baltic Sea. Ships operating in this area must use lower (1.5%) sulphur fuels beginning in May 2006. The next SECA is planned for the North Sea according to an amendment to Annex VI adopted in 2005. The North SECA entered into force in November 2006 and was fully implemented and enforced in November 2007 after a 12-month grace period. New limits for SECA propose the reduction of sulphur fuels from 1.5 to 1% by 2010, while a global cap is proposed at 3.5% by 2012 (GreenPort, 2008j). Annex VI allows countries to set alternative standards that would apply to engines on ships that operate solely in waters under its jurisdiction. (Friedrich, et al., 2007). *(iii) Kyoto Protocol (1997):* The Kyoto Protocol is an international agreement that aims at reducing greenhouse gas emissions from anthropogenic sources, mainly carbon dioxide emissions produced by the use of fossil fuel. Although details vary for each country in terms of objectives and commitments, the Protocol specifies the mechanisms to achieve the objective of emissions reduction – article 6 pertains to the joint commitment for emissions reduction, article 12 concerns the 'clean' development mechanism, and article 17 provides the guidelines for emissions trading (Comtois & Slack, 2007). *(iv) The Montreal Protocol:* The Montreal Protocol stipulates that the production and consumption of compounds that deplete ozone in the stratosphere, notably chlorofluorocarbons (CFCs) and halons, must be phased out. The Montreal Protocol identifies halon as one of the sources depleting the ozone layer (Comtois & Slack, 2007; Friedrich, et al., 2007). Dust emissions control protocols on port sites fall within the jurisdictions of regulations addressing air quality or local regulations on air pollution (Comtois & Slack, 2007).

Water Pollution	*(i) MARPOL:* MARPOL defines waste water as water from toilets, medical premises and spaces containing living animals; it does not include bilge water from machinery. Annex IV of MARPOL that entered into force on September 27, 2003 and was ratified by 99 countries covering 54.35% of the world fleet, focuses on the prevention of pollution by sewage from ships. It considers that on the high seas, the oceans are capable of assimilating and dealing with sewage through natural organic and bacterial actions. Before entering into force, this Annex was revised by Resolution MEPC.88(44) of IMO. Current guidelines of Annex IV prohibit discharge of sewage at sea at a distance less than 3 nautical miles from the coast. Discharge of sewage from ships at sea is authorized when carried out by a disinfecting system approved by IMO, provided the ship is more than three nautical miles from the nearest land. Resolution MEPC.88(44) requires signatory countries of the original Annex IV to implement the revised Annex IV from July 2005 (Comtois & Slack, 2007). *(ii) UN Global Program of Action for the Protection of the Marine Environment from Land-Based Activities:* In 1995, the United Nations adopted the Global Program for the Protection of the Marine Environment from Land-Based Activities, which focuses on three issues (a) municipal waste-water treatment for the prevention and reduction of marine pollution; (b) the joint management of coastal resources and river basins; and 9c) the establishment of partnerships in financing and implementation of the Global Program of Action (Comtois & Slack, 2007; GPA, 2009). There are currently no international regulations concerning storm water or snow removal (Comtois & Slack, 2007).
Dredging and Disposal of Dredged Materials	*(i) London Convention: Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter:* Dredging is regulated by the London Convention that was adopted in 1972 at the Intergovernmental Conference on the Convention on the Dumping of Wastes at Sea. The London Convention was the first global convention for the control and prevention of marine pollution. The Convention entered into force on August 30, 1975. Its control mechanism is based on the complete prohibition of the disposal at sea of particular harmful substances and the establishment of licensing systems for the disposal at sea of all other substances. The Convention provides guidelines to contracting parties, for the selection of disposal sites, disposal techniques and monitoring programmes. Each party has the right to adopt other or more stringent measures that adhere to the principles of international law, to prevent disposal at sea. In 1996, the IMO added a Protocol to the London Convention that adopted

	two new principles: the precautionary approach and the 'polluter pays' principle. The Protocol requires that preventive measures must be taken when there is reason to believe that the wastes introduced into the marine environment are likely to cause harm even when there is no conclusive evidence to prove a causal relationship between inputs and their effects (the precautionary principle). Under the Protocol, those who are engaged in disposal or incineration at sea bear the cost of meeting the pollution prevention and control requirements for the authorised activities (the polluter pays principle) (Salomons & Gandrass, 2001). *(ii) Helsinki Convention (HELCON):* The first Convention on the Protection of the Marine Environment of the Baltic Sea Area was signed in 1974 by the coastal states of the Baltic Sea at that time. In 1992, a new Convention was signed by all countries bordering the Baltic Sea and by the European Economic Community. The new 1992 Convention came into force on 17 January 2000 replacing the 1974 Convention. The governing body of the Convention is the Helsinki Commission - Baltic Marine Environment Protection Commission - also known as HELCOM. The current contracting parties to HELCOM are Denmark, Estonia, European Community, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden. The Helsinki Convention of 1974 was the first international agreement to cover all sources of pollution, both from land and from ships as well as airborne. To accomplish its aim, the Convention calls for action to curtail various sources of pollution. The 1992 Convention overtook these aims and added sea protection from pollutants from offshore industries and protection of nature and biodiversity. Decisions taken by the Helsinki Commission are regarded as recommendations to the governments concerned. HELCON Recommendations are to be incorporated into the national legislation of the member countries (Salomons & Gandrass, 2001).
Ballast Water	*(i) International Convention for the Control and Management of Ships' Ballast Water and Sediments:* This Convention was adopted by IMO by a consensus at a conference at IMO in 2004. Standards for ballast water management (BWM) are dealt with by the Convention in Regulations D-1 and D-2. The Convention introduces these two different protective regimes as a sequential "phase-in" implementation: 1. Regulation D-1 *Ballast Water Exchange Standard* requiring ships to exchange a minimum of 95% ballast water volume; 2. Regulation D-2 *Ballast Water Performance Standard* requires that the

	discharge of ballast water have organism concentrations below specified limits. Eventually ships need to meet the more stringent Ballast Water Performance Standard. This standard will come into force (subject to ratification of the Convention) between 2009 and 2016, depending on the ballast water capacity and age of the ship. According to the Convention, a ship shall whenever possible, undertake ballast water exchange (BWE) at least 200 nautical miles (nm) from the nearest land and in water depths of at least 200 m. When this is impossible, the BWE shall be conducted at least 50 nm from the nearest land and in water at least 200 m in depth. Further, a ship shall not be required to substantially deviate from its intended voyage, or delay the voyage, in order to comply with this particular requirement. In cases where the depth and distance requirements cannot be met, the port state(s) may designate BWE areas. Safety is of paramount importance and on some vessels a safe BWE may only be undertaken under certain weather conditions or may not be undertaken at all (Gollasch, et al., 2007). For ports, the Convention provides guidelines on the procedures and the reception and processing facilities that must be made available to ships in order to reduce introduction of harmful aquatic organisms and sediments. Newly constructed ships, including those undergoing a major conversion, should, "without compromising safety or operational efficiency," be designed and constructed "with a view to minimize the uptake and undesirable entrapment of Sediments, facilitate removal of Sediments, and provide safe access to allow for Sediment removal and sampling" adhering to IMO guidelines and Regulation B-5.1 of the Convention (Firestone & Corbett, 2005, p. 299). This IMO treaty was adopted in 2004, but has not yet been ratified by the required number of signatory countries (Comtois & Slack, 2007; Joshi, 2009). Like many other IMO legislation, the ballast water convention allows for the use of other systems, not described by the convention that can demonstrate an equivalent level of compliance to the regulations (Eason, 2009). *(ii) IMO's GloBallast Water Management Programme:* GloBallast is funded by the International Maritime Organization, the United Nations Development Programme and the Global Environment Facility, which is the financial facilitator of the UN's framework convention on climate change. GloBallast focuses on the legal and political frameworks by which states can implement ballast water convention described above. However, GloBallast also recognises the need to develop alliances with industry in order to bring in their wealth of expertise and resources to address this massive environmental problem (Eason, 2009). GloBallast relies on a target list of species that must be controlled. It adopts an approach

	premised on a port applying a management regime uniformly to all vessels that discharge ballast water. Although data is recorded at the level of an individual vessel trip, results are reported in the aggregate. Thus, GloBallast risk assessments address the relative risk posed by ports that are the source of ballast water uptake to a given destination port (Firestone & Corbett, 2005).
Hazardous Substances	*(i) International Convention for the Prevention of Pollution of the Sea by Oil, 1954 (OILPOL):* This Convention prohibits the deliberate discharge of specified kinds and concentrations of oil mixtures in designated areas 50 miles from land. Amendments to this Convention of 1962 extended to all sea areas the prohibition on discharges from vessels from 20,000 GRT or more, for which the building contract had been placed on or after the date of entry into force of the amendment. OILPOL charges flag states with enforcement, subject only to the right of the contracting states to board suspected vessels in their ports and notify the flag state of violations. The flag state was obliged to conduct an investigation and, to prosecute the owner or master of the vessel in case of sufficient evidence. Port states that are party to the Convention were also obliged to maintain facilities at each port to handle oil wastes. However, by 1973, consensus among contracting parties prevailed that there was a need for substantial improvement and extension. In 1973, therefore, the International Convention for the Prevention of Pollution was adopted and its 1978 Protocol (MARPOL 1973/78) superseded the 1954 OILPOL (Kasoulides, 1993). *(ii) MARPOL: International Convention for the Prevention of Pollution from Ships:* MARPOL Annex I covers the handling of oil leakages and oily wastes and the minimisation of discharges from oil tanker cargo tanks. According to MARPOL Annex I, oily bilge water may be discharged ashore, for which a charge is generally made, or discharged to sea through an oily water separator or filter which theoretically reduces the oil-in-water content to a maximum value of 15ppm. All discharges must be made in line with restrictions in terms of distance from land and location outside special, environmentally vulnerable, areas (Reynolds, 2004). Annex II of MARPOL on the Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk was ratified in 1983. It provides guidelines for the design, construction and operational requirements of chemical tankers and the discharge conditions for noxious liquid substances as a result of shipping activities, tank cleaning operations, de-ballasting operations and procedures for the prevention of accidental discharge at sea. Further, Annex II describes the measures for the control, treatment and disposal of wastes from chemical tankers at discharge ports. Several amendments to Annex II reflect technological developments and knowledge enhancement concerning the impact of chemical products on the marine

	environment (Comtois & Slack, 2007; Farthing & Brownrigg, 1997) Annex III concerning Regulations for the Prevention of Pollution by Harmful Substances carried by Sea in Packaged Forms was ratified in 1992. The Annex identifies harmful substances based on their physical, chemical and biological properties. The IMO's International Maritime Dangerous (IMDG) Code lists hundreds of dangerous goods, several of which have been identified as marine pollutants. The regulations described in MARPOL Annex II provide details on the standards of packaging, marking, labelling, documentation, stowage and quantity limitations on board ships in order to prevent or minimize accidental pollution and for facilitating their recovery by employing clear and specific marks to differentiate them from other cargoes (Comtois & Slack, 2007). *(iii) OPRC: International Convention on Oil Pollution Preparedness, Response and Cooperation:* OPRC aims at providing a global framework for international co-operation in combating major incidents or threats of marine pollution. Parties to the OPRC convention are required to establish measures for dealing with pollution incidents, either nationally or in co-operation with other countries. Ships are required to carry a shipboard oil pollution emergency plan. Operators of offshore units under the jurisdiction of parties are also required to have oil pollution emergency plans or similar arrangements which must be co-ordinated with national systems for responding promptly and effectively to oil pollution incidents. Ships are required to report incidents of pollution to coastal authorities and the convention details the actions that are then to be taken. OPRC calls for the establishment of stockpiles of oil spill combating equipment, the holding of oil spill combating exercises and the development of detailed plans for dealing with pollution incidents. Parties to OPRC are required to provide assistance to others in the event of pollution emergency and provision is made for the reimbursement of any assistance provided (Project GRACE, 2006). *(iv) CLC: International Convention on Civil Liability for Oil Pollution Damage:* CLC was adopted on 29 November 1969 and entered into force on 19 June 1975. It was adopted to ensure that adequate compensation is available to persons who suffer oil pollution damage resulting from maritime casualties involving oil-carrying ships. The Convention places the liability for such damage on the owner of the ship from which the polluting oil escaped or was discharged (Kasoulides, 1993; Project GRACE, 2006). *(v) Bunker Convention: International Convention on Civil Liability for Bunker Oil Pollution Damage, 2001:* Bunker Convention aims at ensuring that adequate, prompt, and effective compensation is available to persons who suffer damage caused by spills of oil, when carried as fuel in ships' bunkers. Bunker convention applies to

	damage caused on the territory, including the territorial sea, and in exclusive economic zones of States Parties (Project GRACE, 2006). *(vi) HNS: International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea, 1996:* The HNS Convention is based on a two-tier system established under the CLC. However, it goes further as it covers not only pollution damage but also the risks of fire and explosion, including loss of life and personal injury as well as loss of or damage to property. Hazardous and noxious substances (HNS) are defined by reference to lists of substances included in various IMO Conventions and Codes. These include oils; other liquid substances defined as noxious or dangerous; liquefied gases; liquid substances with a flashpoint not exceeding 60°C; dangerous, hazardous and harmful materials and substances carried in packaged form; and solid bulk materials defined as possessing chemical hazards. The Convention also encompasses residues left by previous carriage of HNS, other than those carried in packaged form (De La Ru & Anderson, 1998; Lloyd's List, 2008; Project GRACE, 2006). *(vii) Basel Convention (under the United Nations Environment Programme or UNEP):* The Basel Convention regulates the generation, trade and disposal of hazardous waste. Under the Basel Convention, responsibility for the dumping of waste should be fixed on the generator of the hazardous waste, the exporter of the waste or the country of export. However, radioactive waste has been exempted from the Basel Convention (D'Monte, 2009) *(viii) The Rotterdam Convention:* This Convention requires the prior informed consent of importing parties for receipt of hazardous chemicals. The Rotterdam Convention was initially inspired by a North-South dilemma when wealthier countries with bans on certain life-threatening chemicals continued to sell them abroad. However, in recent years, according to the UNEP, South-South trade has increased between newly emerging economies like India and Brazil and other poorer countries. The Rotterdam Convention recognises that in both cases, less advantaged importing countries lack the means to manage hazardous chemicals throughout their lifecycle, from importation, through use and safe disposal; hence the need for prior informed consent of importing parties (D'Monte, 2009)

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