Environmental Impacts of International Shipping

THE ROLE OF PORTS

Edited by Nils Axel Braathen

OECD

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Please cite this publication as:
OECD (2011), *Environmental Impacts of International Shipping: The Role of Ports*, OECD Publishing.
http://dx.doi.org/10.1787/9789264097339-en

ISBN 978-92-64-09682-0 (print)
ISBN 978-92-64-09733-9 (PDF)

Corrigenda to OECD publications may be found on line at: *www.oecd.org/publishing/corrigenda*.

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Foreword

While efficient ports are vital to the economic development of a large surrounding area, the related ship traffic, the handling of the goods in the ports and the hinterland distribution can cause a number of negative environmental impacts.

In 2010, the OECD published the book Globalisation, Transport and the Environment, *which highlighted a number of negative environmental impacts related to freight transport by different modes of transport. This book follows-up as concerns the environmental impacts of international maritime transport, and looks more in detail at the impacts stemming from near-port shipping activities, the handling of the goods in the ports and from the distribution of the goods to the surrounding regions. It is based on a number of case studies that were carried out for OECD's Working Group on Transport. This working group agreed to declassify the present synthesis report at its meeting in October 2010.*

The book provides examples of the environmental problems related to port activities (such as air pollution and emissions of greenhouse gases, water pollution, noise, spread of invasive species, etc.) and highlights a number of different policy instruments that can be used to limit the negative impacts. As such, the book will allow policy makers in this area to learn from experiences of colleagues in a range of other countries.

Acknowledgements

This book is largely based on four case studies of environmental impacts of selected ports:

- Los Angeles and Long Beach in United States, prepared by Bill Sylte, Terry McGuire and Dave Calkins of Sierra Nevada Air Quality Group, LLC, California, United States;
- Vancouver in Canada, prepared by Bryan McEwen of SNC-Lavalin Environment Inc., Canada;
- Busan in Korea, prepared by Dong-Oh Cho, Institute of International Maritime Affairs, Korea Maritime University; and
- Rotterdam in the Netherlands, prepared by Eelco den Boer and Gijs Verbraak of CE Delft, Delft, the Netherlands.

The case studies can be downloaded for free at *www.oecd.org/env/transport*.

The case studies were all based on a scoping paper that had been prepared by Per Kågeson of Nature Associates, Stockholm, Sweden.

The editing of the book was done by Nils Axel Braathen of OECD's Environment Directorate.

The work was conducted by the OECD's Working Party on Transport, under the oversight of OECD's Environment Policy Committee.

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List of Acronyms

ACTA	Alameda Corridor Transportation Authority
AIS	Automatic Identification System
AMP	Alternative Maritime Power
ARB	Air Resources Board (California)
AQMP	Air Quality Management Plan (California)
BMP	Best Management Practices
BOD	Biological Oxygen Demand
BNSF	Burlington Northern-Santa Fe railway company
BPA	Busan Port Authority
CAAP	Clean Air Action Plan (Los Angeles and Long Beach)
CACs	Criteria air contaminants
CARB	California Air Resources Board
CAS	Climate Adaptation Strategy (California)
CCNR	Central Commission for the Navigation of the Rhine
CCS	Carbon Capturing and Storage
CEAA	Canadian Environmental Assessment Act
CEQA	California Environmental Quality Act (California)
CFC	Chlorofluorocarbons
CI/KCAC	Continuous Improvement/Keeping Clean Areas Clean (provisions of the CWS)
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CPA	Canadian Port Authority
CWA	Clean Water Act (United States)
CWS	Canada Wide Standards
DCMR	Environmental Protection Agency of the Rijnmond area in the Netherlands
DFO	Department of Fisheries and Oceans (Canada)
DPM	Diesel Particulate Matter
ECA	Emission Control Area under IMO
EA	Environmental Assessment
EEDI	Energy Efficiency Design Index, of IMO
EEOI	Ship Energy Efficiency Operational Indicator, of IMO
EEZ	Exclusive Economic Zone
EIR	Environmental Impact Report under CEQA
EIS	Environmental Impact Statement under NEPA
EPA	US Environmental Protection Agency
ESPO	European Sea Ports Organisation
FOE	Friends of the Earth, an environmental NGO
GB-PS	Georgia Basin – Puget Sound

GDP	Gross Domestic Product
GHG	Greenhouse Gas
GMAP	Goods Movement Action Plan (California)
GRT	Gross Register Tonnage
HAB	Harmful Algal Bloom
HC	Hydrocarbons
HFO	Heavy Fuel Oil, also called residual oil
IAPH	International Association of Ports and Harbors
IMO	International Maritime Organization
ISM	International Safety Management Code of IMO
ISPS	International Ship and Port Facility Security Code of IMO
KCG	Korean Coast Guard
KMI	Korea Maritime Institute
KOEM	Korea Organization of Environment Management
KPUI	Key Port Utilization Indicators
LED	Light Emitting Diode
MAFF	Ministry of Agriculture, Food, and Fisheries (Korea)
MARPOL	International Convention for the Prevention of Pollution from Ships
METS	Maritime Emissions Trading Scheme
MLTM	Ministry of Land, Transport and Maritime Affairs (Korea)
MOE	Ministry of Environment (Korea)
MOU	Memorandum of Understanding
MPA	Marine Protected Area (Netherlands)
NCP	National Contingency Plan (Korea)
NDZ	No Discharge Zone (United States)
NEPA	National Environmental Policy Act (California)
NIS	Non-Indigenous Species
NGO	Non-Governmental Organisation
NO_x	Oxides of nitrogen
NPDES	National Pollutant Discharge Elimination System (United States)
OCAP	Organic Carbon-dioxide for Assimilation of Plants
ODCY	off-dock container yards
PAC	Ports Advisory Committee (California)
PAC	Polycyclic Aromatic Compound
PCB	Polychlorinated Biphenyls
PM	Suspended particulate matter
PM_{10}	Suspended particulate matter of diameter ten microns or less
$PM_{2.5}$	Suspended particulate matter of diameter of 2.5 microns or less
POLA	Port of Los Angeles
POLB	Port of Long Beach
PoR	Port of Rotterdam
PoRA	Port of Rotterdam Authority
PSC	Port State Control
RAC	Railway Association of Canada
RCI	Rotterdam Climate Initiative
RCG	Regional Contingency Plans (Korea)
RFID	Radio Frequency Identification

RMTC	Rail-Mounted Gantry Cranes
RMP	Risk Management Plan (United States)
RT	Revenue Tonnes
RTG	Rubber-Tired Gantry Crane
RTP	Regional Transportation Plans
RWQCBs	Regional Water Quality Control Boards (California)
SAMP	Special Area Management Plan
SCAG	Southern California Association of Governments
SCAQMD	South Coast Air Quality Management District (California)
SCR	Selective Catalytic Reduction
SOLAS	International Convention for the Safety of Life at Sea
SWRCB	State Water Resources Control Board (California)
TAP	Technology Advancement Program (Los Angeles and Long Beach)
TBT	Tributylin
TEU	Twenty-Foot Equivalent Unit
TMDL	Total Maximum Daily Loads
UNCLOS	United Nations Convention on the Law of the Sea
UP	Union Pacific railway company
US EPA	United States Environmental Protection Agency
VGP	Vessel General Permit (United States)
VMT	Vehicle Miles Travelled
VOC	Volatile Organic Compound
WHO	World Health Organization
WPCI	World Port Climate Initiative
ZECMS	Zero-Emission Container Mover System

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Executive Summary

This book discusses the drivers of port activities, reviews examples of the environmental impacts of port, and discusses the environmental and economic impacts of various policy instruments that are or can be applied to address these impacts. It draws in particular on findings from case studies of five of the largest ports in OECD countries, *Los Angeles* and *Long Beach* in United States, *Rotterdam* in the Netherlands, *Vancouver* in Canada and *Busan* in Korea, in addition to more *ad hoc* information regarding other ports.

Major findings

While well-functioning ports can play an important role in promoting economic development in the surrounding regions and a wider hinterland, this study has also clearly indicated that port activities can have significant negative impacts on the environment. Shipping has an environmental impact both in ports, as well as in the immediate vicinity of the ports. Examples of these impacts are noise from ship engines and machinery used for loading and unloading, exhausts of particles, CO_2, NO_x and SO_2 from the ship's main and auxiliary engines, and dust from the handling of substances such as grain, sand and coal. Road and rail traffic to and from the port area cause additional environmental problems. The environmental impact of ports may thus be divided into three sub-categories: *i)* problems caused by port activity itself; *ii)* problems caused at sea by ships calling at the port; and *iii)* emissions from inter-modal transport networks serving the port hinterland.

Due to the wide range of these impacts, a broad mix of policy instruments needs to be applied to managing environmental impacts, and the "optimal" mix of instruments is likely to vary much from port to port.

Indeed, authorities at various levels have put in place a wide range of instruments to limit negative environmental impacts, both in relation to *near-port shipping activities* as such (*e.g.* limits on the sulphur content of the fuels that may be used, and requirements regarding the treatment of ballast water), in relation to the *handling of the goods* in the ports (*e.g.* emission standards for the handling equipment, and limits on permitted noise levels), and in relation to the *transport of the goods to the hinterland* (*e.g.* emission standards for vehicles used in the transport, and investments in better road and rail infrastructure).

The *types of instruments* applied varies much – including "soft" instruments like information provision; investments in new road and port infrastructure; bans on certain activities (*e.g.* on the use of antifouling containing biocides); standards on input use (*e.g.* on sulphur contents in fuels), on technologies to be applied (*e.g.* double-hulls on tankers) and on emissions (*e.g.* regarding goods-handling equipment); and various sorts of economic incentives (*e.g.* differentiated port dues).

In many cases, economic instruments can provide more flexibility for polluters to find low-cost opportunities to reduce negative environmental impacts than what bans and standards do. As mentioned, a number of economic instruments are being applied to address negative environmental impacts of port – and the related shipping – activities. However, the economic instruments used in this sector are generally of a somewhat "prescriptive" nature and are unlikely to change the economic incentives that generate innovations to address the underlying environmental problems at a lower cost. One reason is the lack of a global framework for addressing environmental impacts of international shipping, making it difficult for individual countries to take action that would "internalise" the climate change impacts (*e.g.* by putting in place a carbon tax on bunkers). Another reason is the difficulties involved in monitoring and enforcing such actions (for example, a tax on the real SO_2, NO_x, or noise emissions from each ship).

The objective of this study was primarily to collect and compare experiences as regards environmental impacts stemming from port activities and to provide examples of policies used to address these impacts. It would also have been interesting to compare the costs and benefits of the related policy objectives, and analyse whether a given (environmental) outcome has been reached at the lowest possible cost to society. That has not been possible to do in this study. However, given the policies addressing international shipping activity at present, it is possible that almost *any* policy implemented to address the externalities caused by that sector *between the ports* would pass a cost-benefit test – if it could be reasonably well enforced. Opposed to this, regarding the *land-based sources* of environmental externalities stemming from port activities, a broad spectre of policies is already in place. The challenge for policy makers is to determine whether it is better to introduce stricter policies regarding these sources or, possibly, to address other priorities in society (environmental or otherwise – such as health, education, etc.).

While it is difficult to identify "best practices" for *all* the environmental impacts that port activities generate, introduction of shore-side electricity would have the advantage of reducing several negative impacts simultaneously, such as SO_2, NO_x and particle emissions, noise – and, possibly, CO_2 emissions. In countries where electricity generation is covered by a "cap-and-trade" system for CO_2 emissions (*e.g.* in the EU), the latter would be the case, regardless of how the electricity used to supply the ships is produced, as long as the "cap" remains unchanged. An important obstacle to a broader use of shore-side electricity is, however, that electricity systems vary between countries, both in terms of voltage and frequency. And it is not enough to make shore-side electricity available: unless ships are obliged to use it, they have few incentives to do so.

Exhaust emissions

Exhaust emissions are among the most pervasive of the environmental impacts of ports, and also some of the impacts that are most challenging to address. Most ships have several diesel engines, including auxiliary engines for onboard electricity production. Among ships with two-stroke, low-speed engines, 95% use heavy fuel oil (HFO) and the remaining 5% are powered by marine distillate oil. Around 70% of ships propelled by medium-speed engines use HFO, with the remainder burning either marine distillate oil or marine gas oil. Approximately 80% of the fuel consumed in international shipping consists of heavy fuel oil and most of the remaining 20% of marine distillate oil or marine gas oil.

Sulphur

The shipping sector use fuel grades that are no longer accepted in land-based installations or road vehicles. Distillate diesel fuel on average contains 0.3-0.5% sulphur and residual fuel oil generally 2.3-3.0%. The average sulphur content was 2.6% worldwide in 2009, or 26 000 ppm, which *e.g.* may be compared to a maximum of 10 ppm sulphur in diesel fuel allowed in European road vehicles from 2009.

There is a worldwide limit on the sulphur content in marine fuels of 4.5%. This "cap" will be reduced to 3.5% from 1 January 2012, then progressively to 0.5%, effective from 1 January 2020, subject to a feasibility review. In special "Emission Control Areas" (ECAs) designated by the IMO, the sulphur content must, since 1 July 2010, not exceed 1%, and this limit will be further reduced to 0.1 %, effective from 1 January 2015.

Nitrogen oxides

In the combustion of fuels, nitrogen in the atmosphere reacts with oxygen to form oxides of nitrogen (NO_x). NO_x emissions have residence times in the atmosphere of 1 to 3 days, which mean they can be transported up to 1 200 km. It is estimated that NO_x emissions from the shipping industry contributes from 10% to 15% of the global anthropogenic NO_x emissions from fossil fuels.

In 2008, the IMO adopted new emission standards for NO_x from *new* ship engines, with two steps. In the first step, emissions are to be cut by between 16 and 22% by 2011 compared to 2000, and in the second step, reaching 80% reduction by 2016. The longer-term limit will, however, only apply in specially designated areas. As regards *existing* ship engines, no significant reductions of NO_x emissions are expected.

Particles

The combustion of residual fuel gives rise to large emissions of particulate matter (PM). The finer fractions of these particles often stay airborne over long distances. It can take hours or days for PM_{10} (particles with an aerodynamic diameter of 10 micrometers) to settle on the ground or sea. Fine particles are strongly correlated with harmful effects on human health. Fine particles also have climate-forcing impacts, either contributing to, or offsetting, the effects of greenhouse gases. Black carbon particulate matter has been identified as an important contributor to radiative heating.

There are currently no emission limits for particulate matter for marine engines. However, low-sulphur fuels produce much less PM than heavy fuel oil.

Measures taken to address air emissions

Many port cities have ambient concentrations of NO_2 and PMthat exceed national or regional/federal standards or the recommendations by the WHO. Port authorities may thus find themselves under pressure to reduce exhaust emissions from ships' manoeuvring in ports and from their use of auxiliary engines at berth. This can in principle be achieved by three different measures: *i)* Improved fuel quality; *ii)* use of after-treatment technologies; and *iii)* use of shore-side electricity.

An example of the first type of measure is the EU Sulphur Directive that requires ships calling at European ports not to use fuel with more than 0.1% sulphur while at berth. This regulation also applies to any fuels used by inland vessels.

Sweden has introduced differentiated fairway and port dues based on the ships' emissions of SO_x and NO_x. Ships using bunker oils with low sulphur content qualify for discounts. Ferries that use fuels with less than 0.5% sulphur, and other ships using fuels with less than 1.0%, get a discount on fairway dues. Also, ports representing more than 90% of the traffic differentiate their dues according to the sulphur content of the fuel used. A number of ships have been certified for a NO_x-related discount of the Swedish fairway dues.

Allowing shore-side electricity to replace power and heat produced onboard by an auxiliary engine can reduce not only NO_x, SO_2 and particle emissions, but also noise. Whether shore-side electricity is a better option than use of environmentally benign fuels, perhaps in combination with after-treatment of exhaust fumes, depends largely on the time the ships spend at berth, the amount of power needed, and (often) the source of the shore electricity itself.

A problem in relation to use of shore-side electricity is the lack of an international standard for the plug-in systems. One challenge in this context is that different parts of the world have different voltages and frequencies in their electricity supply systems. The USA, Canada and Japan use 60 Hz, while most of the remaining world has electricity systems based on 50 Hz. However, systems that can handle any combination of 50 and 60 Hz power supplies are now available.

In response to major local air pollution problems in Southern California, state authorities and the ports of *Los Angeles* (POLA) and *Long Beach* (POLB) have implemented many measures to improve the situation. For example, by 2012, only trucks that comply with EPA emission standards for 2007 model year trucks will be allowed to haul cargo at these ports. The two ports are also levying a USD 35 per TEU container Clean Trucks Fee to provide local funding for financial incentives that help truck owners replace existing truck engines – in addition to funding from state sources.

Until June 2009, the two ports also provided financial incentives to vessel operators to use low-sulphur fuel in their main engines as they approached the ports. However, since the use of low-sulphur fuel within 24 miles of the Californian coast is now a state-wide requirement, the financial incentives have been discontinued. POLB has a *Green Flag Program* with reduced docking fees for vessels that comply with a voluntary speed limit of 12 knots in Southern California waters. Both ports have infrastructure for container and passenger vessels to plug-in to shore power.

The Port of *Rotterdam* Authority (PoRA) and an energy company have conducted a pilot shore-side electricity project in one of its inland shipping ports. As this pilot was successful, shore-side electricity will be made available to all berths for inland shipping in 2012. However, PoRA does not yet offer shore-side electricity to seagoing ships.

The PoRA has equipped some of its ships with particle filters and SCR catalysts that reduce emissions of NO_X with a chemical reaction into other less harmful substances. The PoRA is also promoting clean techniques for inland vessels in the port by pricing mechanisms and bans. The municipality of Rotterdam has decided that, from 2013 onwards, trucks that do not meet the EU Euro V-standard will be banned from much of the port area. From 2016, only Euro VI standard vehicles will be allowed.

Also in the case of *Vancouver* national authorities and port authorities have taken a range of measures to reduce air emissions from port activities. In addition to the establishment of a North American Emission Control Area – under IMO rules, and in co-operation with US authorities – and the introduction of increasingly strict national standards on sulphur contents in fuels, the port has, for example, introduced a differentiated harbour dues programme which provides incentives for ships to reduce emissions beyond legal requirements. In 2009, Port Metro Vancouver also launched a shore power facility at its cruise terminal.

The port is also gradually introducing stricter emission standards for cargo-handling equipment, rail locomotives, trucks, harbour vessels, etc. A "menu" of potential actions to meet the performance measures is also listed for each emission source group, as well as measurement and reporting criteria to track annual progress.

To respond an increasing demand for container cargo and to solve the traffic jam, air pollution and noise caused by container trailers, Korean authorities are developing a new container terminal in a non-residential area about 25 km to the west of *Busan* City. All the container cargoes there are handled in on-dock container yards, and there are dedicated railways and roads for transporting the containers. A number of eco-friendly technologies have been introduced in the new port, such as gantry cranes operated by electricity, shore-side electricity, renewable energy sources, etc.

The older Busan North Port is very limited geographically and there are not enough yards for container handling. Therefore, a number of off-dock container yards (ODCY) are operated for container handling before loading and after unloading. Previously, there was much traffic at the gate when container trucks arrived from an ODCY, resulting in air pollution and time-losses. However, the port authority has introduced a radio frequency identification system for container trucks to pass the gate to designated berths without delay.

Energy use and emissions of greenhouse gases

Most of the energy consumed by shipping is used for propulsion, of which a tiny fraction for manoeuvring in ports where vessels usually operate for a short moment and at low speed. The largest scope for improvement regarding energy use in shipping activities is thus in the voyage between ports. However, there are still a number of measures that ports can take to increase energy efficiency and reduce greenhouse gas emissions.

Measures addressing energy use and greenhouse gas emissions

A prime objective of ports is to "clean up in their own premises" in relation to energy consumption and carbon emissions. However, port authorities may have an additional role to play in providing port-state control for a possible future system to limit CO_2 emissions from international shipping.

Ports make use of buildings, including warehouses, and machinery, including vehicles owned by the port authority. Ports located in arctic and temperate climate zones may improve insulation and heat recovery in buildings, while ports in sub-tropical and tropical

areas can choose efficient means for cooling and air-conditioning. Overall energy savings in the order of 30 to 40% might be achieved through various efficiency measures.

As an example beyond the case studies prepared especially for this report, the port of Seattle has implemented a number of measures to cut waiting times and reduce idling, among them computer tracking systems at cargo terminals to quickly locate containers, alert truck drivers to draw-bridge opening times, and newly-built overpasses and improved intersections for better traffic flow and reduced congestion.

Many ports are located in windy areas and an increasing number make use of these conditions to invest in wind-power. The ports of Amsterdam and Zeebrugge are homes to large wind turbine parks. Wind turbines have also been installed at the ports of, for example, Liverpool, Marseille, Gothenburg and Freemantle. Solar energy is increasingly used for powering navigation buoys and may also be used as a supplement to the production of fossil-based electricity in locations where solar radiation is relatively evenly distributed over the months of the year.

The Marine Environment Protection Committee of IMO has "recognized the need to develop an energy efficiency design index" for new ships in order to stimulate innovation and technical development in the design of ships.

The ports of *Los Angeles* and *Long Beach*, and their parent cities, are undertaking major efforts to address climate change. For example, in May 2007, the City of Los Angeles adopted *Green LA: An Action Plan to Fight Global Warming*, which directs the port to develop an individual Climate Action Plan to explore opportunities to reduce GHG emissions from municipal operations. Such a plan was presented in December 2007, and as part of that and its numerous GHG reduction measures, the POLA began reporting emissions inventories in 2008. Similar actions have been taking by POLB and both ports are following the adopted *San Pedro Bay Ports Clean Air Action Plan*.

Many Californian policies and regulations to reduce GHGs greatly affect the two ports. The most immediate and far-reaching measures are contained in the Scoping Plan under the *California Global Warming Solutions Act* of 2006. In some cases, the measures are meant to reduce both conventional air pollutants and GHG emissions. This includes a phase-in up to 2020 of a requirement for most container, passenger and refrigerated cargo ships to receive power from the electrical grid, and stricter emission standards for many sorts of equipment.

The port of *Rotterdam* is involved in the *Rotterdam Climate Initiative*, which joins together a number of important actors to try to limit the CO_2 emissions in the Rotterdam area, including those from port-related activities. The goal is a 50% CO_2 emission reduction by 2025, compared to the level in 1990. The port is, amongst other things, seeking to become a hub for capturing, transport and storage of carbon, and the most energy-efficient port and industrial cluster in the world.

Another initiative of the PoRA is a sustainability index for its own activities. The index covers a number of issues, with CO_2 as one of the most important. The PoRA has calculated its own CO_2 footprint, covering mobility, building energy consumption and energy management, including emissions from subcontractors. The footprint measures the direct CO_2 emissions (not the whole supply chain) from the activities of the port, and can be used as a tool to identify areas where emission reductions can be achieved.

Another way the PoRA uses its sustainability index is in its tendering processes. As the PoRA is the governing body of the port area, it can decide what type of organisations, and

under what conditions, they will accept at the port. Through the use of sustainability conditions in tendering processes, the organisation promotes enhanced practices. For some sectors, energy use can play an important role in the tendering process.

Port Metro *Vancouver* is updating its annual corporate emissions inventory and developing a GHG reduction plan, including targets and metrics for ongoing measurement, to provide information needed to make appropriate environmental management decisions, and so that it may be ready for future reporting requirements. The *Air Action Program* includes initiatives being undertaken by the Port, terminal operators, other industries and regulatory agencies, which all help to reduce port-related air emissions. Port Metro Vancouver has established air emission baselines and maintains databases for specific port sites. Furthermore, as the Official Supplier of Port Service to the Vancouver 2010 Olympic and Paralympic Winter Games, Port Metro Vancouver partnered with VANOC and Offsetters to voluntarily offset carbon emissions created by the Games-time activities. By offsetting all of the port's operations during the Vancouver 2010 Winter Games, the port was able to contribute to a carbon-neutral Games.

As regards *Busan*, in February 2009, a *Presidential Committee on Green Growth* was established to implement the national project of "Low-Carbon, Green Growth", presented as a national vision by President Myeong-Bak Lee in August 2008. In July 2009, this committee finalised a *Five-Year National Plan for Green Growth*. Based on this, all the relevant ministries are establishing action plans, and already in 2008, the Ministry of Land, Transport and Maritime Affairs established a plan that *i.a.* focused on fuel oil efficiency and reduction of CO_2 emissions from ships.

Noise

Noise in port areas is caused by many sources, for example by ship engines, fans, cranes, tractors and trucks. The extent to which noise from harbour activities is perceived as a nuisance depends on the sound pressure and frequency, the distance to local communities, etc.

Measures addressing noise in ports

Citywide noise "ordinances" are imposed by the cities of *Los Angeles* and *Long Beach*. They limit noise-producing activities to 7:00-21:00 on most days, and prohibit them altogether on Sundays and national holidays. Maximum ambient noise levels are capped for residential, hospital and school zones at all times.

The Rijnmond area is divided into several zones that have been granted an average specific sound emission per m^2 for industry noise. The *Rotterdam* Port Authority is free to differentiate the noise emission levels in contracts with its clients, as long as the average level is maintained. As the permitted sound level is stricter during the night, the standards present an obstacle to 24 hour operations in some locations. The interdiction for barges to use their auxiliary engines at locations where electrical power outlets are available helps limiting noise generation. This policy will be expanded to all berths for inland barges in the next years.

The City of Vancouver administers a Noise Control Bylaw that establishes limits of noise levels for weekdays and weekends. Port Metro Vancouver has identified noise as a

corporate social responsibility issue and is developing a noise and nuisance management and monitoring plan and is proactively pursuing solutions to existing noise issues.

The electrification of rubber-tired gantry cranes in *Busan* is expected to significantly reduce noise levels.

Ballast water

Ships use ballast water to control draught and centre of gravity in order to insure stability at sea. Ballast water acquired in one region may contain invasive aquatic species which, when discharged in another part of the world, may thrive in a new environment and disrupt the balance of the marine ecosystem.

Measures addressing ballast water

In 2004, the IMO adopted the *International Convention for the Control and Management of Ships' Ballast Water and Sediments*, according to which the Parties shall adopt stringent measures to prevent, reduce and eliminate the transfer of harmful aquatic organisms and pathogens from ships' ballast water and sediments. However, this convention is not yet in force, as not enough countries have ratified it. However, individual countries are nevertheless moving ahead with measures to address the adverse environmental effects of ballast water as the impacts are locally often very significant.

In December 2008, the US EPA established a system of Vessel General Permits (VGP). The VGP will affect nearly 100 000 vessels using US ports, including the ports of *Los Angeles* and *Long Beach*. The EPA has approved California's certification, thereby providing for full implementation of the VGP in the State. The VGP establishes effluent limits for many discharge streams, covering aquatic nuisance species in ballast waters, substances typically found in wastewater, metals, nutrients, pathogens and toxic pollutants.

California's approach to managing ballast water and reducing the introduction of non-indigenous species consists of *ballast exchange requirements* in coastal waters, and *ballast water discharge requirements* that phase in between 2009 and 2020. California has two ballast water exchange requirements; one that applies to vessels travelling within the Pacific Coast Region, and another for all other vessels. The ballast water discharge requirements begin with interim requirements that ballast water be treated or disinfected so that it meets specific biological requirements. These requirements limit the numbers of organisms per water volume. The final regulations, which will become effective after 2020, require that ballast water discharged contain *no* (zero) detectable, living organisms.

The Netherlands signed the IMO Ballast Water Convention in 2005. The port of *Rotterdam* has not set any additional measures to control ballast water discharges.

Canada ratified the IMO Ballast Water Convention in 2010 and is proceeding with regulations under the *Canada Shipping Act, 2001*. Transport Canada operates the *Canadian Ballast Water Program* in response to significant national concern with the introduction of alien invasive species by international shipping – in *Vancouver* and other Canadian ports. The programme has a mandatory ballast management requirement with four allowed options for ship ballast: Exchange at sea; retain onboard; pump ashore to treatment; or use on-board treatment.

Transport Canada currently has an enforcement programme at the national level. Ship inspections occur for approximately 25% of ships arriving to coastal ports and include record checks as well as sampling of ballast for salinity to verify that the water had been exchanged at sea.

The *Canada Marine Act* provides port authorities with the ability to monitor ships about to enter a port and establish practices and procedures to be followed. This includes management of safety and efficiency and environmental protection. Port Metro Vancouver has defined local practices to protect the marine environment. This gives the Harbour Patrol a mandate to board ocean-going vessels within the port's jurisdiction to communicate the port's environmental policies.

Sewage, sludge and oil spills

Sewage and wastewater are generated onboard all ships, sometimes in large quantities. Discharges of these wastes into port waters may include organic, biological, chemical and toxic pollutants.

Measures addressing sewage, sludge and oil spills

Deliberate discharge of oily machine room water remains a problem many places, despite IMO's guidelines for the prevention of pollution by oil. A control revealed that 90% of the ships calling at Gothenburg did not have well-functioning oil separation systems.

Large accidental oil and chemical spills may occur as a result of collisions involving tankers, the largest of which can carry several hundred tonnes of crude oil. New tankers are now to have double hulls or alternative designs having similar properties. Ports in several parts of the world have differentiated port fees to stimulate early introduction of double hulls. In Finland, the *Oil damage levy* has 50% lower rates for ships with double hulls compared to other ships.

The port of Stockholm operates treatment plants at its ferry terminals, in order to prevent toilet and kitchen wastewater from being rejected into the sensitive brackish water system of the Baltic Sea. A 2004 agreement between the port of Seattle, the Washington State Department of Ecology and the Northwest Cruise Ship Association prohibits all untreated cruise ship wastewater discharges.

Regarding the ports of *Los Angeles* and *Long Beach*, California has sought to impose stringent liquid wastes discharge limits on ocean-going vessels. Except for sewage, state law prohibits liquid waste discharges in California coastal waters unless vessels are unable to either store or offload wastes. Federal law prohibits discharging untreated sewage into US waters and California is working with federal authorities to create no discharge zones in which all sewage discharges would be prohibited.

Waste reception facilities have been installed by the port of *Rotterdam*, to facilitate and promote safe and environmental friendly disposing of waste products. It is obligatory for ships to discard their waste products at the designated waste reception facilities. To make sure the ships hand in their effluents, all ships have to notify the port on the waste on board and their capacity for waste storage.

For visiting ships, the Harbour Patrol of Port Metro *Vancouver* seals the engine room bilge discharge valve(s) with a tamper-proof seal. Any accidental discharges must be reported to the port immediately. One Harbour Patrol craft has thermal imaging that can be used to identify oil in water.

The *Busan* coastal area is biologically very productive, but the risk of oil spills from vessels is high because of the dense vessel traffic. Therefore, the Korean Coast Guard has established a regional contingency plan of the area and secured resources for effective oil spill responses.

Garbage

Routine operations of crew and passengers create solid wastes from activities such as food preparation and ship operations, and from cargo-related activities, such as spillage and disposal of packing materials. These wastes may include organic, biological, chemical and toxic pollutants that should not be disposed in port waters.

Measures addressing garbage

Many ports have well-designed systems for the reception of ship waste, where debris is integrated into the local or regional system for recovery and recycling. Examples of this can be found in the ports of Portland, New York and New Jersey, as well as in Stockholm and Gothenburg.

The port of *Long Beach* has a comprehensive recycling and solid waste management programme.

To facilitate and promote safe and environmental friendly disposing of waste products, waste reception facilities have been installed by the *Rotterdam* Port Authority. It is obligatory for ships to discard their waste products at the designated facilities. Ships are obliged to pay a fee for waste disposal, whether or not they use these facilities. The fees vary with the engine size. In exchange, the ship is allowed to dispose some garbage free of charge. If more garbage is handed in, the ship owner will be will charged for the additional costs.

Port Metro *Vancouver* does not permit any discharge of problematic garbage to the marine environment and discourages non-problematic discharges. Local suppliers are available to receive discharges from ocean-going vessels, for limited volumes.

Port reception facilities for garbage have been installed by private companies in the ports of *Busan* and Incheon. Such facilities have been installed by the Korea Organization of Environment Management in small ports in Korea.

Hinterland distribution and feeder traffic

The environmental impact of hinterland distribution of goods is affected by the efficiency of the transport chain, the choice of mode and the standard of the fuels and vehicles used. Generally, transport by rail, in-land waterways and short-sea shipping require less energy per tonne transported than transport by road, and cause fewer emissions of greenhouse

gases. However, where emissions of NO_x, SO_x and PMare concerned, the choice of fuel and exhaust-treatment systems may be more important.

Measures addressing hinterland distribution and feeder traffic

The ports of *Los Angeles* and *Long Beach* engage in three types of rail loading: 1) on-dock rail yards that load cargo onto trains in the marine terminal, thus eliminating any truck trips on local roadways, 2) near-dock rail yards that are within five miles of the terminal and can serve both ports, and 3) off-dock rail yards, usually located 25-50 miles from the terminal, such as in downtown Los Angeles. To accommodate future growth of the ports, two new on-dock and two near-dock rail facilities are planned.

A major project for reducing rail transport congestion was the creation of the *Alameda Corridor* that opened in 2002, with a below-ground, triple-tracked rail line that is 10 miles long. Total cost was USD 2.4 billion. The corridor has reduced air pollution from idling cars and trucks, cut travel time, and reduced NO_x and PM_{10} emissions significantly. A follow-up Alameda Corridor East line is under construction. This will connect the ports to the transcontinental rail network and greatly improve distribution of cargo, and provide further emission reductions.

To reduce the levels of congestion of the truck routes to and from the port, and to increase the energy-efficiency of its operations, the port of *Rotterdam* has set the goal to ship more goods over water and railways, and less by the road. For 2030, the objective is to ship 35% by road, 45% by inland barges and 20% by rail. To be able to create a big modal shift, the PoRA has made binding agreements with container terminals at the *Maasvlakte 2* area for such a split. PoRA also tries to create a modal shift in the existing port areas, but their influence here is limited. One can, for example, not expect a modal shift from road to rail or inland shipping if there is no access to these modes.

The PoRA is also promoting the use of inland shipping by creating more loading capacity for inland barges; limiting the increase of port dues for inland barges; and optimises the service to inland barges. The situation of rail transport has also been improved with the completion a dedicated link for electric rail cargo transport to Germany.

Port Metro Vancouver is an important player in the development of the Pacific Gateway. The Pacific Gateway is a multimodal network of transportation infrastructure in Western Canada focused on trade with Asia. Through the Asia-Pacific Gateway and Corridor Initiative, the federal government has partnered with the private sector to invest in transportation infrastructure and technology, which will relieve traffic congestion and reduce air emissions.The *Busan* New Port is designed to carry container cargoes by dedicated railways and roads situated in the suburb of the City, thus limiting traffic jams, air pollution and noise. A new road connecting the old and new port, avoiding the City centre, will be completed in 2011.

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Chapter 1

Introduction, Background and Concluding Remarks

This chapter provides some context for the subsequent chapters. Activity levels in the world's largest ports are compared, and the main negative externalities related to near-port shipping, the handling of goods in the ports and the transport to and from the ports' hinterlands are outlined. Some main conclusions of the project are also drawn.

1.1. Introduction

This book is mainly based on a scoping paper prepared by Per Kågeson of Nature Associates, Sweden, and four case studies of the environmental impacts of the ports in Los Angeles and Long Beach in United States, Rotterdam in the Netherlands, Vancouver in Canada and Busan in Korea. It discusses the drivers of port activities, gives examples of the environmental impacts that port activities have, and discusses the economic and environmental impacts of various policy instruments that are already being or could be further applied to address these impacts. The book is limited to the environmental effects of commercial seaports. Military ports, fishing ports and leisure boat marinas are left out of consideration.

Shipping is the predominant mode in international freight transport. About 90% of all such volumes, expressed as tonne kilometres, are carried by ships. In addition shipping is an important domestic carrier of goods and passengers in some countries.

Commercial shipping of goods and passengers may be divided into five categories or sectors:

- Deep-sea international shipping, usually between continents.
- Coastal or short-sea shipping (journeys on enclosed seas or along coasts).
- Inland shipping (barges and ships on rivers, lakes and canals).
- Ferries.
- Cruise shipping.

Under ideal conditions, maritime transport is an efficient and relatively clean mode of transport. However, although generally less fuel-consuming than aviation and the land-based modes, a large part of the global fleet of commercial vessels is far from energy-efficient. An even more pronounced problem is that international shipping is used as a dump for residual fuel oil that for environmental restrictions can no longer be used in land-based facilities. The combustion at sea and in ports of approximately 300 million tonne heavy bunker fuel per year gives rise to very large emissions of sulphur dioxide and significant amounts of particles. In addition, the medium- and slow-speed diesel engines used in shipping produce large emissions of NO_x, an important precursor of ozone, in particular on the high seas where the background level of NO_x is naturally low. Figure 1.1 illustrates the average annual contribution from ships to wet disposition of sulphur and nitrate in different parts of the world.

Accidental and deliberate oil spills and the spreading of foreign species through exchange of ballast water between continents and climatic zones are other environmental problems caused by shipping. In harbours and their inlets, dredging sometimes cause environmental problems.

Maritime transport for a long time grew by 3-4% annually before the recent economic crisis set in, and total volumes may double within the next 25 years. Globalisation and

rapid economic development in parts of the world are major drivers of shipping growth. So long as freight transport is inexpensive and large differences in labour cost exist between industrialised nations and developing countries, international trade will continue to grow faster than the national economies.

The rapid increase in trade causes demand for expansion of existing harbours and the creation of new ports, in particular in developing nations. In many instances, the construction of new or extended port facilities cause conflicts over land use, for instance with wildlife refuges and bird habitats, but in some cases also with local house planning.

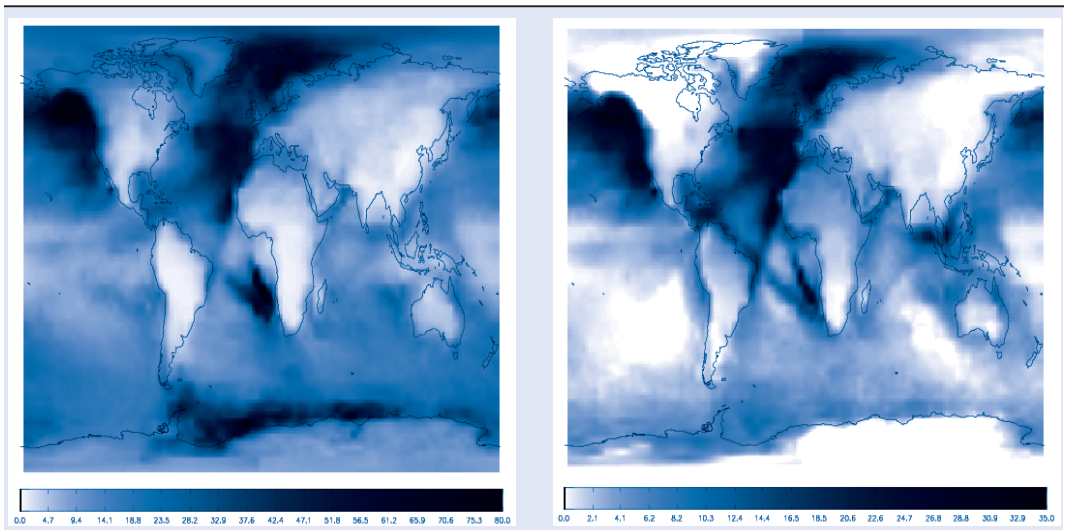
Ports constitute an important part of the global shipping infrastructure by supplying the terminals needed in inter-modal transport chains. Incoming goods are distributed to the hinterland by truck, train or inland waterways, and to coastal regions by feeder boats.

Part of the environmental impact of shipping occurs in or in the immediate vicinity of the ports. Examples of this are noise from ship engines and machinery used for loading and unloading, exhausts of particles, NO_x and SO_2 from the ship's main and auxiliary engines, and dust from the handling of substances such as grain, sand and coal. Road and rail traffic from/to the port area cause additional environmental problems.

Ports contribute towards reducing the disposal of waste and waste water at sea by providing reception facilities for different kinds of waste and by encouraging ship-owners to make use of them. Some ports have differentiated their dues in order to provide incentives to ship-owners to use environmentally benign technologies and fuels. These examples show that ports may influence behaviour beyond what is required for complying with rules intended for the protection of human health and the environment in the port city itself. However, there is nevertheless an important difference between environmental problems over which port authorities can exercise legal rights and those which largely lie outside their field of competence.

Figure 1.1. **Yearly average contribution from ship traffic to wet disposition**

Per cent



Note: Nitrate (left), sulphur (right).

Source: Dalsøren *et al.* (2008).

1.2. Activity levels in ports

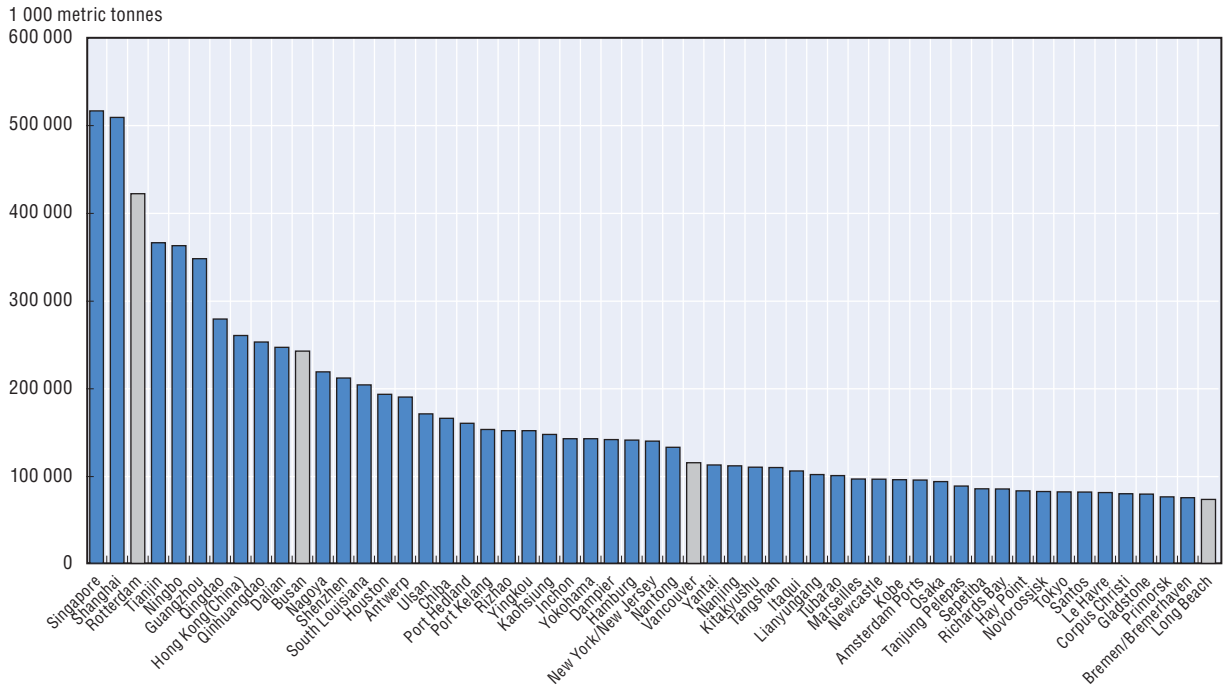
Ports differ in size and type of traffic. Some are highly specialised. A few are industry ports, serving only a specific industrial site, such as a refinery or a mine. Most harbours, however, are publicly owned and open to calls by ships regardless of ownership or origin. Many contain several ports or terminals specialised on different types of shipping such as containers, Ro-Ro, bulk and mineral oils.

Figure 1.2 provides a "ranking" of the world's largest ports, based on the total tonnage of their throughput. Most of the ports covered in the case studies are emphasised with diagonal shading (Los Angeles is "too small" to be included in this graph). This "ranking" probably gives a relatively correct picture as to which are the very largest ports overall (Singapore, Shanghai, Rotterdam…), but comparisons are complicated by the use of different indicators, etc. The "ranking" also does not take *e.g.* cruise shipping into account, which can be important for some ports (*e.g.* Miami).

Figure 1.3 focuses on only *one* type of cargo shipping, namely containers, and gives a ranking of the largest ports within this category in 2004 and 2008 – measures in thousands of Twenty-Foot Equivalent Units (again with a highlighting of the case study ports). Singapore and Shanghai were the two largest also here in 2008, followed by Hong Kong, Shenzhen and Busan. The strong growth between 2004 and 2008 of many Chinese container ports is remarkable. Concerning the case study ports, while Los Angeles was not among the "top 55" for overall cargo throughput, it was the 16th largest container port in the world in 2008.

Figure 1.2. **The world's largest ports**

Based on tonnage of their throughput, 2008

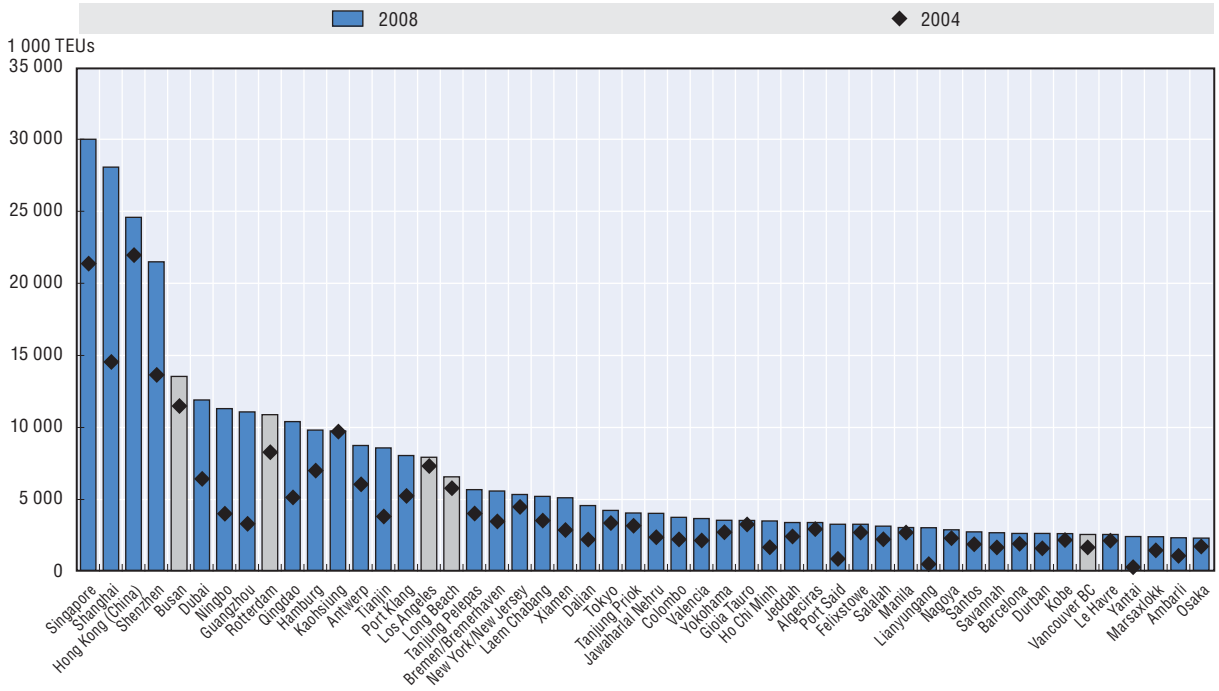


Note: The cargo rankings based on tonnage should be interpreted with caution since these measures are not directly comparable and cannot be converted to a single indicator.

Source: American Association of Port Authorities, *http://aapa.files.cms-plus.com.*

Figure 1.3. **The world's leading container ports**

2004 and 2008



Source: International Association of Ports and Harbors, *www.iaphworldports.org/world_port_info/statistics/container-4.pdf*.

Addressing only ports in Canada and the United States, Figure 1.4 shows the 15 largest ports in the two countries (only Vancouver is in Canada) according to total throughput tonnages, with a differentiation between foreign and domestic trade. One can *i.a.* see that in the three ports studied further in this project, most of the activity stems from foreign trade.

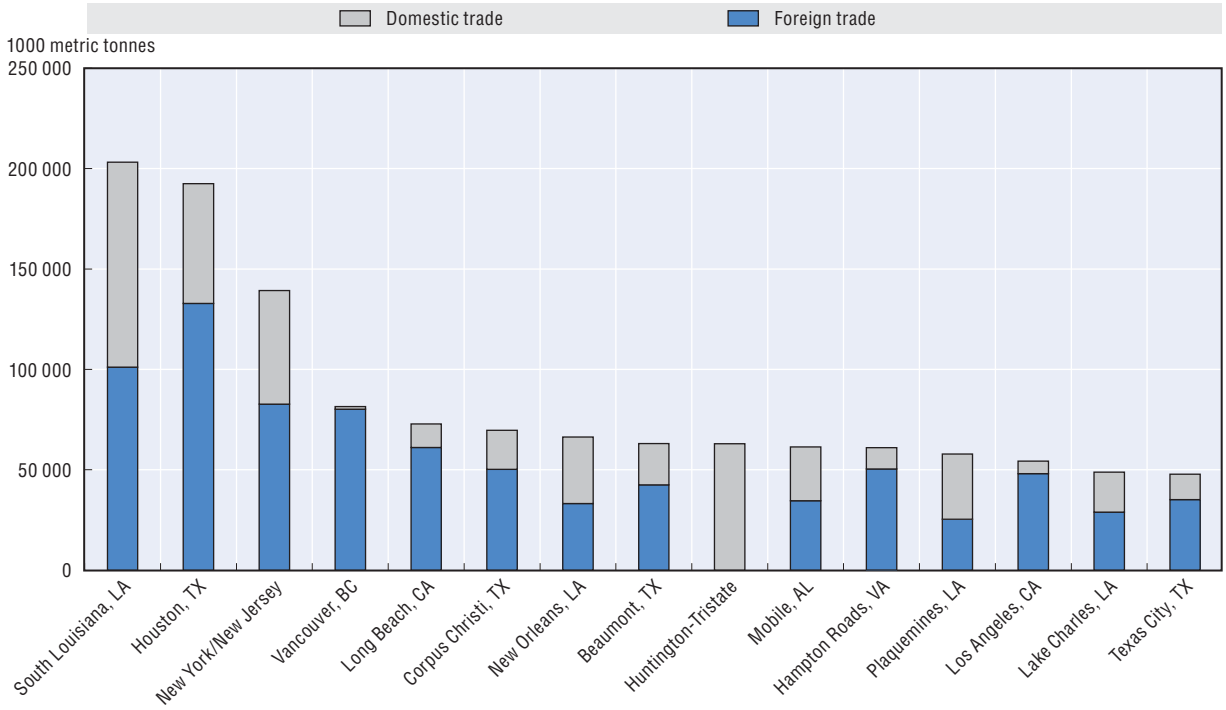
Turning to Europe, Figure 1.5 illustrates activity levels in the major ports, according to the type of cargo traded. Rotterdam is by far the largest port, partly because of its major role as regards liquid bulk trade – but the port is also the largest one for the other categories, with the exception of RoRo traffic (roll-on, roll off), where Calais is larger.

Figure 1.5 also illustrates that traded volumes decreased – often significantly – in most ports between 2007 and 2009, in response to the economic crisis.* Figure 1.6 gives examples of *relative* developments in port activity levels over the period 2007-09 in Rotterdam, Antwerp, Hamburg and Marseille. In several of the ports, solid bulk cargo decreased in relative importance.

* However, from first quarter 2009 to first quarter 2010, throughput in the port of Rotterdam increased 14%; *cf. www.portofrotterdam.com/en/news/pressreleases/2010/20100415_03.jsp*.

Figure 1.4. **Ports in Canada and the United States, according to type of trade**

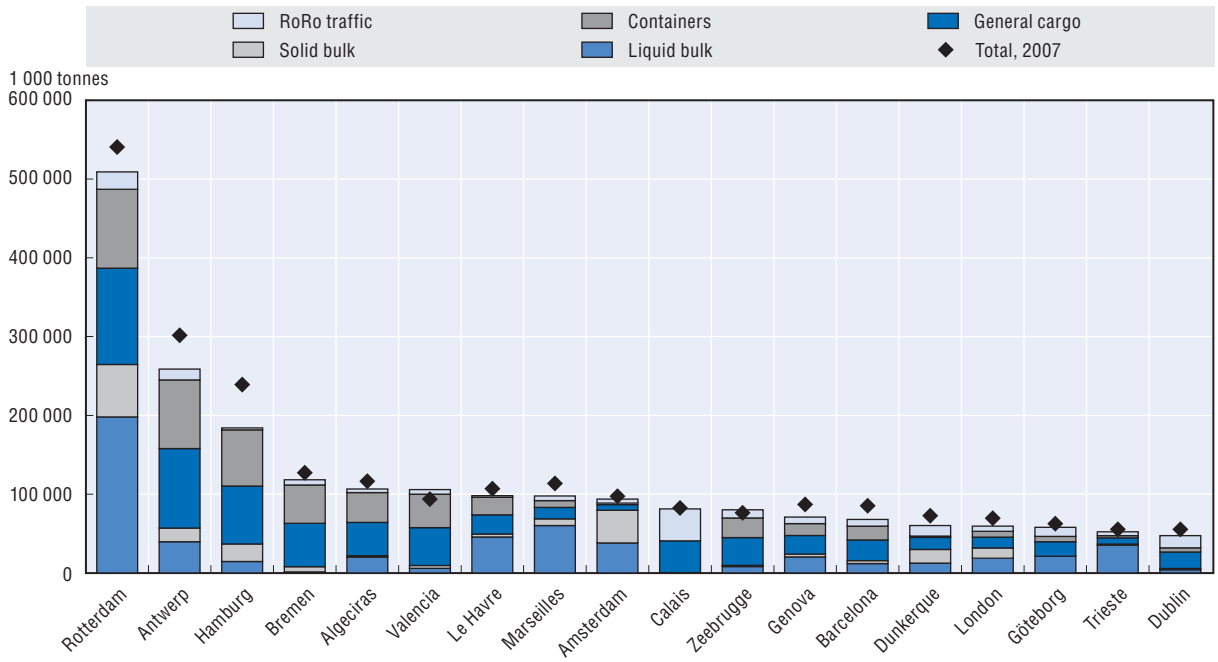
2008 (2007 for Vancouver)



Source: American Association of Port Authorities, *http://aapa.files.cms-plus.com.*

Figure 1.5. **Major ports in Europe, according to type of cargo traded**

By type of cargo for 2009, totals only for 2007

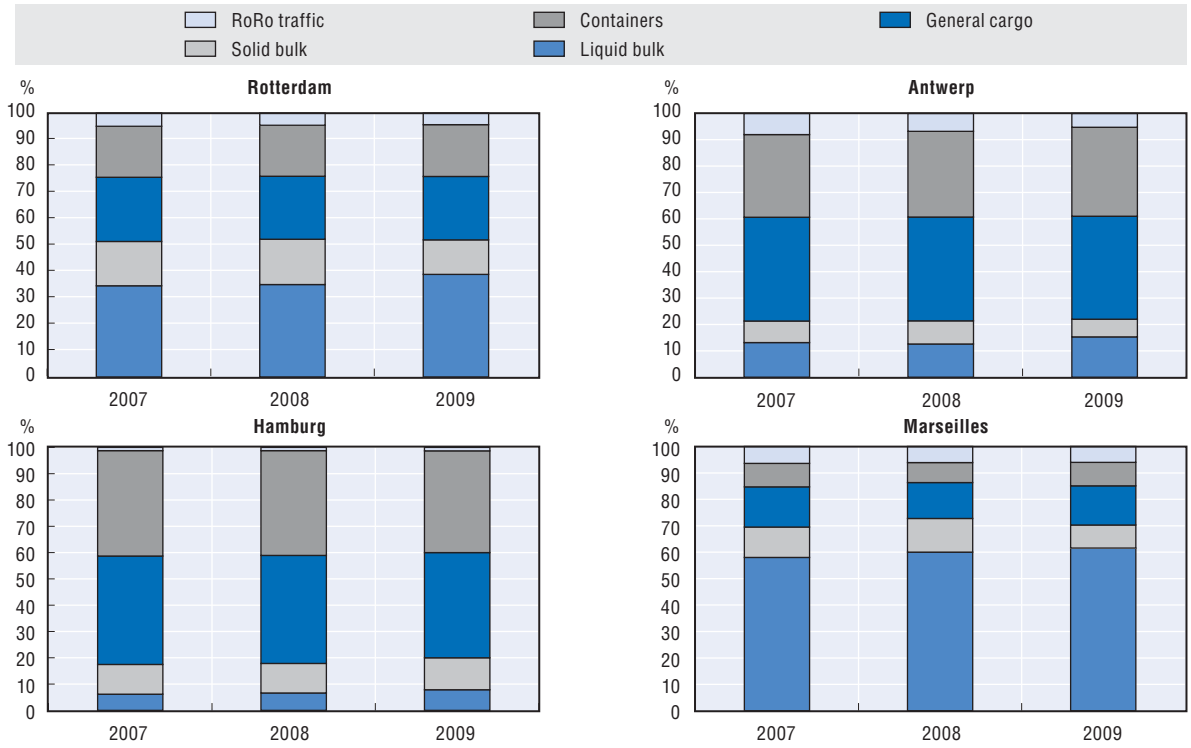


Note: There can be an element of double-counting when the cargo is counted by type, *e.g.* between general cargo and RoRo traffic.

Source: European Sea Ports Organisation, *www.espo.be/Home.aspx.*

Figure 1.6. **Developments in port activity over time**

Rotterdam, Antwerp, Hamburg and Marseille, 2007-09



Source: European Sea Ports Organisation, *www.espo.be/Home.aspx*.

1.3. Environmental issues related to port activity

Some of the environmental problems caused by port activities are related to specific types of ships or cargo, but most are generic effects of ship movements and use of auxiliary engines at berth. The environmental impact from loading and unloading and moving goods in the port area differs somewhat between the various types of cargo. The effects of land-use and dredging are more site-specific. The overall environmental impact of ports depends among many other parameters on the type of location. Ports may be situated on rivers or estuaries, or on a sheltered or an open coast.

The environmental effects of ports may be direct, *i.e.* taking place in the port area, or indirect, as a result of ship movements or the use of other types of vehicles in an inter-modal transport chain. The environmental impact of ports may thus be divided into three sub-categories:

- problems caused by port activity itself;
- problems caused at sea by ships calling at the port;
- emissions from inter-modal transport chains serving the port hinterland.

As evident from Table 1.1, some types of nuisance may occur in more than one of the sub-categories. Emissions of CO_2, NO_x and SO_x are examples of this.

Evidently, the port authority has a greater responsibility for the limitation of nuisances that occur in the port and its immediate vicinity than for problems caused elsewhere by ships and land-based vehicles that call at the port. However, where waste of different types

Table 1.1. **Examples of major environmental concerns in the shipping sector and places of occurrence**

Environmental concern	In the port area	At sea	In the hinterland
Exhausts of NO_x	x	X	x
Exhausts of SO_x	x	X	(x)
Exhausts of particles	X	x	x
Energy use and emissions of CO_2	x	X	X
Emissions of other greenhouse gases	(x)	x	(x)
Noise emissions	X	–	x
Ballast water handling	X	X	–
Oil spill	x	X	–
Disposal of sludge and other types of oily waste	X	–	–
Disposal of sewage	X	x	–
Disposal of garbage	X	–	–
Snow and rain water removal	x	–	–
Dust prevention	x	–	–
Handling of hazardous cargo	x	x	x
Use of anti-fouling paints	X	x	–
Dredging and contaminated soils	X	–	–
Land-use and resource conservation	X	–	(x)

X = large impact, x = medium impact, (x) = minor impact.

is concerned, the port is generally the place where the disposal, recycling or safe destruction can take place.

The port is also the location where port-state control of visiting vessels takes place in order for the international community to make sure that commercial ships comply with the safety and environmental minimum standards introduced by the International Maritime Organization (IMO).

A study conducted by Comtois and Slack (2007), based on an analysis of websites of 800 ports and 120 shipping lines from North America, Europe and Asia, indicates that the top five environmental issues mentioned by port authorities were water quality (mentioned by 25%), waste disposal (21%), air quality (19%), habitat conservation (19%) and noise (15%).

1.4. Conclusions

While well-functioning ports can play an important role in promoting economic development in the surrounding regions and a wider hinterland, this study has demonstrated that port activities can have significant negative impacts on the environment. The study has also provided many examples of measures that can be taken by authorities at different administrative levels to limit these impacts, ranging from a ban on certain activities to economic incentive to promote better performance.

Due to the wide range of environmental issues affected by port activities, clearly a broad mix of policy instruments will need to be applied. It is also necessary to take into account the fact that national and local circumstances vary a lot between different ports, so the "optimal" mix of instruments is likely to vary much from port to port.

Authorities at various levels have put in place a number of different instruments to limit negative environmental impacts, both in relation to near-port shipping activities as such (*e.g.* limits on the sulphur content of the fuels that may be used, and requirements regarding the treatment of ballast water), in relation to the handling of the goods in the

ports (*e.g.* emission standards for the handling equipment, and limits on permitted noise levels), and in relation to the transport of the goods to the hinterland (*e.g.* emission standards for vehicles used in the transport, and investments in better road and rail infrastructure).

The *types of instruments* applied varies much – including "soft" instruments like information provision; investments in new road and port infrastructure; bans on certain activities (*e.g.* on the use of antifouling containing biocides); standards on input use (*e.g.* on sulphur contents in fuels), on technologies to be applied (*e.g.* double-hulls on tankers) and on emissions (*e.g.* regarding goods-handling equipment); and various sorts of economic incentives (*e.g.* differentiated port dues).

While many of the instruments applied are of a "command and control" nature, a number of economic instruments *are* being used. In many cases, economic instruments can provide greater opportunities for the interested parties to find low-cost abatement options than what most regulatory instruments do. However, one can note that most of the economic instruments found in this study are relatively "prescriptive" in character: One gets a reduction in port dues or taxes if using low-sulphur fuels, complying with voluntary speed limits, have double hull, etc. While such rate differentiations certainly can be useful, they do not *directly* address the environmental externalities involved (acidification and smog caused by SO_2 emissions, climate change caused by CO_2 emissions, biodiversity loss and other negative environmental impacts caused by oil spills, etc.) – and they provide few possibilities for the polluters to make innovations that address the underlying environmental problems at a lower cost.

There are a number of reasons for this being the case. One is the lacking global framework for addressing environmental impacts of international shipping. Given the very mobile nature of these activities, it is difficult for individual countries to take action that would "internalise" the climate change impacts of the shipping activity (*e.g.* by putting in place a carbon tax on bunkers) – the ship could simply buy its bunker fuel in a neighbouring country not applying such a tax instead. (All harbour equipment could, however, be made subject to carbon taxes, with much less risk of "carbon leakage".)

Another reason is the difficulties involved in monitoring and enforcing such actions (*i.e.* a tax on *e.g.* the real SO_2, NO_x, or noise emissions from each ship) – and of each unit of equipment operating in each harbour. But while this probably would be impossible to do for the harbour equipment, one *could* probably in principle do so for, at least, the larger ships – assuming that an adequate international framework was put in place. Given the huge costs of building a new ship, the additional costs of installing the necessary equipment to provide real-time monitoring of many of the relevant emissions would be relatively modest.

In principle, any assessment of policies in the environmental (and other) policy areas ought to compare the costs and benefits of the related policy objectives, and to analyse whether a given (environmental) outcome has been reached at the lowest possible cost to society. That has not been done in this study. Besides the fact that such a comprehensive assessment would have required much more resources than what was available for this project, one "excuse" is the fact that at least the shipping-related negative environmental impacts of port activities are largely unregulated at present – compared to the state of affairs in other sectors of the economy. Just to give one example, while the limit on sulphur content in bunker fuels currently is 45 000 ppm (and, in special Emission Control Areas,

15 000 ppm), the maximum sulphur content in diesel fuel for road vehicles allowed in Europe is 10 ppm. Hence, it is possible that almost *any* policy implemented to address the externalities caused by the sector would pass a cost-benefit test – if the policy could be reasonably well enforced.

The situation is different regarding the land-based sources of environmental externalities stemming from port activities. A broad spectre of policies are already addressing them, and policy makers should in each case consider carefully whether they would get more "bang for the buck" by introducing stricter policies regarding these sources than by addressing other sources of the same (or another) environmental problem – or by *e.g.* addressing a non-environmental problem in the society.

While it is difficult to "best practices" for *all* the environmental impacts port activities generate, introduction of shore-side electricity would have the advantage of reducing several negative impacts simultaneously, such as SO_2, NO_x and particle emissions, noise – and, possibly, CO_2 emissions. An important obstacle to a broader use of shore-side electricity is, however, that electricity systems vary between countries, both in terms of voltage (110-220 volt) and frequency (50 or 60 Hz). And as the case study of Busan indicates, it is not enough to make shore-side electricity available: unless ships are obliged to use it, they have few incentives to do so.

In countries where electricity generation is covered by a "cap-and-trade" system for CO_2 emissions (*e.g.* in the EU), CO_2 emissions would be reduced if shore-side electricity was applied, regardless of how the electricity used to supply the ships is produced, as long as the "cap" of the trading system remains unchanged. This is because any increase in CO_2 emissions caused in the process of generating the required amount of electricity would lead to an increase in emission permit prices and a decrease in emissions somewhere else in the trading system.

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Chapter 2

Description of the Case Study Ports*

This chapter provides a description of the five ports that have been studied in particular in this project, namely Los Angeles and Long Beach in United States, Rotterdam in the Netherlands, Vancouver in Canada and Busan in Korea. Information is given on the location and activity of each port, their institutional contexts, and on their environmental situation. Attention is in particular given to their situations regarding air pollution, greenhouse gas emissions, water pollution and noise.

* The description of the ports varies somewhat, due to differences in the information available.

Ports differ in ownership, financial structure and activities. Some port organisations are responsible for management of the whole port area and may own port companies (including cargo operation companies), while others may only act as landlord or have mixed functions with respect to port operations. The port area management is in some countries or cases governed by environmental permits, and in other cases not. This section gives a description of the ports that have been part of special case studies for this project, and of their institutional contexts.

2.1. Los Angeles and Long Beach

Location and activity

The ports of Los Angeles and Long Beach are located adjacent to one another in Southern California, but are operated separately. Their importance to US and world trade derives primarily from the container cargo volume they handle. The Port of Los Angeles (POLA) and the Port of Long Beach (POLB) are the first and second largest container ports in the US, collectively handling over 60% of the US's 19.1 million TEU volume in 2009.[1] In terms of world ranking, the POLA and the POLB combined would be the world's fifth-busiest container port complex, behind Singapore, Shanghai, Hong Kong, and Shenzhen. The two ports also handle dry and liquid bulk, break bulk, and automobiles. The POLA also has a large cruise ship terminal, called World Cruise Facility.

Institutional context

Environmental activity at the two Southern California ports is carried out by a complex array of government agencies and stakeholders. Numerous government agencies are involved, and their jurisdictions frequently overlap and occasionally compete as they deal with port-related environmental issues. What follows is a partial list of government agencies, featuring those that are most important in the present context.

- US Environmental Protection Agency (US EPA) is the federal government agency that administers, among other mandates, the *Clean Air Act* and the *Clean Water Act*. US EPA engages in direct regulation, for example air emissions standards for locomotives, marine engines and trucks, and it oversees states as they carry out the mandates contained in federal law, such as federally mandated permit programmes.
- The United States Coast Guard is a multi-mission, maritime service within the Department of Homeland Security that is considered one of the nation's five armed services. It is charged with maintaining Maritime security, waterway management, vessel safety and some domestic and international environmental agreements.
- The Air Resources Board (ARB) is California's state air pollution regulatory agency. In recognition of California's unique and serious air quality problems, the federal *Clean Air Act* gives California the authority to adopt its own mobile source emissions standards and fuel requirements, subject to case by case approval by the US EPA. The ARB does not have the authority to regulate interstate locomotives or vehicles registered in other

states or to set emissions standards for marine vessels, but can impose fuel use requirements within the State and in California coastal waters. The ARB also has the lead in controlling pollutants that pose an airborne cancer risk to the public.

- The South Coast Air Quality Management District (SCAQMD) is the regional air pollution control agency for the Los Angeles area. It has jurisdiction over stationary sources, develops and updates the federally required Air Quality Management Plan (AQMP) for the area, and administers a number of programmes that provide incentive grants to retrofit and/or replace older, high polluting equipment with cleaner equipment.
- The State Water Resources Control Board (SWRCB or State Board) and the nine Regional Water Quality Control Boards (RWQCBs or Regional Boards) are responsible for the protection and, where possible, the enhancement of the quality of California's waters. The SWRCB sets state-wide policy, and together with the RWQCBs, implements state and federal laws and regulations.
- Southern California Association of Governments (SCAG) has overall regional and transportation planning responsibility for most of Southern California, with the exception of San Diego and Santa Barbara counties. Its members are the 175 cities and 6 counties of the Los Angeles region, and it is the largest metropolitan planning agency in the United States. It has a number of responsibilities, but the most relevant to port issues is its charge to maintain a planning process that results in a *Regional Transportation Plan* and a *Regional Transportation Improvement Program*. SCAG is also charged with the analysis and determination that all projects and regulations in the region "conform" to the mobile source emission budgets contained in the AQMP, and serves as a regional clearinghouse for programmes that provide federal financial assistance and direct development activities to the region.
- The Ports of Los Angeles (POLA) and Long Beach (POLB) are governed and administered independently from one another, though in recent years, they have co-operated on a number of environmental issues. The Cities of Los Angeles and Long Beach each appoint a Harbor Commission to oversee its respective ports. The two cities operate the ports under the provisions of the California *Tidelands Trust Act*, which provides a degree of financial separation between the two cities and their ports. The ports generate their own funds and do not use any tax dollars from the cities' general funds. The *Tidelands Trust Act* states that all the money generated by the Port must be used to further commerce, navigation and fisheries, therefore a major portion of the revenue generated goes toward the continual process of building and renovating the wharves, warehouses and other structures on the waterfront. The ports are sometimes described as *landlord ports*, because they lease their property to tenants who then operate their own facilities. The ports derive their revenue from rents and by providing such services as dockage, wharfage, pilotage, storage, etc. Neither port has direct regulatory authority over air or water pollution, but can use its contractual authority with tenants and service providers to further environmental policy and/or regulatory goals. Because of the key position of the two ports in US West Coast trade, they can exert considerable leverage on the shipping industry on environmental issues.
- The Cities of Los Angeles and Long Beach control land use adjacent to the ports and provide public services to nearby residents. While the cities exert some policy influence through their appointment of the Harbor Commissioners that govern the ports, the ports are not under the direct control of the cities' mayors or city councils.

- The Marine Facilities Division of the California State Lands Commission regulates port activities, including marine invasive species and oil transportation.

The process by which California agencies adopt and amend regulatory requirements is lengthy and contains numerous opportunities for those affected to provide input. The ARB, SCAQMD and SWRCB conduct a number of workshops before making formal regulatory proposals to their governing boards for decision. The rule development process tends to assure open and complete communications between the regulatory agencies and affected parties. Lawsuits challenging California regulatory decisions typically address situations where affected parties contend that the agency has either exceeded its legal authority or abrogated its legal responsibility. Lawsuits tend to be more frequent where sources or operations are being regulated for the first time, as has been the case with a number of port-related regulations.

Environmental situation

Air pollution

The Los Angeles area[2] has what is generally regarded as the most serious overall air quality problem in the US Air pollution levels in the Los Angeles area frequently exceed national and state ambient air quality standards for ground level ozone and fine particulate matter ($PM_{2.5}$). The Los Angeles area is also the most populous and industrialised part of California, and the air pollution emissions generated there affect not only regional air quality but also areas downwind, including some parts of the neighbouring states of Nevada and Arizona. Owing to the severity of the air pollution problem, the regional Air Quality Management Plan (AQMP) for the Los Angeles area is also one of the most comprehensive and far reaching in the nation.

National air quality goals are extremely difficult to attain in the Los Angeles area, despite decades of stringent air pollution control efforts and the substantial improvement that has occurred because of those efforts. According to the 2007 AQMP, population exposure to unhealthy levels of ozone had declined by roughly 35% since 1990, and even the most heavily polluted areas of the region had seen almost a 50% decline in the number of days they exceed the national ambient air quality standard for ozone.[3] Average particulate levels have also been declining, though less sharply than ozone. Nevertheless, the 2007 AQMP estimates that to attain the national ozone standard by 2024 as required by the US Clean Air Act, it will be necessary to reduce regional nitrogen oxides (NO_x) emissions by nearly 90% compared to 2006 levels. To attain the $PM_{2.5}$ standard, it will be necessary to reduce regional NO_x emissions by 55%, and $PM_{2.5}$ emissions by 15%, also compared to 2006 levels.[4]

The two San Pedro Bay ports are substantial contributors to regional emissions of air pollutants. The Clean Air Action Plan estimates that in 2006 the two ports contributed 9% of the NO_x, 12% of the diesel particulate matter (DPM) and 45% of the sulphur oxides (SO_x) produced in the Los Angeles region.[5] The relative and absolute importance of port-related air emissions has increased considerably since 1990. Non-port related emissions have declined substantially during this period because of both intensive emissions control efforts and the gradual decline in heavy industrial activity in the Los Angeles area. Meanwhile, port-related emissions have grown because of substantially increased port activity and relatively less stringent controls of port-related emissions sources.[6] As a

result, emissions from the ports have attracted considerable attention since 2000, and the sources of those emissions have been targeted by the AQMP.

A second and more closely related air pollution issue that affects air quality regulations at ports is the cancer risk to the public that is posed by exposure to DPM. While there are many other sources of airborne cancer risk, DPM stands out. In 1998, the State of California identified DPM as an airborne carcinogen and estimated that it was responsible for roughly 70% of the total population-weighted cancer risk in California from all air pollutants combined. Both the level of risk and the contribution of DPM to that risk tend to be higher in urban areas, particularly near facilities where numerous, large diesel engines are in operation. Since virtually every piece of mobile equipment in use at ports uses a diesel engine, DPM emissions at the two San Pedro Bay ports have drawn considerable attention from air regulators.

Greenhouse gas emissions

The issues related to global warming and climate change affect all nations of the world. California has committed to reducing state-wide greenhouse gas emissions to 1990 levels by 2020, about a 30% reduction from *Business-as-Usual*, and the state has adopted a goal of an 80% reduction below 1990 levels by 2050. The ports and goods movement activities overall, are a major source of GHG emissions and therefore will be affected significantly by State and other programmes to address climate change.

Water pollution

Current water quality conditions in the Ports of Los Angeles and Long Beach waters are generally good. Dissolved oxygen concentrations are close to those in the nearby ocean, with few exceptions (copper and zinc), concentrations of dissolved metals do not exceed California criteria, and concentrations of dissolved organic compounds above regulatory limits are rarely detected. Recent exceedances of bacteriological contamination criteria have been localized.[7] Nevertheless, the two harbors are classified as "impaired" waters for purposes of federal law. A detailed presentation of water quality conditions in the Los Angeles and Long Beach harbors is presented in Appendix A to the Ports' Water Resources Action Plan.[8]

Noise

There are many sources of noise at the two ports during normal operations, including rail car wheel squeal, slamming containers, the operation of cargo handling equipment, locomotive operation and train assembly, vessel whistles and heavy-duty truck traffic. Additional noise occurs during construction activities associated with port improvements and expansion. Nearly all types of construction equipment produce high levels of noise with such equipment as pile drivers and rock drills standing out.

2.2. Rotterdam

Location and activity

The Port of Rotterdam is situated in the Rhine and Meuse delta in the Netherlands. The port stretches between the city of Rotterdam and the North Sea. Due to its depth and the relatively small influence of the tides, the port offers good opportunities, even for the biggest vessels. On the land side, the port offers good hinterland connections, including via inland waterways and the newly constructed "Betuweroute" rail link to Germany.

The port is spread across the entire waterfront between the city of Rotterdam and the North Sea and due to the proximity of residential areas, the opportunities for growth are limited.

Institutional context

The port is managed by the Rotterdam Port Authority (PoRA). However, this organisation is not the owner of the port area. The owner of the port is the municipality of Rotterdam. The municipality leases its land on a leasehold basis to the PoRA. The PoRA on its turn leases the land also on a leasehold basis to the individual organisations in the port area. Thus the PoRA manages the port and financially exploits the area. The area they manage does not include public areas, like for example the public motorways.

The PoRA manages the waterways in the port and it is, for example, responsible for traffic management in the port. Ships at berth are considered to be part of the installations; therefore, berthing ships fall under the jurisdiction of the public authorities.

This ownership structure also clarifies the sphere of influences the PoRA possesses. As the port is the governing body of the port area, it is able to decide – within the limits of the law – the type of organisations and under what conditions they will be accepted in the port.

Environmental licenses are awarded to industrial companies by the DCMR Environmental Protection Agency, which is the environmental agency of the local and regional authorities operating in Rijnmond, the larger "Port of Rotterdam" area in the Netherlands. However, environmental criteria are also used in private law contracts between PoRA and industrial partners, in order to go beyond environmental laws in the Netherlands and the EU.

Environmental situation

Air pollution

The PoRA is subject to EU regulations on air quality, as described in EU Directive 2008/50. This Directive describes several limit values for the concentration of air pollutants. NO_X, PM_{10} and SO_2 are the most relevant substances.

In Table 2.1, the emissions from ships and industry in the Port of Rotterdam area are depicted. The table shows that industry is the main source of air pollutants, except for fine particulates.

The levels of NO_2 and PM_{10} are measured at various urban locations throughout the port area (DCMR, 2009). The data below show that air quality does not meet the standards

Table 2.1. **Air pollutant emissions in the Port of Rotterdam area**

1 000 tonnes

	Maritime			Industry
	Sailing	Manoeuvring	Berthing	
NO_X	1	4	4	17
Fine particulates (combustion)	0.1	0.2	0.3	0.2
SO_2	0.6	3	2	31

Note: sailing comprises emissions from the point of entering of the pilot. Industry emissions apply to 2007. Dry bulk transhipment generates another 400 tonnes of fine particles. Maritime emissions apply to 2004.
Source: DCMR (industry) and own model calculations.

Table 2.2. **Yearly average NO_x concentration and number of hours above 200 and 220 mg/m^3**

Station	Average (mg/m^3)	Number of hours with concentration > 200 mg per m^3	Number of hours with concentration > 220 mg per m^3
Schiedam	40.1	0	0
Hoogvliet	33.9	0	0
Maassluis	35.7	0	0
Overschie	53.2	2	0
Ridderkerk	46.4	2	1
Statenweg	49.6	5	4
Berghaven	34.1	1	0
Pernis	37.1	2	1
Rotterdam (RIVM)	39.6	1	0
Vlaardingen (RIVM)	40.8	6	3
Rijnmond	36.6	0	0

Source: DCMR, 2009.

Table 2.3. **Yearly average PM_{10} concentration and number of 24h periods above 50 mg/m^3**

Station	Average (mg/m^3)	Number of hours with concentration > 50 mg per m^3
Schiedam	27.3	12
Hoogvliet	23.9	6
Maassluis	26.2	10
Overschie	28.3	14
Ridderkerk	27.1	16
Berghaven	27.1	13
Rotterdam (RIVM)	25.6	10
Vlaardingen (RIVM)	27.2	17
Bentinckplein (RIVM)	31.1	30
Rijnmond	25.8	9

Source: DCMR, 2009.

set by EU Directive 2008/50. These stations are all located in the vicinity of residential areas.

Calculations made in the context of the construction of *Maasvlakte 2*, show that the EU air quality standards cannot be met everywhere in the Rijnmond area with *Maasvlakte 2* in operation. The 24-hour standard for PM_{10} and the yearly average NO_X concentration will be exceeded along fairways and in Hoek van Holland, a region that is located near to the harbour entrance (Royal Haskoning, 2007).

With industry as the biggest source, the contribution of sea and inland shipping in the Rijnmond region is significant at hotspots. The relative contribution of shipping to the total NO_x emissions in the region is 13-25%. Ships and inland shipping contribute 5-20% of the NO_2 concentration, while the contribution of ships and inland shipping to the total PM_{10} concentration is more limited, 10-15% at maximum. The share of sea ships and inland barges is roughly equal (Royal Haskoning, 2004).

The influence on local air quality depends on the specific activities taking place in a port. Liquid bulk (*e.g.* chemicals) may have bigger emissions of Volatile organic compounds, whereas dry bulk transhipment may cause particle emissions.

Greenhouse gas emissions

Port-related activities are heavily dependent on energy. For example, energy is used for the incoming flow of goods, various kinds of processes taking place in the port and subsequently the outgoing flow of goods. For energy use caused by incoming and outgoing flows, one should think of energy consumed for shipping, road transport, rail cargo, pipelines etc. For energy used in processes taking place in the port area itself, one can think of energy consumed by industrial processes and cargo handling. These different types of processes consume vast amounts of mostly fossil fuels and thereby result in the emission of greenhouse gasses.

To illustrate the impact of the Port of Rotterdam, the emissions of ships in the port are set against regional greenhouse gas emissions by industry in Table 2.4.

Table 2.4. **CO_2 emissions in the Port of Rotterdam area**

Sailing	Manoeuvring	Berthing	Industry
0.2	0.1	0.5	25

Note: sailing comprises emissions from the point of entering of the pilot. Industry emissions apply to 2007. Maritime emissions apply to 2004. Source: DCMR (industry) and own model calculations.

The emissions of manoeuvring and berthing (*e.g.* auxiliary engine use and fuel heating) are relatively limited compared to industrial emissions in the PoR area. If all transport related emissions (sailing ships and hinterland distribution) would be included, the share of transport would be higher.

As mentioned, at the moment *Maasvlakte 2* is under construction. This development will result in a significant increase of CO_2 emissions. According to Friends of the Earth Netherlands, the proposed *Maasvlakte 2* plan would result in a 5% to 8% increase of the total CO_2 emission in the Netherlands in 2020.[9]

Water pollution

The water quality can be heavily affected by activities in a port. One such example is spills of mineral oils that lead to pollution of water and sediments. Such oil spills can be accidental or illegal. In the Port of Rotterdam, spills regularly occur; for example, in 2008, 193 spills occurred. Compared to the number of spills in 1993 (600 spills) the occurrence had dropped by two thirds.

Noise

Ports and port-related activities can generate high noise levels. These sound emissions can originate from a wide variety of sources; industry, shipping, cargo handling, hinterland transport, maintenance, etc. Noise emissions have been found to negatively impact its surroundings. For example, high levels of noise have found to have a serious negative impact on health (DCMR, 2009). As the port of Rotterdam is situated in the vicinity of residential areas, noise has had continuous attention.

The DCMR has concluded that sound levels in the port present problems. They have described the effect of sound levels on residential areas. An analysis from 2004 showed that the sound levels generated by traffic in this area caused significant health problems.

High noise levels exist in the port area, in particular close to the road- and rail-based hinterland connections. Industry noise is also prominently present in port areas.

2.3. Port Metro Vancouver

Location and activity

Port Metro Vancouver is situated on the west coast of North America, in the Canadian province of British Columbia, in the Georgia Basin – Puget Sound (GB-PS) bi-national area. Marine traffic to the ports of Metro Vancouver, Seattle and Tacoma share the common transport corridor along the Strait of Juan de Fuca. Port Metro Vancouver, together with the Port of Prince Rupert to the north and US ports to the south (Seattle, Tacoma, Los Angeles and Long Beach) are considered "gateway" ports to Asia, since large volumes of goods that originate from or are destined to Asia pass through these locations. Aside from relatively high marine traffic levels at and near the ports, rail transport (and to a lesser degree trucking) is actively utilized to move goods to/from inland locations.

Port Metro Vancouver has long served as the dominant Canadian port for access to Asia-Pacific markets. In recent years, the flow of containerized goods has been dramatically increasing at the port, as this mode of shipping has increased in popularity. There have been recent container terminal expansion activities at the port to meet the expected increase in container shipments in the future.

Port Metro Vancouver is Canada's largest and busiest port and is the fourth largest port in North America based on total tonnage, *cf.* Figure 2.3. It is also a highly diversified port, with five main business sectors, including automobiles, break-bulk, bulk, container and cruise. Port operations include 28 major marine cargo terminals and over 50 smaller marine-related facilities. In 2008, the Vancouver Port Authority amalgamated with the Fraser River Port Authority and the North Fraser Port Authority to become the Vancouver Fraser Port Authority. As such, Port Metro Vancouver's marine facilities extend along the two arms of the Fraser River in addition to its terminals in the Burrard Inlet and the Georgia Strait.

The port borders 16 municipalities and therefore works with municipal and regional government officials as well as provincial and federal agencies. The port also successfully partners with industry and industry associations to plan and implement environmental studies or programmes.

Institutional context

Management and regulation of marine vessels and the marine environment occurs at the national level in Canada, with provincial representation for waters within provincial jurisdiction. Three federal governmental agencies have a mandate that includes stewardship of the marine environment. Environment Canada has a broad mandate to preserve and enhance the quality of the natural environment, including water, air and soil quality. However, Environment Canada is a science-based department and often conducts studies to help other governmental agencies establish appropriate environmental programmes, policies and requirements.

The Department of Fisheries and Oceans (DFO) manages Canada's oceans and freshwater resources. The DFO operates the Canadian Coast Guard, which has an environmental response programme to deal with all marine pollution incidents (*e.g.*, fuel

or cargo spills) in Canadian waters. The DFO additionally manages fisheries, habitat and aquaculture and conducts related research in a similar capacity to Environment Canada.

Transport Canada is directly responsible for the nation's transportation system, including the security and environmental performance of Canadian ports. This responsibility includes regulation of vessels for environmental protection, including pollution prevention, environmental response and liability. Transport Canada also plays a role in administering international commercial maritime rules in Canada. Under the 1995 National Marine Policy, 19 major Canadian ports were deemed vital to Canada's domestic and international trade. These 19 ports were designated Canada Port Authorities (CPAs) under the *Canada Marine Act* of 1998.

Transport Canada is the lead agency responsible for the national *Oil Spill Preparedness and Response Regime* (origin 1995), which is an active partnership between government and industry that provides a clear structure to respond to marine oil and fuel spills. This policy serves two main purposes: to ensure that adequate legislation exists for managing fuel spills in Canadian waters and to establish a cascading response programme on a region by region basis. Transport Canada administers liability through the *Marine Liability Act*, which will additionally provide the basis for future regimes to cover liability from hazardous noxious substances incidents.

Transport Canada additionally conducts research, primarily on marine policy and standards (including environmental standards) but also on emerging technologies and transportation systems. As such, policies, strategies and programmes are developed to advise and/or assist the CPAs take locally appropriate actions regarding environmental stewardship. These studies often involve Environment Canada and the Department of Fisheries and Oceans in a technical advisory role.

Given the overlap of environmental responsibilities between federal departments, such as Environment Canada, the DFO and Transport Canada, federal departments commonly collaborate to support and develop policies and regulations to protect the air, land and water resources. For this reason, many environmental programmes and policies that have been developed over the past years have involved the several federal departments as well as individual port authorities.

Transport Canada and the CPAs often collaborate on issues that relate to national security or transfer of ownership of port lands. Other issues are largely managed by the CPAs, who must adhere to the *Canada Marine Act*, as do their tenants.

In addition to the *Canada Marine Act*, several other Acts of Canadian legislation have particular significance to the operation of Canadian ports. The *Canada Shipping Act, 2001* (CSA 2001) is the principal legislation governing protection of the marine environment. The CSA applies to all vessels in waters under Canadian jurisdiction and to Canadian vessels everywhere. The CSA includes Canadian provisions related to pollution from ships and additionally implements Canada's obligations under international conventions, such as the International Maritime Organization (IMO) MARPOL Convention. The CSA provides the basis for enforcement of marine laws and establishes penalties for polluting. Transport Canada, and the CPAs within port jurisdictions, are responsible for upholding the CSA.

The *Fisheries Act* deals with the management of fisheries resources and protection of fish and fish habitat. This Act applies to the whole of Canada, including private property in every province and territory. Fish habitat is defined as spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly to

carry out their life processes. The Fisheries Act is often cited for day-to-day management of port operations as well as development activities. In particular, Section 35 of the Act prohibits the harmful alteration, disruption or destruction of fish habitat.

The *Canadian Environmental Protection Act* (CEPA), designed to protect the environment and human health, provides a wide range of tools to manage toxic substances, other pollution and wastes and ensures that the most harmful substances are phased out or not released into the environment in any measurable quantity. Environment Canada administers and enforces regulations that have been made under this act, such as the *Disposal at Sea* programme for the management of dredged materials.

An additional piece of Canadian legislation has significance for CPAs, in particular during project planning and construction activities. The *Canada Port Authority Environmental Assessment Regulations*, promulgated pursuant to the *Canadian Environmental Assessment Act*, establish a process that allows Canadian port authorities to carefully consider proposed projects in order to ensure that they do not cause significant adverse environmental effects, taking into account activities undertaken during the construction, modification, operation, decommissioning and abandonment of the project, and recommending appropriate mitigation measures.

The *Canadian Environmental Assessment Act* was formally introduced in 1995 and amended in 2003. The number of government agencies involved in a project environmental assessment is dependent on the project and the expected impacts to the environment. For large-scale projects, the various agencies often develop a collaborative framework (and a written agreement for cooperation) before enacting the various stages of the process. A federal environmental assessment provides a decision as to whether or not the project would present significant adverse environmental effects to the environment, and thereby enables federal regulators to determine whether to proceed with issuing specific authorizations, permits, or approvals.

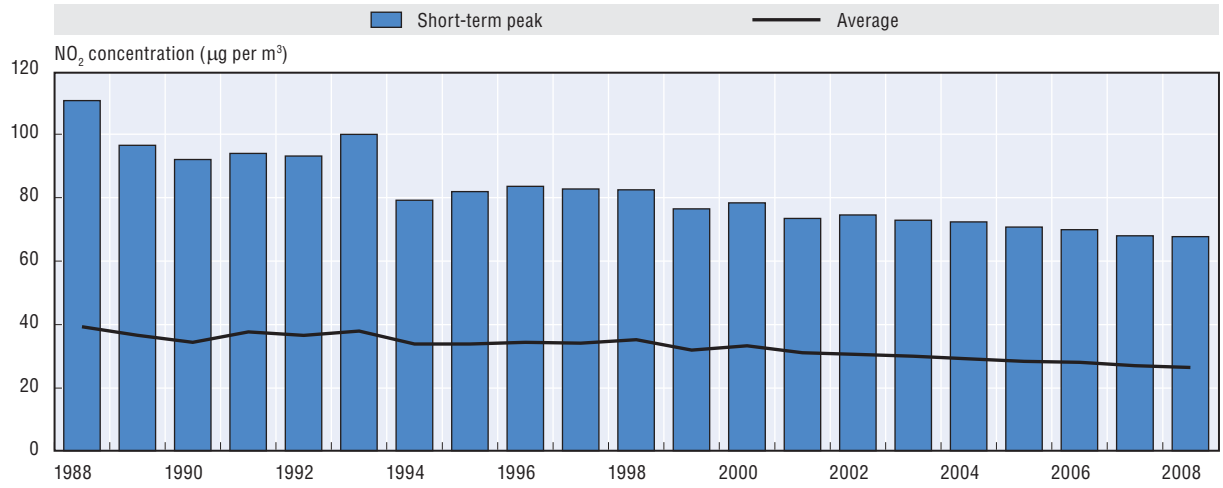
Environmental situation

Air pollution

Although air quality in the Canadian portion of the Georgia Basin – Puget Sound area is usually described as "good", there is a desire at the community and local government level to reduce emissions and improve air quality over time. Figures 2.1 to 2.4 show that ambient air quality has improved in the area and at Port Metro Vancouver over the last two decades (these charts represent averaged results from several air quality monitoring stations in the region). Continued improvement is desired, and the slight increasing trend in ground-level ozone over the last decade is considered a regional issue of concern. Presently, this increasing trend is believed to be due to a general rising trend in regional background ozone levels and not due to an increase in locally produced ozone precursor contaminants (NO_2 and hydrocarbons in particular) (Metro Vancouver, 2008). It is also possible that the region is a hydrocarbon limited area, meaning that reductions in NO_2 emissions over time may not have a lowering effect on ambient ozone.

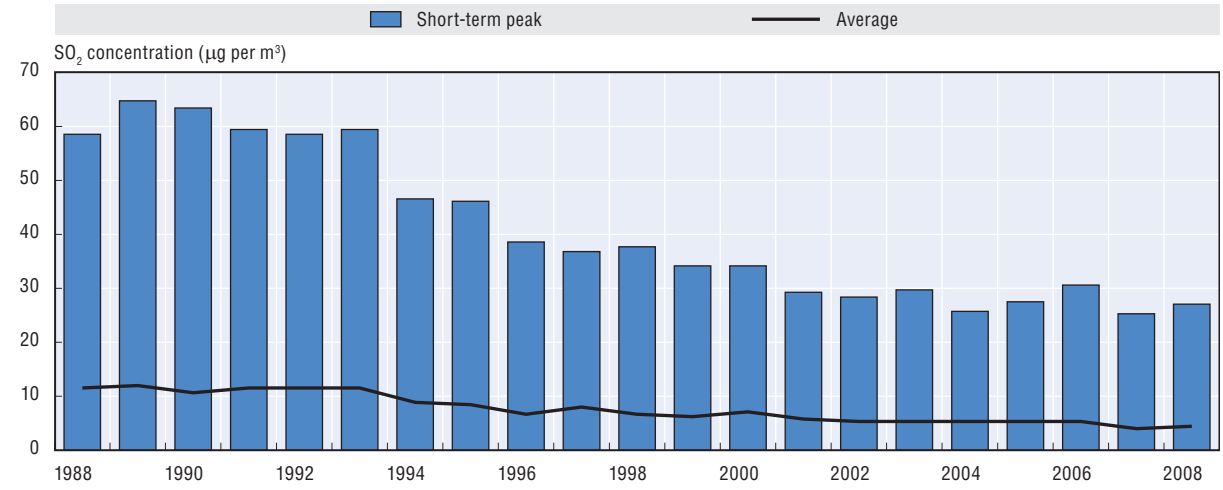
Figure 2.5 provides an illustration of an air quality issue that is somewhat unique to the Lower Fraser Valley of British Columbia. Communities east of the Metro Vancouver municipalities experience the highest levels of ground-level ozone in the region, even though the eastern communities release relatively little of the ozone precursor contaminants. Regional flow patterns move NO_x and hydrocarbon emissions released in

Figure 2.1. **Ambient air quality trends for NO_2 in the Lower Fraser Valley**



Source: Metro Vancouver.

Figure 2.2. **Ambient air quality trends for SO_2 in the Lower Fraser Valley**



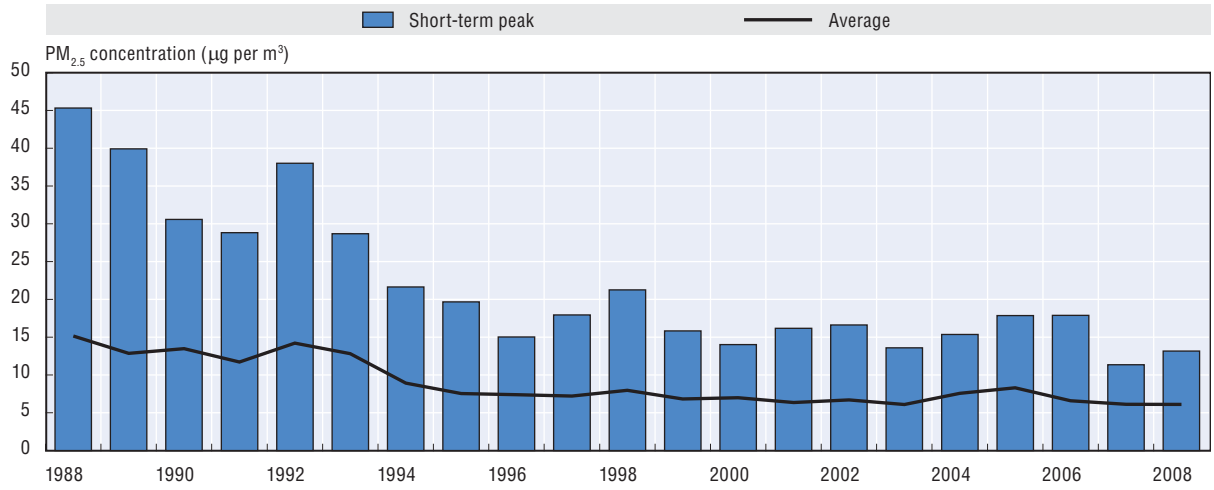
Source: Metro Vancouver.

Metro Vancouver east to communities such as Hope and Chilliwack, where photochemical reactions during the summer months lead to short-term ozone concentrations that are very near the CWS standard and infrequently may exceed the Metro Vancouver 8-hour ambient ozone objective.

Water Pollution

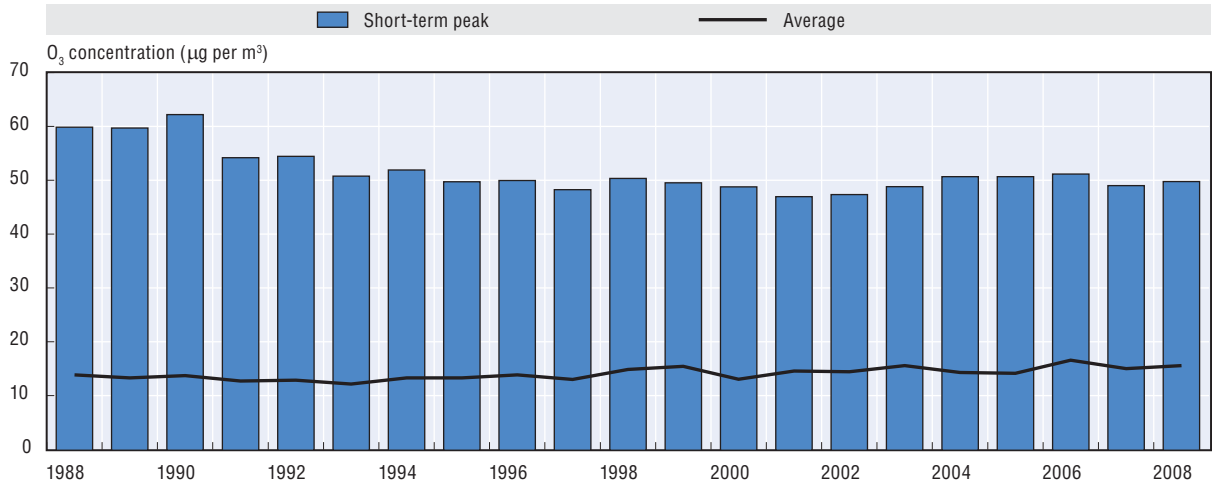
Protecting marine habitat and water quality is an important issue for Port Metro Vancouver. Oil spill preparedness and response is of national concern and has held a strong focus over the last two decades. A defined framework has been in place since 1995, backed by legislation and mutual agreements between government agencies and industry. The national oil spill management framework has been updated very recently, consistent

Figure 2.3. **Ambient air quality trends for $PM_{2.5}$ in the Lower Fraser Valley**



Source: Metro Vancouver.

Figure 2.4. **Ambient air quality trends for O_3 in the Lower Fraser Valley**



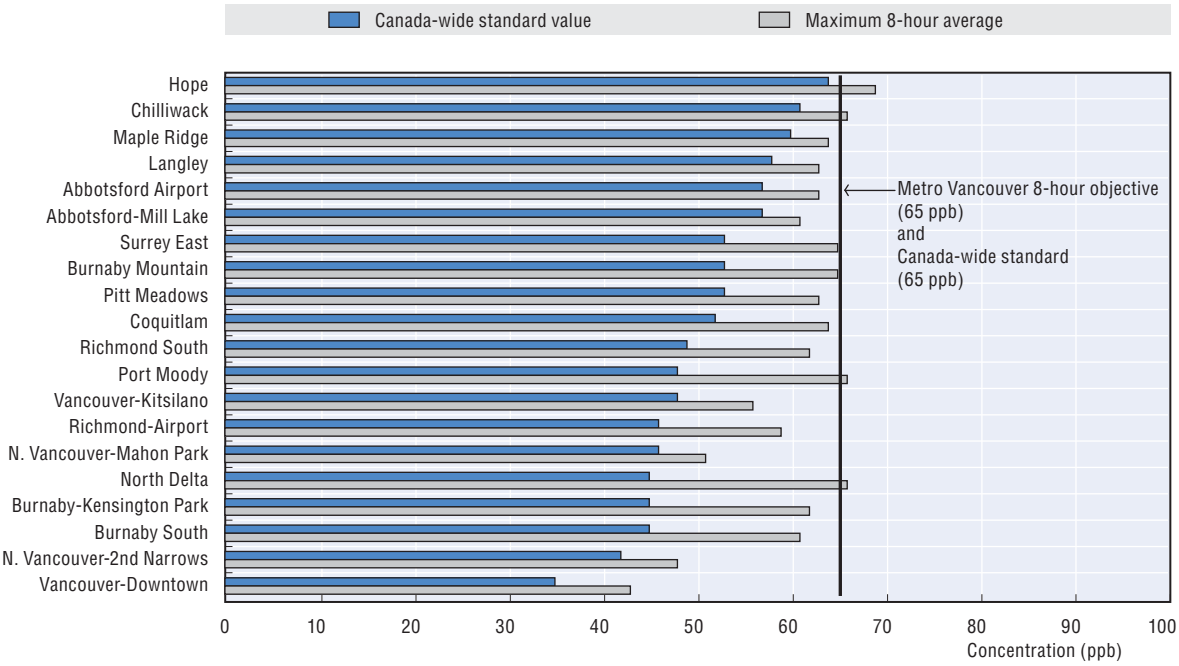
Source: Metro Vancouver.

with international strategies and agreements between countries engaging in high levels of trans-oceanic trade. Disposal of sludge, sewage and garbage, snow and rainwater removal, use of anti-fouling paints and land use and resource conservation are regionally oriented issues that CPAs deal with, often in collaboration with municipal or regional government officials.

Noise

Negative impacts of noise are a local issue that is of concern to communities surrounding Port Metro Vancouver. Sources for elevated noise levels include the operations of the port itself, including construction activities, as well as the relatively high levels of trucking and rail activity within the area.

Figure 2.5. **Ground-level ozone concentrations for stations in the Lower Fraser Valley**



Source: Metro Vancouver.

2.4. Busan

Location and activity

Busan is the 2nd largest city, and has the biggest port, in Korea. The city is situated on the south coast of Korea, and has a population of about 4.5 million. The Port of Busan is geographically very limited, facing mountains northwards and the ocean southwards, so it expands narrowly eastwards and westwards.

Korea's economy depends on imports of major materials and exports of manufactures, totalling together more than 80% of GDP. As the biggest port in Korea, the Busan Port handled more than 70% of the container traffic (11 955 thousand containers) in 2009. Busan Port also handled 18 million tonnes of general cargo in 2009.

Import and export of cargo through the Port of Busan has continuously increased during the last years. In 1997, a total of 59 million revenue tonnes (RTs) of cargo were imported and 47 million RTs of cargo were exported through the Port of Busan. However, in 2008, import and export cargo had increased to 119 million RTs and 122 million RTs respectively. Import and export cargo volumes increased at the rate of 6.5% and 9.0% respectively during the period 1997-2008.

In 1970, a total of 38 633 vessels entered and left Busan for carrying import and export cargo and coastal cargos. The number of vessel increased at an annual rate 3.6%. In 2008, a total of 57 979 vessels (416 338 thousands Gross Tonnes) entered the Busan Port.

The Port of Busan is also the biggest container port in Korea and 5th largest in the world. In 1993, a total of 2 998 thousand containers were handled in the Port of Busan. However, it increased to 13 453 thousands in 2008; an annual rate of increase of 10.5%.

The rate of increase in the number of containers passing through Busan (10.5%) is higher than economic development rate of Korea. With the increasing demand for

Table 2.5. **Trend of import and export cargo volumes through the Busan Port**

1 000 Revenue Tonnes

	1997	2000	2002	2004	2006[1]	2008[1]
Import	59 543	67 412	90 943	101 418	115 085	119 536
Export	47 099	49 817	74 734	113 615	114 854	122 146
Total	106 642	117 229	165 677	215 033	215 033	241 682

1. The numbers for 2006 and 2008 includes the activities at the Busan New Port.
Source: MLTM, 2010.

Table 2.6. **Number of vessels entering and leaving the Busan Port**

	1970	1980	1990	1995	2000	2005	2008
Vessels	38 633	22 873	37 419	61 387	72 022	96 711	115 931

Source: MLTM, 2010.

Table 2.7. **Trend of import and export of containers through the Busan Port**

	1993	1996	2000	2002	2004	2006	2008
1 000 TEU	2 998	4 374	6 383	9 453	11 492	12 039	13 453

Source: MLTM, 2010.

Table 2.8. **Container terminals at the Busan North Port**

Container Terminal	Quay length	Total area	Handling capacity
Jaseongdae	1 447 m	647 000 m^2	1 500 000 TEU
Shinseondae	1 500 m	1 039 000 m^2	1 039 000 TEU
Gamman	1 400 m	731 000 m^2	731 000 TEU
Singamman	826 m	308 000 m^2	308 000 TEU
Uam	500 m	184 000 m^2	184 000 TEU

Source: MLTM, 2010.

container handling in Busan over the last 1980s, 1990s, and early 2000s, the Korean government developed container berths at the Busan North Port accordingly; that is, the Jaseongdae Container Terminal, the Shinseondae Container Terminal, the Gamman Container Terminal, the Singamman Container Terminal and the Uam Container Terminal. When container berths were not enough for handling increasing demand of container, then those containers were handled at general cargo berths, that is, Pier No. 1, 2, 3 and 4 of the Busan North Port.

The destination of most containers imported through the Port of Busan is the Seoul Metropolitan City (Seoul City) and the surrounding areas, where about three fourths of total population of Korea lives; that is, most container cargos imported are consumed at the Seoul Metropolitan City and surrounding area. Also most containers exported through the Port of Busan come from the Seoul City and surrounding areas.

Although new container berths were developed for the increasing demand for container cargoes at the Port of Busan, enough terminals were not supplied because of geographical limitation of Busan City. Therefore, many off-dock container yards (ODCY) were developed for container handling in the downtown of Busan City. There are now 13 ODCYs at Busan City. Many containers were unloaded at the container berths, carried to

the ODCYs by container trucks, and then carried to the Seoul City and surrounding area. Many export containers were also handled at ODCYs, and then carried to the container berths and loaded to container vessels.

Institutional context

In Korea, all the ports are national property. All the commercial ports have been operated by the Ministry of Land, Transport and Maritime Affairs (MLTM) and fishing ports have been operated by the Ministry of Agriculture, Food, and Fisheries (MAFF) and local governments, depending on the size of the ports. However, there have been concerns that the commercial ports operated by the government is inefficient, so management of port operation should be transferred to local governments or some other organisation, like in some other countries.

In 2004, the Korean government enacted the *Port Authority Act* to transfer port management to local governments. In the same year, Busan Metropolitan City (Busan City) established the Busan Port Authority (BPA) to take over management of the Busan Port. Basically, BPA took over the commercial management on the land side, such as terminal operation, facility construction, facility maintenance and repair.

In Korea, all the public waters, such as coastal waters, rivers, lakes, etc. belong to the nation. Therefore, although the commercial management of the Busan Port has been transferred to BPA, the management and control of public water, that is, the Busan coastal waters, is the responsibility of MLTM.

MLTM is in charge of management of the marine environment, including sea water quality, based on the *Marine Environment Management Act*. MLTM is also in charge of management of the marine ecosystem, based on the *Marine Ecosystem Management Act*. Examples of marine environments and ecosystem management in the Busan Port are the Busan Special Area Management, protection and preservation of wetlands, habitats, and wildlife, dredging, marine debris management, etc.

The *Marine Environment Management Act* covers implementation of the MARPOL Convention, so MLTM is in charge of ship-based oil pollution and air pollution. MLTM is also in charge of maritime safety and security management based on the *Maritime Transportation Safety Act* and some other relevant acts. The *Maritime Transportation Safety Act* includes implementation of the SOLAS Convention. Examples of maritime safety management are operation of vessel traffic systems, management of navigation aid systems, dredging for safety, Port State Control, the ISM Code and ISPS Code, etc.

By the *Government Organization Act*, the environmental management in Korea has become a dual system based on spatial divisions: the terrestrial environment and air quality are managed under the Ministry of Environment (MOE) and the marine environment, under MLTM. MOE is charged with the air-environment management based on the *Air-Environment Preservation Act*.

The water quality management on land remains under the charge of MOE, based on the *Water Quality Preservation Act*. The coastal water quality management, however, is under the charge of MLTM, based on the *Marine Environment Management Act*. The jurisdiction of wetlands management is also divided between land-wetlands and tidal-wetlands, based on the *Wetlands Preservation Act*. Solid waste management is divided between land waste and marine debris.

The Korean Coast Guard (KCG) is charged with the implementation of laws on maritime security, maritime safety and marine environment. While the MLTM Port Office

is charged with vessel traffic systems within ports, KCG is charged with vessel traffic systems at coastal channels outside of ports. KCG is also charged with oil spill response, that is, establishes and implements the National Contingency Plan (NCP) and Regional Contingency Plans (RCG). KCG holds resources for oil spill response, such as manpower, vessels, equipments and materials for oil spill response. KCG is a branch office of MLTM.

While the Ministry of Environment (MOE) is charged with the *Air-Environment Preservation Act* and the *Water Quality Preservation Act*, usually MOE establishes standards of air-environment quality and water quality environment and subsidize the local governments for implementation of the above acts. Hence, the Busan Metropolitan City enforces the *Air-Environment Preservation Act* and the *Water Quality Preservation Act*.

Environmental situation

Air pollution

The traffic of container trailers from off-dock-container yards in downtown Busan to container terminals at the Busan North Port are long standing contributors to environmental issues in the Busan City, causing heavy traffic jams, air pollution, and noise. There is also a rail transportation system for container cargoes from Seoul to Busan City. However, most customers of container cargos prefer road transportation to rail transportation because of the short distance (less than 500 km) between Seoul and Busan. Citizens of Busan City have always criticized the traffic jams, the air pollution, and the noise.

As can be seen in Table 2.9, most air quality parameters in Busan City, such as SO_2, PM_{10}, CO, NO_2 and O_3, met the national environmental standards in 2009. This is because there are neither many manufacturing factories, nor heavy and chemical industry, in Busan City. However, emissions from automobiles are a major air pollution source.

Table 2.9. **Trends in air pollution in Busan City**

	Standard	2001	2002	2003	2004	2005	2006	2007	2008	2009
SO_2	< 0.02 ppm	0.008	0.006	0.006	0.007	0.006	0.006	0.006	0.006	0.005
PM_{10}	< 50 μg/m^3	59	69	55	60	58	59	57	51	49
CO	< 9 ppm	0.7	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.4
NO_2	< 0.03 ppm	0.027	0.028	0.026	0.024	0.023	0.023	0.022	0.022	0.021
O_3	< 0.06 ppm	0.025	0.024	0.023	0.024	0.023	0.024	0.024	0.026	0.027

Source: www.busan.go.kr/share/inc/printpage.html.

Water pollution

The environmental impacts of the Busan port on the Busan coastal area are very severe. About 19.3 km^2 of the Busan coastal area were reclaimed for berths and terminals. Although the water quality of small rivers entering the Busan coastal area is getting better, some of the port areas are heavily polluted by heavy metals and organic-toxic substances. The environment and biological situation is as follows:

- The Busan coastal area is biologically very highly productive, with sea water circulation and the warm Taiwan current, but it is threatened by reclamation.
- The man-made shore line is about 48% of the total shore line, 275km, and the reclamation area is 19.3 km^2. About 32.7 km^2 is planned to be reclaimed for development in the near future.
- Most of the watershed of the Busan coastal area is mountainous and the land area for houses, factories, etc. is 175.6 km^2, which represents only 15.2% of the total land area.

- The population of the Busan coastal area is 4.2 million and the population density is 3 669 persons per km^2, which is higher than that of Busan City (2 457 per km^2) and much higher than the national average (397 per km^2).
- The fisheries industry is very active in the western coastal sea of the Port of Busan, including Gangseo-Gu, Saha-Gu, Youndo-Gu, of which fishery production is 55 000 tonnes annually. There are 50 small fisheries ports, 2 689 fishery families, 4 624 coastal fishing vessels, 385 ocean-going fishing vessels, and 36 fishery villages.
- The sewage treatment coverage is 96.2%; however, 3rd grade treatment of sewage treatment coverage is only 25.7%, with focus on Busan City and the Nagdong River.
- 51% of a total of 2 790 waste water discharge plants are in the western part of Busan City, such as Sasng-Gu, Sahh-Gu, Kimhae-Si, so the water quality in that area is very low.
- However, the general water quality in the Busan coastal area is getting better. Recently there occurs on average one harmful algal bloom annually, while there were about 10 harmful algal blooms annually in the early 2000s.
- Compared with water quality, the sediment of the Busan Port is severely polluted, with heavy metals such as cadmium, chromium, copper, etc., in the Sooyoung-Bay, the Busan North Port and the Busan South Port.

Notes

1. American Association of Port Authorities website, *www.aapa-ports.org/Industry/content.cfm?ItemNumber=900&navItemNumber=551*.
2. The area is called the *South Coast Air Basin* in California law.
3. 2007 AQMP, Appendix II, SCAQMD website, *www.aqmd.gov/aqmp/07aqmp/index.html*. The national ambient standard for ozone is a concentration of 0.075 parts per million, measured over 8-hours.
4. In the Los Angeles area, studies have shown that controlling NO_x emissions is critical to reducing the atmospheric formation of both ozone and secondary particulate matter. SO_x are also an important contributor to secondary particulate formation.
5. Final CAAP, San Pedro Bay Ports, 2006.
6. For example, in 2009 the POLA handled 6.7 million TEUs, compared to 2.1 million in 1990. See POLA website, *www.portoflosangeles.org/maritime/stats.asp*.
7. Water Resources Action Plan, Ports of Long Beach and Los Angeles, Final Plan, 2009. *www.polb.com/civica/filebank/blobdload.asp?BlobID=6610*.
8. ibid.
9. *http://www1.milieudefensie.nl/verkeer/activiteiten/maasvlakte/index.htm*.

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Chapter 3

Exhaust Emissions

This chapter discusses exhaust emissions related to port activities – from near-port shipping and from the handling of the goods in the ports. Emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter and volatile organic compounds (VOC) are covered, and – in addition to examples of measures taken elsewhere in the world to limit such emissions – an in-depth discussion of measures to limit such emissions that are applied in the case study ports is provided. These include restrictions on the fuels ships may use, requirements regarding the use of after-treatment technologies, limits on emissions from goods-handling equipment and provision of shore-side electricity. The chapter covers measures applied by the port authorities themselves, and measures taken by national, provisional or local political authorities.

Marine diesel engines are the predominant means for propulsion of merchant vessels. Most ships have several diesel engines, including auxiliary engines for onboard electricity production. Among ships with two-stroke, low-speed engines, 95% use heavy fuel oil (HFO) and the remaining 5% are powered by marine distillate oil. Around 70% of ships propelled by medium-speed engines use HFO, with the remainder burning either marine distillate oil or marine gas oil. High-speed engines operate on distillate oil or gas oil, and gas turbines use gas oil (Corbett, 2006).

Approximately 80% of the fuel consumed in international shipping consists of heavy fuel oil and most of the remaining 20% of marine distillate oil or marine gas oil. Natural gas (LPG) is also used to a small extent.

In a report to the European Commission, ENTEC (2005) found that the average operating time of ship engines per year is 6 000 hours at sea and 700 hours at berth. However, for ferries, cruise ships and some Ro-Ro vessels, the share in port may be substantially higher.

It has been estimated that premature deaths caused by air pollution from international shipping could total over 80 000 per year by 2012. The base-line scenario in this estimation assumes continued worldwide use of marine heavy fuel oil, with an average sulphur content of about 2.7%. A "coastal scenario", assuming the use of marine distillate fuel with a sulphur content of 0.1% by ships sailing within 200 nautical miles of the world's coastlines, could reduce premature mortality rates by almost 50%, to 42 200, compared to about 60 000 in 2002. A "global scenario", with *all* ships using marine distillate fuel with a 0.5% sulphur cap, could cut premature mortality rates by around 60%, to 33 700 (Corbett *et al.*, 2008).

3.1. Sulphur oxides

The shipping sector is using inferior fuel qualities that are no longer accepted for use in land-based installations or road vehicles. Distillate diesel fuel on average contains 0.3-0.5% sulphur and residual fuel oil generally 2.3-3.0%. According to monitoring results presented to the 61st session of IMO's Marine Environment Protection Committee, the average sulphur content a mass of fuel basis worldwide in 2009 was 2.6%,[1] or 26 000 ppm, which may be compared to the maximum of 10 ppm in diesel fuel allowed in European road vehicles from 2009. Approximately 95% of the fuel sulphur appears in the exhaust gases, the rest remains in the lubricating oil and the sludge.

SO_x are a major cause of acid rain and the acidification of soil, groundwater and lakes. SO_x react with water vapour in the stratosphere to form a dense, optically bright, haze layer that reduces the atmospheric transmission of the sun's incoming radiation. They thus have a negative radiative forcing.[2]

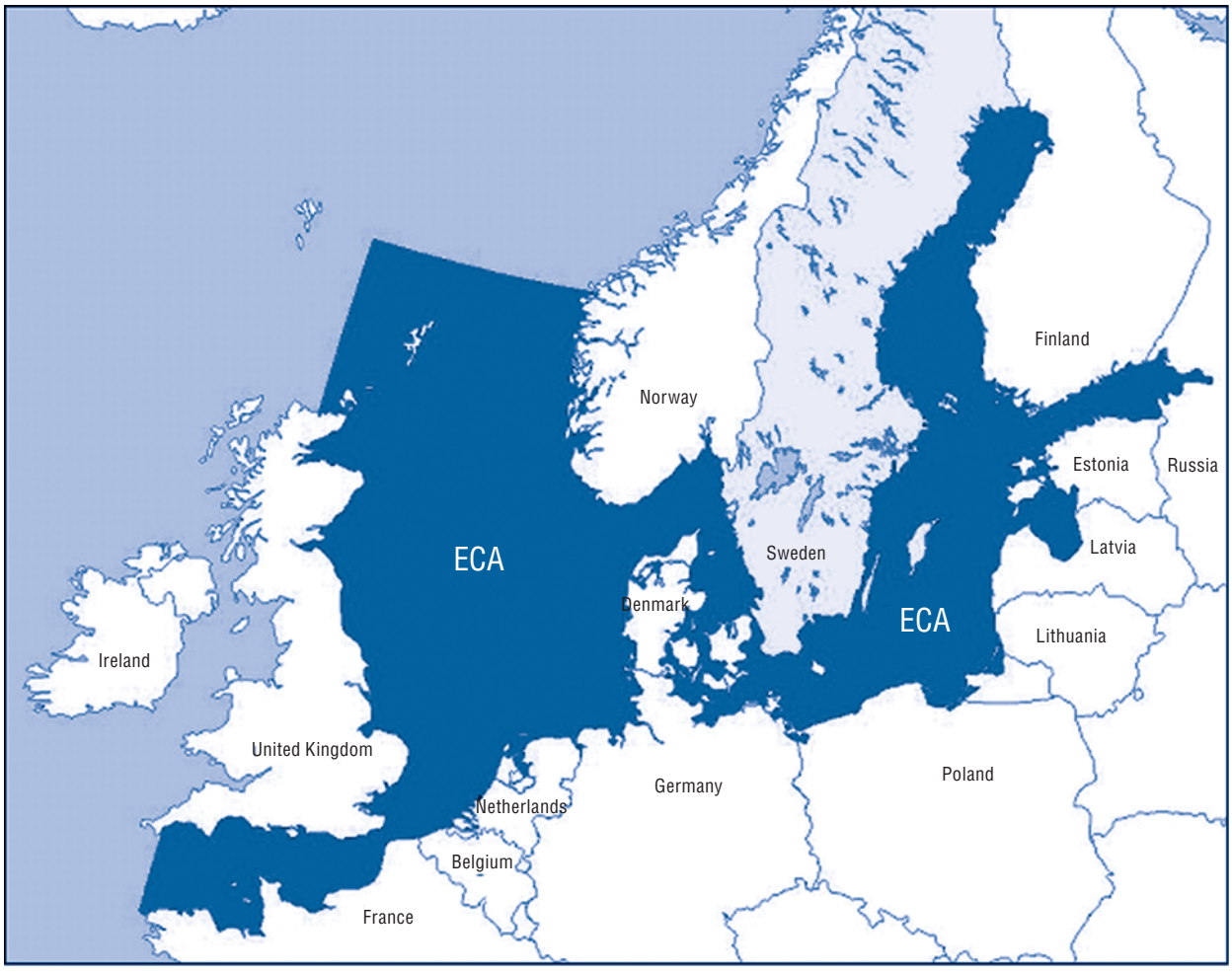
MARPOL Annex VI regulates emissions from ships by a worldwide limit on the sulphur content in marine fuels of 4.5% (corresponds to 45 000 ppm). In special Emission Control Areas (ECAs), the sulphur content must not exceed 1% as of 1 July 2010. Alternatively, ships

may fit an exhaust gas cleaning system or use any other technological method to limit SO_x emissions to less than 6 g per kWh in the exhaust gas. Currently, there are ECAs in the Baltic Sea and the North Sea, *cf.* the dark zones in Figure 3.1.

In March 2010, the IMO adopted the *North American Emission Control Area* proposed by Canada and the United States with the support of France. Large ships within the North American Emission Control Area, covering waters of Canada, the United States and France (Saint-Pierre and Miquelon), south of 60 degrees North, extending 200 nautical miles offshore, will be subject to environmental standards that will limit air pollution. The new measures are expected to significantly reduce both nitrogen and sulphur oxide emissions, as well as emissions of fine particles from exhaust. Enforcement within the North American Emission Control Area will begin in 2012.

According to European law (EU, 2005), operators of passenger vessels on regular services to or from any port in the Community must comply with the 1.5% limit when they are in EU territorial seas and the Exclusive Economic Zones of the Member States, regardless of whether they sail in ECAs or in other seas.

Figure 3.1. **ECAs in the Baltic Sea and the North Sea**



Source: Sjöfartsverket (2010).

IMO's Maritime Environment Protection Committee (MEPC) has agreed to gradually introduce more stringent emission limits. The world-wide maximum limit will fall in stages to 3.5% in 2012 and to 0.5% in 2020, subject to a feasibility review to be completed no later than 2018. ECAs face a stricter limit of 1.0% from July 2010 and 0.1% (*i.e.* 1 000 ppm) in 2015.

3.2. Nitrogen oxides

Nitrogen makes up around 20% of the volume of the atmosphere. In the combustion of fuels, nitrogen reacts with oxygen to form oxides of nitrogen (NO_x). NO_x emissions have residence times in the atmosphere of 1 to 3 days, which mean they can be transported up to 1 200 km. Worldwide, NO_x from shipping have been estimated to about 10% to 15% of the global anthropogenic NO_x emissions from fossil fuels (OECD, 2010).

Shipping is a large source of acid deposition in many countries in Europe, *cf.* Figure 1.1. Especially in sensitive coastal regions, ship emissions contribute notably to overstepping the critical loads of acidification. NO_x also causes eutrophication, affecting biodiversity both on land and in coastal waters.

Nitrogen oxides contribute to the formation of ozone, a major health hazard in many regions of the world and a cause of vegetation damage and reduced crop yields. Ozone is also a greenhouse gas. According to a study commissioned by the IMO, the radiative forcing resulting from increased levels of ground-level ozone due to NO_x from international shipping is "highly likely to produce positive forcing effects that will contribute to global warming and that could be in the same range as (or larger than) direct forcing from CO_2" (Committee on the Environment, Public Health and Consumer Policy, 2003).

The Technical Code of MARPOL Annex VI regulates NO_x emissions from diesel engines with a power output greater than 130 kW installed on a ship constructed after January 2000. The specified NO_x limit represents only a small reduction in emissions compared to unregulated engines. However, in 2008, the IMO's MEPC adopted new emission standards for NO_x from new ship engines, to be introduced in two steps. In the first step, emissions are to be cut by between 16 and 22% by 2011 relative to 2000, and in the second step, by 80% by 2016. The longer-term limit will, however, only apply in specially designated areas. As regards existing ship engines, no significant reductions are expected. It was only agreed that some of the largest existing engines from the period 1990-99 should be – subject to availability and costs – fitted with an emission-reducing "kit" that is expected to be able to reduce NO_x emissions from those engines by 10-20%.

3.3. Particulate matter

The combustion of residual fuel gives rise to large emissions of particulate matter. The finer fractions of these particles often stay airborne over long distances. It can take hours or days for PM_{10} to settle on the ground or sea. Emissions at sea thus definitely have an impact on human health. Fine particles are strongly correlated with harmful effects on human health, as they can penetrate deep into the lungs. There is insufficient evidence to determine a safe level of human exposure to particles, and in practical terms, all emissions of PM should be regarded as harmful.

Diesel pollution is a major contributor to air quality problems in cities surrounding the United States' ten largest ports, according to Cannon (2008).

Fine particles have climate-forcing impacts, either contributing to, or offsetting, the effects of greenhouse gases. Black carbon particulate matter has been identified as an important contributor to radiative heating.

MARPOL Annex VI currently provides no limits for emissions of particulate matter. However, low-sulphur fuels produce much less PM than heavy fuel oil. By using 0.1% sulphur marine gas oil, PM emissions can be cut by as much as 80% (ICCT, 2007).

3.4. Volatile organic compounds

Emissions of volatile organic compounds (VOC) are less of a problem in *shipping* in general than the exhausts of SO_x, NO_x and particles, as slow-speed diesel engines produce relatively small amounts of VOCs. However, addressing more specifically the environmental impacts of *ports*, the loading and unloading of petroleum products, in particular petrol, may give rise to significant VOC emissions, also compared to other land-based sources of VOC.

3.5. Measures taken to address air emissions in ports – in general

Before addressing measures to limit air emissions described in the case studies, this section provides *examples* of other measures in this area. It is emphasised that the list of examples provided is *not* comprehensive.

The International Association of Ports and Harbours (IAPH) has adopted a Clean Air Program for ports and a tool box aimed at tackling air quality problems in port areas. IAPH urges ports to take active and effective steps towards clean air programmes, while stressing the critical need to develop integrated action plans for respective ports and recognising that no one-size-fits-all solution exists for ports with their large variations in pollution levels, emission sources, geographical and meteorological conditions. The purpose of the "*Tool Box for Port Clean Air Programs*" is to provide ports quick access to information, options and tools that can be used to start the planning process to address port-related air quality issues.

Exhausts emitted in port areas can contribute to the exceeding of relevant air quality standards. Many port cities have ambient concentrations of NO_2 and PM_{10} (or $PM_{2.5}$) that exceed national or regional/federal standards or the recommendations by the World Health Organization (WHO). Local port authorities may thus find themselves under pressure to reduce exhaust emissions from ships' manoeuvring in ports and from their use of auxiliary engines at berth. This can in principle be achieved by three different measures:

- Improved fuel quality.
- Use of after-treatment technologies.
- Use of shore-side electricity.

Improved fuel quality

An example of the first type of measure is the adoption by the European Union of the Sulphur Directive (EU, 2005) that requires ships calling at European ports not to use fuel with more than 0.1% sulphur at berth, a regulation that became effective in 2010. This regulation also applies to any fuels used by inland vessels.

In 1998, the Swedish Maritime Administration (SMA), the Swedish Port Organisation and the Swedish Ship-owners Association agreed that the fairway and port dues should be

differentiated based on the ships' emissions of SO_x and NO_x. Ship-owners who verify their continuous operation of ships on bunker oils with low sulphur content qualify for discounts. Ferries that use fuels with less than 0.5% sulphur (by weight), and other ships using fuels with less than 1.0%, get a discount on the SMA's fairway due. The exact discount depends on the extent to which the sulphur content falls below these limits.

By December 2006, 1 006 ships had been granted a discount for low-sulphur bunker fuel. These vessels represent around 75% of the annual ferry tonnage and more than 45% of the cargo tonnage calling at Swedish ports. In addition, close to 30 ports, representing more than 90% of the traffic in Sweden's 52 ports, differentiate their dues for the sulphur content of the fuel used. They apply a differentiation of their port dues, based on data of qualified ships from the SMA, but their systems are outside the influence of the SMA and differ somewhat between ports. A few ports in Finland have also introduced a similar differentiation for ferries.

The Northwest Ports Clean Air Strategy (NWCAS) is a partnership with the Ports of Seattle and Tacoma to address port-related contributions to air quality and climate change in the Georgia Basin-Puget Sound air-shed. The NWCAS was created to reduce port-related diesel emissions in the Georgia Basin-Puget Sound via voluntary, collaborative means among the three major area ports – Seattle and Tacoma in Washington and Metro Vancouver in British Columbia.

Use of LPG may also contribute towards lower ambient concentrations of unwanted substances. For instance, LPG-powered forklift trucks are in use by the Port of Tyne's warehousing department.

Use of after-treatment technologies or electricity

In many circumstances, ports have an opportunity to influence the choice of machinery used for the loading and unloading of ships. They may introduce technical requirements on in-port machinery, regardless of whether the equipment is owned by the port itself or is used by firms operating in the port area. Diesel trucks and tractors maybe equipped with particle filters if ultra-low sulphur fuel is available. The *Bay Area Air Quality Management District* has approved a plan to install diesel exhaust filters on as many as 1 000 of the Port of Oakland's heavy-duty vehicles.

Electrification of cranes, rig trucks and tractors provides another opportunity. The Port Authority of New York and New Jersey have replaced diesel-powered cranes with electric cranes and so has the Port of Seattle. When upgrading its Savannah port, Georgia Ports Authority installed electrified cargo racks and transferred its ship-to-shore cranes to electric power.

Hybrid systems (diesel/battery power) are another option. Hybrid ECO-RTG drive systems to cranes have been delivered to the ports of Saigon and Djibouti.[3] New York and New Jersey are also among the ports that use hybrid machinery.

Nitrogen oxide emissions can be significantly reduced in the port area by making frequent visitors install NO_x-reducing technologies on their machinery, and in particular on the auxiliary engines most frequently used at berth. By the end of 2006, 47 ships had been certified for a NO_x-related discount of the Swedish fairway due. The NO_x-related reduction of the due is based on the emissions measured in grams per kWh. If the emissions at 75% engine load are above 10 g per kWh, no NO_x discount is given. Below this level, the discount increases continuously down to a level of 0.5 grams per kWh. Close to

20 Swedish ports have introduced discounts for low emissions of nitrogen oxides that provide additional incentive to ship-owners.

A recent decision by the Swedish Supreme Environment Court in the case of the city of Helsingborg *versus* two ferry lines shows that a port authority can, without violating the United Nations Convention on the Law of the Sea (UNCLOS), require ships of all nationalities calling at a specific port to install technologies for reducing NO_x below the NO_x curve of MARPOL's Annex VI, if this is needed for the port city's compliance with the European Union's air quality standards or for compliance with national environmental law.

The Port of Seattle has replaced diesel power units with on-dock electrical plug-ins for 600 refrigerated containers.

The Port of Gothenburg has equipped its oil harbour with a vapour recovery system containing three installations with a combined capacity of close to 6 000 m^3 per hour. These plants have an adsorption capacity of 95% and have reduced annual emissions of VOC from ship loading from approximately 450 to 25 tonnes. The Port of Amsterdam is about to install a similar system.

Shore-side electricity

Ships often make use of their auxiliary engines while in port. Heat is needed for heating heavy bunker oil and for keeping crew and passengers warm. Power is used for lighting, fans, appliances and a variety of other electric engines. Large amounts may be required when ship-based machinery is used for loading or unloading cargo. Passenger ferries and cruise ships are floating communities with all the needs related to housing and meals.

Allowing shore-side electricity to substitute power and heat produced onboard can be an effective way of reducing not only NO_x, SO_2 and particle emissions, but also sound as the auxiliary engines often produce low-frequency noise. Whether shore-side electricity is a better option than use of environmentally benign fuels, perhaps in combination with after-treatment of exhaust fumes, depends largely on the time spent at birth and the amount of power needed. For vessels that only make very short calls, such as a ferry in frequent crossing of a narrow sound, connecting to the grid may offer little improvement over measures that can be taken onboard.

A problem in relation to use of shore-side electricity is lack of an international standard for the plug-in systems. One challenge in this context is that different parts of the world use different voltages and frequencies. The USA, Canada and Japan use 60 Hz, while most of the remaining world has electric systems based on 50 Hz. Siemens, however, now offers a flexible modular system for ships that can handle any combination of 50 and 60 Hz power supplies from the medium-voltage public utility grid.[4]

Current use of high-voltage shore-side electricity include some of the berths or terminals of the ports of Gothenburg, Rotterdam, Zeebrügge, Lübeck, Los Angeles and Long Beach and the small Finnish ports of Kotka, Kemi and Oulu. In the European case, most of the high-voltage shore-side electricity is used in ro/ro vessels, while the first trials in California concern container vessels and tankers. Several other ports have plans for the introduction of shore-side electricity.

Low-voltage shore-side electricity has been used in a few ports for a somewhat longer period of time. The Port of Stockholm started in 1987 and has gradually expanded its system. Low-voltage systems have the same effect on in-port emissions has high-voltage.

The difference lies mainly in high-voltage systems being simpler to apply (once installed), as they require fewer cables.

In Sweden, the government is currently considering a proposal from the shipping industry and the ports to remove the tax on electricity used at shore-side, making it a less costly option. The fuel used on board for power production is not taxed.

3.6. Measures taken to address air emissions in ports – case study examples

Los Angeles and Long Beach

In response to the air quality problems described above, California has carried out several major initiatives to reduce air emissions from port-related sources. The 2007 AQMP and its predecessors, the state-wide 2000 *Diesel Risk Reduction Plan* and the 2006 *Goods Movement Emissions Reduction Plan*, each contained measures designed to reduce nitrogen oxide and/or diesel particulate matter (DPM) emissions from port-related equipment. The *Goods Movement Emissions Reduction Plan*, which was developed by the California Air Resources Board, addressed virtually every port-related source of emissions. It incorporated actions taken at the national and regional levels, but also added commitments to a substantial number of California-specific regulatory actions. In combination, the measures in the *Goods Movement Emissions Reduction Plan* are expected to reduce public DPM exposure by 80 to 90%, depending on the exposed community. The measures will also provide considerable NO_x and SO_x reductions. Table 3.1 provides a list of the most important control strategies that are being carried out under the umbrella of the *Goods Movement Emissions Reduction Plan*.

Table 3.1. **Strategies to reduce emissions from ports and goods movement**

Strategy	Status (adopted or proposed)	Compliance date	Notes
		Marine vessels	
Vessel Speed Reduction Agreement for Southern California	2001	In effect	Voluntary programme encouraged by financial incentives.
ARB Expanded Vessel Speed Reduction Programs	Proposed	2010 or later	Mandatory programme to reduce speed to 12 MPH within 24 or 40 miles of ports.
US EPA Emission Standards for Marine Vessel Main Engines	2003	In effect	Affects US flag vessels but are consistent with prior MARPOL Annex VI standards.
Incorporate in IMO Standards more stringent NO_x emissions limits for new vessel main engines and reduce fuel sulphur limits,	2008	2011 to 2016	2008 IMO Annex VI revisions.
US EPA Main Engine Emission Standards	Proposed by EPA and scheduled for finalization in late 2009	2011-16	Implements new MARPOL Annex VI standards for US flag vessels.
ARB Rule for Ship Main Engine fuel	2005	2009 and 2012	All vessels must use 0.1% S fuel within 24 miles by 2012.
ARB Rule for Ship Auxiliary Engine Fuel	2005	2009 and 2012	All vessels must use 0.1% S fuel within 24 miles by 2012.
Emission Control Area (ECA)	2010	2015	The ECA area extends 200 miles from coast line. The 0.1% S limit will eventually displace California rule.
ARB Shore Based Electrical Power Rule	2007	Phase in 2010-20	Reduce at-berth emissions from auxiliary engines by 80% by 2020.
		Cargo handling equipment	
US EPA Non-Road Diesel Fuel Rule	2004	2007 and 2010	Reduces sulphur allowed in diesel fuel to 500 ppm in 2007 and to 15 ppm in 2010. Affects all off-road diesel equipment at ports.
ARB Rule for Diesel Cargo Handling Equipment	2005	2007	New equipment must meet EPA standards and in-use equipment (gantry cranes, top picks, etc.) must phase out older engines on an accelerated schedule.
California Financial Incentives for Cleaner Engines (Carl Moyer Program and others)	2000	Ongoing	Provides grants to equipment owners to retrofit or replace older high-emitting diesel engines. Harbour craft, locomotives and trucks are also eligible.

Table 3.1. **Strategies to reduce emissions from ports and goods movement** *(cont.)*

Strategy	Status (adopted or proposed)	Compliance date	Notes
		Harbor craft	
ARB Rule on New and In-Use Harbor Craft Engines	2007	2009	Replacement engines must meet EPA emissions standards. In-use harbor craft must replace their engines with new engines on accelerated schedule.
US EPA Standards for New Marine Engines	2004	2008 and 2014	Affects tugs and other harbor craft. In-use engines must be upgraded during overhaul; new engines must meet EPA Tier IV off-road standards by 2014.
CAAP Cold Ironing Strategy	2006		Tugs home ported at POLA and POLB must use shore power while at berth.
		Cargo trucks	
US EPA/ARB Rule for New Heavy-duty On-road Diesel Engines	2000	2007 to 2010	Emission limits require all new trucks to utilize diesel particulate filters and advanced NO_x control systems.
ARB Drayage Truck Replacement Rule	2008	2010-13	Bans use at ports of trucks with older engines, starting with oldest trucks first. All trucks must be 2007 or newer by 2013. Financial assistance is available to truck owners.
ARB In-use Truck Rule	2008	2011-23	Accelerates the retirement of all heavy-duty trucks state-wide. Allows some trucks to retrofit with emissions control systems as an interim measure. The ARB was considering extending the compliance schedule in late 2009. Limited financial assistance is available to truck owners.
ARB Truck Idling Rules	2003	2008	Limits idling to 5 minutes by manually shutting down engines or by using automatic shutdown devices.
		Locomotives and railyards	
US EPA Standards for New Locomotive Engines	2004	2008 and 2015	Affects line haul and switching locomotive engines. In-use engines must be upgraded during overhaul; new engines must meet EPA Tier IV off-road standards by 2015.
ARB Fuel Rule for Intrastate Locomotives	2004	2007	Locomotives operating within California must use ultra-low sulphur diesel fuel.
Railyard Risk Reduction Plans (MOU between State and Railroads)	2005	2010	Railyards must develop plans to reduce NO_x and DPM risk using such tools as idle restrictions and better maintenance practices. In Los Angeles, locomotives must meet EPA Tier II standards by 2010.
ARB Recommendations to Implement Further Locomotive and Rail Yard Emission Reductions	Currently Proposed	2014-20	Involves five measures to retrofit locomotive engines with NO_x and DPM controls and to accelerate the introduction of EPA Tier IV engines.
		Other port related sources	
ARB Reefer Rule	2004	2009	Reduces operation of diesel powered refrigeration units on trucks and containers by making electrical grid power available and imposing other operational restrictions.
On-board Incineration Rule	2005	2007	Bans operation of on-board incinerators within 3 miles of California shoreline.

Source: Goods movement emissions reduction plan, updated with information from the California Air Resources Board website, *www.arb.ca.gov/planning/gmerp/gmerp.htm*.

As shown in the Table 3.1, nearly all of the port-related emission reductions measures are already in effect or are in the process of being implemented. Collectively, the measures represent a comprehensive effort by California to reduce port-related emissions through regulatory action and present a major challenge to the ports and the maritime industry. Regional agencies like the SCAQMD and SCAG have linked their planning efforts to elements of the State's regulatory programme. The two San Pedro Bay Ports have joined to assist their service providers, tenants, shipping lines and vessel operators to comply with the new regulations and to encourage early action to reduce emissions. Many regulations rely on a combination of regulatory mandates and financial incentives to accelerate the

retirement of older, dirtier engines and replace them with engines meeting new, stringent national emissions standards.

In November 2006, the POLA and POLB port commissions adopted the San Pedro Bay Ports *Clean Air Action Plan* (CAAP). The CAAP is a commitment by the two ports to co-operate with the regulator agencies and use their authority to accelerate the implementation of some of the most important and potentially effective, regulatory measures listed and described in Table 3.1. The goal of the CAAP is to reduce port-related emissions, particularly NO_x, DPM and SO_x, by about 45% over a 5-year period ending in 2012. An overview of the CAAP is provided below.[5]

> In the final action plan, the ports developed commitments and milestones for achieving air emission reductions and have committed to use pollution-based impact fees so that polluters pay their part to improve air quality.
>
> The ports agreed to develop tariff-based incentives and requirements, such as vessel speed reduction incentives and port-mandated fuel requirements, to curb harmful air emissions, and committed to work with the air quality regulatory agencies (AQMD, CARB and EPA) to establish San Pedro Bay air quality standards, as well as mechanisms for tracking improvements in air quality.
>
> The Plan commits the ports to invest hundreds of millions of dollars in air quality improvement programs, along with the local air district, the State and port-related industry.
>
> Under the Plan, the ports will endeavor to eliminate dirty diesel trucks from San Pedro Bay cargo terminals within five years by helping to finance a new generation of clean or retrofitted vehicles.
>
> The Plan also calls for all major container cargo and cruise ship terminals at the ports to be equipped with shore-side electricity within five to ten years, so that vessels at berth can shut down their dirty, diesel-powered, auxiliary engines and plug into clean electricity. The Port of Long Beach will develop shore-side electricity for ships at 10 to 16 Long Beach berths in five years; the Port of Los Angeles will facilitate shore-side electricity for ships at 15 berths within five years. To reduce emissions of air pollutants, ships will also be required to reduce their speeds when entering or leaving the harbor region, use low-sulfur fuels, and employ other emission-reduction measures and technologies.

The programme to replace all the older, diesel trucks with newer, clean trucks is a centrepiece of the CAAP, and it has moved forward amid considerable controversy and litigation. The core of the programme is the phase-out of older trucks by banning their use on port property. By 2012, only trucks that comply with US EPA emission standards for 2007 model year trucks will be allowed to haul cargo at the two ports. The CAAP supports the CARB regulatory requirement with a programme of financial incentives that help truck owners replace existing truck engines with 2007 compliant trucks and engines. While substantial state funding is provided, the two ports are also levying a USD 35 per Twenty-Foot Equivalent Unit (TEU) container *Clean Trucks Fee* to provide a local source of funding. The fee is paid by cargo owners and collected by terminal operators. According to POLA, the programme is moving forward rapidly despite some controversy and on-going and still unresolved legal actions, with close to 60% of the cargo at the port being handled by 2007-compliant trucks as of mid-2009.

Until June 2009, the two ports provided financial incentives to vessel operators to use low-sulphur fuel in their main engines as they approached the ports. The programme covered the differential between the cost of regular and compliant fuels. However, since the use of low-sulphur fuel within 24 miles of the California coast is now a state-wide regulatory requirement, the financial incentive programme has been discontinued. POLB continues to operate its *Green Flag Program* that provides reduced docking fees to vessels that comply with a voluntary speed limit of 12 knots in Southern California waters. Both ports continue to install the dockside infrastructure needed for container and passenger vessels to plug-in to shore power during their visits. This infrastructure is being used on a voluntary basis at present until "cold ironing" – *i.e.* the use of shore power – becomes mandatory under California regulatory requirements.

The ports are also carrying out a number of efforts to promote new and innovative air pollution control technologies, the greater use of electrification, and the use of alternative-fuelled equipment, like compressed natural gas engines. These efforts both support the short-term goals of the CAAP and encourage technologies and practices that could reduce emissions in the more distant future.

For example, the two ports have developed a *Technology Advancement Program* (TAP) to support development and demonstration of new technologies in the port environment. The TAP is primarily funded by both Ports, but the SCAQMD and other agencies provide additional funding.

The POLA and SCAQMD have helped the *Balqon Corporation* develop a heavy-duty, electric, short-haul drayage truck, which the Port says is the first of its kind to be used at any port worldwide. It can pull a 60 000-pound cargo container at a top speed of 40 mph, and has a range between 30 to 60 miles per battery charge. In 2009, after successful prototype testing, the POLA took delivery of the first of 25 trucks.[6] These trucks will help the port meet the emissions reduction goals of the CAAP.

The two ports and the Alameda Corridor Transportation Authority are calling for technology ideas to one day replace the diesel trucks that travel between Port marine terminals and a local rail yard with a pollution-free cargo-moving system. The Port officially issued a "Request for Concepts and Solutions" on 3 June 2009, outlining the goals and requirements of the project, known as the zero-emission container mover system (ZECMS). The proposed technologies might include electric guide ways, zero-emission trucks or electrified rail, all of which use electricity to power the movement of cargo, rather than diesel-fuelled trucks.

There are numerous grant programmes operated particularly by the US EPA and California air agencies, the ARB and SCAQMD that provide incentive funds to demonstrate new technologies and to assist operators with conversions and retrofits of mobile equipment to alternative fuels or other low emission technologies. Most categories of emission sources that operate at the two ports are eligible for these grants. Some of the grant programmes contain restrictions that do not allow their funds to be used to comply with regulatory requirements, but others can be used to support both regulatory requirements and the measures contained in the CAAP.[7]

To conclude, a major effort is underway to reduce air pollutant emissions from the two San Pedro Bay Ports. At its core is a California regulatory programme that has already changed the type of fuel used near the California coast, and which will, within 5 to 10 years, result in the replacement of most existing harbour craft engines, cargo trucks and

cargo handling equipment and alter port operations. Although financial assistance is available from a variety of local, state and national sources, compliance will also impose costs on service providers, tenants, shipping lines and vessel operators. The two ports are committed to supporting accelerated implementation of regulatory requirements and to encouraging the development of new technologies.

Rotterdam

The Rotterdam Port Authority (PoRA) attempts to limit the emissions of air pollutants, paying special attention on how to limit the impact *Maasvlakte 2* on air quality. In the existing port areas, the PoRa uses stricter emission standards in contract renewal processes. However, the ability for tightening of standards is limited in these negotiations as compared to the issuing of new land.

The storage and transhipment of coal can significantly influence local air quality (DCMR, 2009). To limit the emission of dust, measures have been taken. The Rijnmond Environmental Protection Agency determines which technical and behavioural measures a company involved in dry bulk handling has to implement (DCMR, 2009). Technical measures to decrease the emission from transhipment include closed transhipment, or the use of suction filters. To prevent dust emissions from the storage of dry bulk outdoors (ore, coal), surfaces are kept wet or are covered under a crust of cellulose or latex materials.

Also behavioural codes for handling dry bulk have been set (DCMR, 2009). In these codes, for example, conditions for material handling with machinery are described. The codes also include factors such as the maximum wind speed under which handling is allowed to take place.

A monitoring network has been created around the major dry bulk terminals. The digital network provides these organisations with information on when dust is emitted. The DCMR also uses the network to check compliance with regulations. Without these networks, it would be very difficult to check the compliance of regulations (DCMR, 2009).

Air pollution can also be prevented by installing shore-side electricity in the port. When barges switch from their generators to the grid electricity, a reduction in air polluting emissions is achieved. The production of electricity in the Netherlands is more efficient compared to that of small generators. The PoRA and Utilinq (a subsidiary of the Eneco energy corporation) have conducted a pilot shore-side electricity project in one of its inland shipping ports (PoR, 2009a). As this pilot was successful, the decision has been made to increase the availability of shore-side electricity to all public berths (257) in the port in 2012 (PoR, 2009a).

Shore-side electricity can also be applied at seagoing ships, but this is not yet done in the PoR. The slow adoption of shore-side electricity by ports can – apart from economic considerations – be found in the fact that (as mentioned) no common system standards have yet been set, and due to the relatively large investment costs involved. A development that will foster the positive influence of shore-side electricity for seagoing ships is being planned by the PoRA and Stena Line. They have signed an intention declaration on shore-side electricity for passenger ships in Hoek van Holland (PoR, 2009a).

An alternative to shore-side electricity supply is the installation of exhaust gas treatment systems. The PoRA has adopted such techniques on its own ships. Four of its ships are equipped with SCR catalysts and particle filters (PoR, 2007). The SCR catalysts reduce emission of NO_X with a chemical reaction into other less harmful substances. As

the activities of the PoRA are highly visible in the sector, such an action might cause others to follow.

On a larger scale, the Dutch State is also promoting cleaner techniques. For the installation of SCR catalysts and cleaner engines, SenterNovem (an agency of the Dutch Ministry of Economic Affairs) ran a subsidy programme from 2005 to 2008 for NO_x measures on inland shipping barges. A small number of owners (10) used the programme to fit their ships with a catalyst. A possible explanation for the limited result can be found in the fact that the subsidy did not compensate for the additional operating costs.

The option of choosing a CCNR-2 (Central Commission for the Navigation of the Rhine[8]) engine was much more popular, as 366 ships were fitted with one under the programme. Because CCNR-2 has become an EU standard for new engines in inland barges, the programme was changed, and in 2009, companies could only apply for a subsidy for the installation of SCR catalysts (SenterNovem, 2009).

The PoRA is also promoting further adoption of clean techniques by inland vessels in the port by pricing mechanisms and complete bans (PoR, 2009a). This was one of the criteria set by the State for the granting of the construction license for the *Maasvlakte 2*. From 2010 onwards, the most polluting ships will be charged additionally. The differentiation of the port dues will stimulate a faster penetration of cleaner ship engines. As the extra revenues generated by the differentiation will be directed to the State for the investment in the above described programme, the effect could be even higher.

In case the State deems the effect to be too low, additional measures will be taken. The PoRA indicates that in this case, a speed reduction for the most polluting ships will be set at the main waterways (PoR, 2009a). From 2025 onwards, barges using old, polluting engines will be completely banned from the PoR (CCNR-1 and older). As the port of Rotterdam is a major hub for inland shipping barges, this measure will affect a large number of barges. Not only will the local air quality benefit from this measure, but the hinterland areas as well.

The municipality of Rotterdam is also putting in place a similar measure for road freight transport, with the creation of an environmental zone. The zone will be implemented by the municipality at the *Maasvlakte 1 and 2* area from 2013 onwards (PoR, 2009a). This zone will be set up to compensate for the impact *Maasvlakte 2* is predicted to have on air quality in the port. From 2013 onwards, trucks that do not meet the EU Euro V-standard will be banned from the *Maasvlakte 1 and 2* area. In 2016, the measure will be sharpened to the Euro VI standard (PoR, 2008). The measure will promote the application of cleaner engines and will directly result in a reduction of emissions from the vehicles that are active in the transport from both *Maasvlakte* areas to the hinterland.

Possible measures to promote clean techniques in sea-going ships may also result from the development of the Environmental Ship Index. The PoRA is currently studying the possibilities to give preferential treatment to clean sea going ships by *e.g.* a reduction in port dues from 2011 onwards (PoR, 2009a).

The negative environmental impacts of current techniques can also be reduced by the application of cleaner fuels. To harvest these benefits, a coalition of nautical service providers in the PoR have agreed to only use the low-sulphur diesel in their ships. From 2011 on, 10 ppm fuel will be mandatory for inland shipping due to EU regulation. The

(approximately) 130 ships they operate have already switched to the use of 10 ppm EN590 fuel.[9]

After being pressured by the environmental NGO Friends of the Earth (FOE), PoRA agreed to do Further research on how the environmental impact of the growth of the port can be reduced. PoRA and FOE have signed an agreement to limit emissions originating from the *Maasvlakte 1 and 2* or from transport that originates from this area, focusing on a number of substances, including NO_X and SO_2. They agreed that the emission level should be reduced by an additional 10% in 2020 compared to a baseline scenario (Milieudefensie, 2009).

Together with Rotterdam Railfeeding and Alstom, the PoRA is currently testing a prototype hybrid shunting locomotive.[10] This locomotive can reduce the emission of air polluting substances (NO_X, PM_{10}) and CO_2 by 50%. The noise levels will also be reduced by 15 dB. No hybrid locomotives are currently in operation on a commercial basis, since trials are not finished.

Vancouver

Under a nation-wide accord for environmental harmonization, the Canada Wide Standards (CWS) were developed to address environmental contaminants of national concern. Canada has long had a wide set of national objectives targeting environmental pollutants (including those addressed in the CWS) and therefore the CWS go further in meeting Canadians expectation of a common high degree of environmental quality. In general, the Standards are developed through a risk-based approach, using scientific principles. Socio-economic factors and technical feasibility are also accounted for. The Standards contain a numeric limit (*e.g.*, concentration in air or soil), but additionally may include a timetable for attainment of the Standard, a framework for monitoring progress and a list of actions to attain the Standard.

Current environmental contaminants in the Canada Wide Standards include:

- benzene;
- dioxin and furan emissions (specifically from conical waste combustion of municipal waste, incineration, coastal pulp and paper boilers, iron sintering plants and steel manufacturing electric arc furnaces);
- mercury emissions (specifically from waste incineration, base metal smelting, mercury-containing lamps and dental amalgam waste);
- petroleum hydrocarbons in soil; and,
- particulate matter and ground-level ozone.

The CWS include additional, related provisions of *Continuous Improvement* and *Keeping Clean Areas Clean* (CI/KCAC). These provisions relate to the $PM_{2.5}$ and ground level ozone (and ozone precursor compounds) standards only, and not other air contaminants addressed in the CWS. The rationale for the CI/KCAC provisions is expressed below:[11]

> *To ensure that, in the vast areas of Canada with air quality better than the CWS numerical targets for PM and ozone, air quality is not significantly degraded and is maintained or improved to the extent practicable, to minimize risk to human health and the environment for the benefit of future generations.*

The existence of the CI/KCAC places a unique environmental responsibility for management of PM and ozone (and indirectly NO_x and SO_x) that is subject to interpretation

from all stakeholders – regulatory, public and private. The CWS in general require ongoing monitoring activities to ensure the standards are met, while the CI/KCAC provisions have emphasis on project development and avoidance of unnecessary emissions.

Similar to other countries, Canada has established the link between fuel quality and emissions from transportation sources. In particular, this has led to sulphur in fuel regulations that are generally harmonized with the US, since refineries and fuel suppliers in North America often serve both countries. However, the scheduling of the current sulphur in diesel regulations (see Table 3.2) is largely driven by the fuel requirements of advanced emission control technologies for diesel engines. Additional time has been allowed for Canada's Northern Supply Area, which includes the national Arctic regions.

Table 3.2. **Environment Canada's sulphur in fuel regulations**

		On-road diesel fuel	Off-road diesel fuel	Rail and marine diesel fuel
500	Production or Import	Since 1998	1 June 07	1 June 07
	Sales	Since 1998	1 Oct. 07	1 Oct. 07
22	Sales	1 Sept. 06	n.a.	n.a.
15	Production or Import	1 June 06	1 June 10	1 June 12
	Sales	15 Oct. 06	1 Oct. 10	n.a.

Lower sulphur levels in diesel fuel have been shown to reduce engine emissions of SO_x and PM and may additionally influence NO_x emission rates.

Canadian investigations of marine exhaust emissions have involved internationally oriented working groups. This acknowledges the need to contribute to and support internationally based regulations from groups such as the IMO. The regulations in Table 3.2 for marine diesel fuel have a limited effect on international vessels that visit Canadian ports, which may source diesel fuel from areas outside of Canada. In recent years, Canada has been active developing agreements and participating in working groups with related US governmental agencies. An emphasis has been to establish harmonized environmental standards (such as fuel standards).

The environmental mandate of the Canada Port Authorities (CPAs) has evolved considerably over the past two decades. There is a growing trend towards more direct environmental stewardship as part of the day-to-day management of port operations. This often includes determination of effective collaboration with Transport Canada and the Department of Fisheries and Oceans by identifying specific roles the port could assume to increase environmental management performance. For longer-term strategies, actions by the port often would include developing agreements with its tenants and with shipping lines or associations. For day-to-day management, a port authority is the local expert for operational realities within its jurisdiction and therefore is well suited to adopt a "First Responder" approach within the port jurisdiction for environmental issues such as fuel spills or leaks.

Port Metro Vancouver has an *Environmental Programs Department* to manage environmental issues associated with both developmental projects as well as day-to-day operations. The Department also deals with various agencies and organisations in both Canada and the US in development of harmonized agreements.

A data baseline for air quality, including CAC and GHG emissions has been more recently developed for port operations. Currently, it consists of two activity-based emission

inventories; one completed for ocean going vessels in 2007, that was led and published by a shipping association (BC Chamber of Shipping, 2007) and one completed for landside mobile sources, that was conducted by the port directly (SENES Consultants, 2008).

The development of an air quality data baseline has supported a number of direct environmental policies and programmes, as longer-term strategic goals focussing on environmental performance and day-to-day procedures to promote and support programme initiatives. For day-to-day procedures, the port is able to rely upon its Harbour Patrol. The Port Metro Vancouver Harbour Patrol programme operates with five vessels and 13 full time staff members (additional crew are available on a part-time basis). This programme has existed for several decades, with duties largely consisting of investigation of spills, search and rescue, hazard removal, assistance to police and assistance for special events in the harbour such as fireworks. During the last 15-20 years, the responsibilities of the Harbour Patrol programme have been extended to support environmental policies and programmes initiated by the port, including application reviews for reduced harbour fee dues associated with use of cleaner fuels or other eligible emission reduction measures. The Harbour Patrol regularly boards up to 98% of the ships that call to the port over any given period (anecdotal estimate by the port).

The port has developed a programme to deal with its CAC emissions in a relatively short amount of time. Beginning with identification/clarification of the issue in 2002 (Environment Canada *et al*., 2002) and a regional emissions inventory for the Fraser Valley shortly after (Metro Vancouver, 2003), ship exhaust emissions were identified as a significant, and growing, concern for the region. The port's *Air Action Program*[12] was developed in 2006 to address air quality (and climate change) issues for the port.

A Georgia Basin Marine Vessel Air Quality Work Group was formed in 2004 to formally investigate commercial marine vessel emissions and develop coordinated policies for air quality management. The working group is currently active and involves the port, Environment Canada and Transport Canada (as well as provincial and regional government representation) and substantial participation from industry associations. The British Columbia Chamber of Shipping took on the lead role in the working group to ultimately construct a spatially and temporally resolved activity-based emissions inventory of ocean-going vessel emissions off the coast of British Columbia for 2005/2006. (B.C. Chamber of Shipping, 2007). A previous study completed for Environment Canada (SENES Consultants, 2004) had identified the need for industry participation in such assessments and this approach was ultimately adopted by the B.C. Chamber of Shipping, with financial support from Environment Canada and Metro Vancouver. This working group and the resultant emissions assessment present a good example of the benefit that can be achieved through partnerships between governments, industry and a port authority. The 2005/2006 inventory was recognised in North America for its high level of detail, which was made possible by use of a comprehensive vessel survey programme managed by the Chamber of Shipping. Over 1700 vessels were surveyed during 2005/2006, enabling identification of engine displacement and usage (engine loads) patterns, as well as boiler fuel consumption. The inventory directly used vessel tracking data from the Canadian Coast Guard. Through ship *Automatic Identification System* (AIS) fields and other data forms extracted from the Coast Guard tracking system, the B.C. Chamber of Shipping was able to develop a database of ship positional information off the coast of British Columbia in 3-7 minute time steps.

The B.C. Chamber of Shipping inventory included a number of valuable outputs to facilitate air quality management, including:

- An accounting of all vessel modes of activity, including intra-harbour movements, as well as anchoring and bunkering.
- Distinction of fuel consumption – amounts consumed during different activity modes, amounts of high sulphur *versus* low sulphur fuels used.
- An accounting of vessel practices by ship class – engine sizes, engine uses, cruising speeds, periods of stay dockside.

The inventory provides information on actual shipping lanes, times spent awaiting a marine pilot or at anchor and previously un-documented activity, such as additional travel for vessel fuelling and movements related to queuing while awaiting a berth. This high-quality ocean-going vessel emissions inventory has been shared with provincial and regional government agencies to help identify smaller-scale initiatives for their communities. Of particular importance, the inventory is fully activity-based and accessible within a database environment, facilitating site-specific summaries of vessel movements. Through data sharing facilitated by the working group, inventory summaries were ultimately used for two regional emission inventories.[13]

During development of the marine inventory, the port initiated a landside emissions inventory for port-related activities (including over 50 marine terminals and facilities). Similar to the marine inventory, the landside inventory accounted for CAC (and GHG) emissions on a detailed activity basis, relating specific pieces of equipment to their associated emissions on a terminal-by-terminal basis. Table 3.3 provides an example summary of the port-related cargo handling equipment activity. Similar summaries can be extracted for fuel(s) consumption and emission amounts.

The result of these two activity-based assessments provides a detailed air emissions baseline for the port, with which to plan emission reduction strategies.

Table 3.3. **Port Metro Vancouver cargo handling equipment activity rates by terminal type**

Facility Group	Equipment group	Number in port	Average year	Oldest year	Newest year	Minimum hours of use (year)	Maximum hours of use (year)
Break Bulk	Aux	6	2001	1996	2006	50	1 200
	Loader	140	1997	1976	2006	300	1 400
	Stack/Crane	6	1980	1979	1982	450	450
Container	Aux	6	2001	1996	2006	100	150
	Loader	28	1998	1975	2006	100	2 800
	Stack/Crane	126	2000	1987	2006	500	6 240
	Off Road Truck	191	2001	1993	2006	900	6 000
Dry Bulk	Aux	14	1997	1991	2004	200	1 000
	Loader	85	1998	1973	2006	17	2 500
	Stack/Crane	2	1981	1980	1982	300	500
	Off Road Truck	13	1992	1981	2002	400	3 380
Liquid Bulk	Loader	5	2001	1996	2005	44	1 101
Other	Aux	38	1992	1981	2006	104	2 340
	Loader	92	1993	1964	2006	104	6 336
	Stack/Crane	14	1980	1961	2005	260	2 080

Source: SENES (2008). This summary does not include port-related facilities on the Fraser River.

The port's *Air Action Program* includes acknowledgment of national and international standards and their effective implementation dates. The *Northwest Ports Clean Air Strategy*, part of the *Air Action Program*, identifies specific emission reduction strategies with defined performance metrics and reporting requirements.

The *Air Action Program* has several defined components, including:

- The *Northwest Ports Clean Air Strategy* (a collaborative strategy with the ports of Seattle and Tacoma).
- The *EcoAction Program for Shipping*, formerly known as the *Differentiated Harbour Dues Program* (provides incentives for ships to reduce emissions beyond requirements).
- The *Canada Place Shore Power Initiative* (dockside electrification for cruise ships, involving a partnership between the port, two cruise lines, the provincial and federal government and the provincial power authority).
- The *Container Truck Licensing Program* (phases out use of older trucks and includes mandatory opacity and idling limits).
- Logistical improvements for container trucking management, including a mandatory reservation system and extended gate hours to reduce congestion.
- On- and off-road vehicle idle reduction programme (including education packages for port tenants).
- A project construction programme to require tenants to commit to emission reduction measures (expressed as part of the permit).

The *EcoAction Program for Shipping*, available to vessels calling Burrard Inlet and Roberts Bank (to be rolled out to the entire port in 2010), establishes harbour dues which are payable for the first five visits by a particular vessel during the calendar year, differentiated according to three levels – gold, silver and bronze:

- *Gold* (Dues: CAD 0.057 per GRT): For a ship to qualify for gold they must demonstrate that they have any one of the following:
  - Lloyds Register Environmental Protection Classification plus any two of the supplemental notations for SO_x (S), NO_x (N), or Vapour control/recovery (V) (equivalent classification by other societies is also accepted);
  - use of fuel with ≤ 0.5% SO_x in auxiliary engines within 24 nautical miles of the port's Navigational Jurisdiction Boundary;
  - use of fuel with ≤ 0.2% SO_x in auxiliary engines at anchor and dock;
  - select engine emission controls in main and/or auxiliary engines;
  - other select fuel options such as use of biodiesel or fuel-borne catalysts in main and/or auxiliary engines; or
  - shore power capability.
- *Silver* (Dues: CAD 0.067 per GRT): For a ship to qualify for silver they must demonstrate that they have any one of the following:
  - Lloyds Register Environmental Protection Classification plus any one of the supplemental notations for SO_x (S), NO_x (N), or Vapour control/recovery (V) (equivalent classification by other societies is also accepted); or
  - use of fuel with ≤ 1.0% SO_x at anchor and dock in main and/or auxiliary engines.

- *Bronze* (Dues: CAD 0.077 per GRT): For a ship to qualify for bronze, they must demonstrate that they have any one of the following:
  - Lloyds Register Environmental Protection Classification (equivalent classification by other societies is also accepted);
  - use of fuel with ≤ 2.0% SO_x at anchor and dock in main and/or auxiliary engines; or for fuel barges and tankers, use of vapour control or recovery system.

This programme has been described by the port as a recognition programme for those vessels choosing to reduce emissions beyond requirements, more so than an incentive programme. This is because the lowered dues may only make up a portion of the potential increase in operating costs. In 2008, 19% of the vessel calls for which harbour dues were payable within the Burrard Inlet and Roberts Bank experienced the reduced rates.[14]

Central to the *Air Action Program*, the *Northwest Ports Clean Air Strategy* is a comprehensive initiative that encompasses other local programmes and also involves collaborative efforts and agreements, principally with the ports of Seattle and Tacoma. The *Clean Air Strategy* targets PM, NO_x and SO_x emissions from diesel engines and has a key goal to stay in attainment of ambient air quality objectives, acknowledging the continuous improvement provision of the Canada Wide Standards.

The Clean Air Strategy contains policies and related performance measures for the following emission source groups:

- ocean-going vessels;
- cargo handling equipment;
- rail locomotives;
- trucking (including smaller vehicles);
- harbour vessels (which currently do not have attributed performance measures); and,
- administration.

The performance measures are expressed in terms of fuel and engine standards, rather than a total or per cent reduction in emissions over time (2010 and 2015 years are used to measure progress in the short term and the long term). For example, the performance measures for cargo handling equipment are expressed as:

By 2010:

Reach the port-wide equivalent PM reduction of Tier 2 or Tier 3 engines operating with ultra low sulphur diesel or a biodiesel blend of an equivalent sulphur level, and promote early implementation of the requirements between now and 2010. All new terminals will be equipped with new CHE equipment meeting the highest standards that are practicable for the anticipated use at the time of purchase.

By 2015:

Reach a port-wide equivalent of Tier 4 engines, for 80% of equipment. Retrofit the remainder of equipment with best available verified retrofit technologies. Purchase of cleanest available cargo handling equipment that is practicable for the anticipated use at the time of scheduled capital upgrades.

A "menu" of potential actions to meet the performance measures is also listed for each source group, as well as measurement and reporting criteria to track annual progress.

The *Air Action Program* also serves to incorporate and disseminate the results of past and ongoing initiatives by the port or one or more port tenants (*e.g.*, case studies for dockside equipment or use of gen-set locomotives). Many of these initiatives have included access to the national funding programmes run by Transport Canada, such as ecoFREIGHT.

For example, in 2009, with funding from the ecoFREIGHT Marine Shore Power Program, Port Metro Vancouver launched the *Canada Place Shore Power Initiative,* which provides a facility to supply electricity to cruise ships for their lighting, air conditioning, communication equipment etc., allowing them to turn off their diesel engines while docked, and reducing air emissions, particles and marine vessel stack smoke.

The port authority is currently determining its corporate CAC (and GHG) footprint, with additional assessment of future emission reduction opportunities. These actions are also part of the port's *Air Action Program*.

Busan

To respond an increasing demand of container cargo and to solve the traffic jam, air pollution, and noise caused by the container trailers, the Korean government decided to develop a new container terminal at the western part of Busan City, about 25 km from the City centre. In 1996, the Korean government established a development plan where the Busan New Port should be economically highly efficient and also environmentally friendly. Therefore, the Busan New Port should be in a non-residential area, all the container cargoes should be handled in an on-dock container yard and there should be dedicated railways and roads for transporting containers. And eco-friendly technology should be introduced in the Busan New Port, such as Rail Mounted Gantry Cranes (RMTCs) operated by electricity, provisions should be made for Alternative Maritime Power (AMP), use of geothermal energy, etc.

579 000 TEU of container cargo were handled in Busan New Port in 2007, increasing to 1 579 000 TEU and 2 720 000 TEU in 2008 and 2009 respectively. It is expected that it will increase sharply when more construction of phases are completed in 2011.

There are a total of 186 Rubber Tired Gantry Crane (RTG) units at container berths of the "old" Busan North Port. RTGs are owned and operated by the terminal operators, not by BPA, and they are operated by fuel oil, which produce air pollution and noise.

BPA has decided to convert oil-using RTGs to electricity-driven RTGs (e-RTG). The total cost of converting from oil to electricity per unit is about USD 400 thousand, half of that (USD 200 thousand) is for converting the engine system of the RGTs and the other half is for the construction of the electricity supply system.

The terminal operators and BPA have agreed to share the total cost half and half, that is, half of the cost (the cost for converting the engine systems of the RGTs) is covered by the terminal operators and the other half (the cost for the construction of the electricity supply system) is covered by BPA. A total of 94 units of RTGs are expected to have been converted to e-RTG by the end of 2010.

The Busan New Port will be equipped with a total of 267 transfer cranes if a total of 30 berths are developed by 2015. From the beginning of the Busan New Port Planning, BPA decided to install rail-mounted gantry cranes, which are operated by electricity, not by fuel oil as RTG.

Table 3.4. **Plan of construction of rail-mounted gantry cranes at the Busan New Port**

	Until 2009			After 2010				Total
Phase	1-1/1-2	2-1	2-2	2-3	2-4	2-5	2-6	
Units	80	42	32	38	28	19	28	267

Source: Busan Port Authority.

As mentioned, the Busan New Port berths are equipped with alternative maritime power (AMP) for supplying land-based electricity to vessels at berth. However, using land-based electricity is not mandatory, and until the Summer of 2010, no vessel had been using AMP.

The Busan North Port is very limited geographically and there are not enough yards for container handling. Therefore, 13 off-dock container yards (ODCY) are operated for container handling before loading and after unloading. Previously, when container trucks arrived at Busan North Port from an ODCY, there was usually heavy traffic at the gate, because of container information limitation, resulting in air pollution and time-losses by long lines of container trucks into the Busan Downtown.

However, BPA invented a *Gate Automation System* using Radio Frequency Identification (RFID) for container trucks to pass the gate to designated berths without delay. At present there is not a long line of container trucks at the gates waiting information to designated berths.

BPA and terminal operators have also introduced tandem container cranes which can load and unload 4 containers of 20 feet at the same time. BPA also introduced a yard tractor pulling system at container berths for operating container trucks effectively at loading and unloading.

At the Busan New Port Terminal, BPA uses renewable energy sources in the buildings, such as solar energy and geothermal energy. Buildings at Phase 2-1 of Busan New Port use geothermal energy in heating and air-conditioning, by circulating water in the depth of 150 meters underground. Buildings at Phase 2-2 and other areas use solar energy, by constructing new solar energy systems on the roofs and windows. BPA estimates that solar energy will produce 10 MW, which is about 10% of total energy consumed in the Busan New Port when the development of the Busan New Port Distripark is completed.

Korea is a member of MARPOL, so ozone depleting substances, SO_2, NO_x and VOCs are regulated according to MARPOL Annex VI and the relevant domestic law, the *Marine Environment Management Law*.

From 1 January 2012, the sulphur content of fuel oil will be regulated as follows:

1. The sulphur content of diesel is to be less than 1.0%, however, the sulphur content of diesel used in ships operating only in territorial waters and the Exclusive Economic Zone is to be less than 0.05%.
2. The sulphur content of heavy oil A, heavy oil B and heavy oil C is to be less than 2.0%, 3.0% and 4.5% respectively.

The *Marine Environment Management Law* stipulates that fuel oil suppliers should submit the samples of fuel oil with the specification of fuel oil to the ship-owner. And the Korean Government officials will carry out ship inspections to check the oil samples and specification. Although the *Marine Environment Management Law* does not give any

obligation to oil refineries, they will make and sell fuel oils that meet the regulation to the fuel oil suppliers.

After the Busan New Port started handling container cargoes in 1996, demand for transhipment of containers between the Busan New Port and the Busan North Port has continuously increased. The distance between ports is 25 km. The cost of transhipping containers by truck is about UDS 80 per TEU and the cost of transporting the containers by shuttle ship is higher than that. However, the container trucks must run through the downtown of Busan City, which creates traffic jams, air pollution and noise. BPA estimates that the social cost of truck transport, through pollution, road damages, traffic jams and road accidents, is USD 9.5 million per year.

In 2007, BPA started to support one private business for shuttle coastal transportation by pusher tug and hold barge between the two ports. The cash incentive to the private business is USD 200 000 as basic cost and USD 41 per TEU. From October 2007 to December 2009, a total of 79 370 TEUs were transported by the shuttle transportation, that is, an average of 210 TEUs daily. At present, the share of truck and coastal shuttle transportation of containers between the two ports is about 70% and 30% respectively.

The final destination of most containers unloaded at the Port of Busan is the Seoul Metropolitan City and surrounding cities, and most of the containers are transported between these two regions by trucks, which create traffic jams and air pollution. Road transportation of containers consumes much oil compared to coastal transportation, and damages roads. Therefore, there have been numerous requests that coastal transportation should be activated.

Historically there was coastal transportation of containers between the Port of Busan and the Port of Incheon, and between the Port of Busan and the Port of Kwangyang, in the 1990s and early 2000s. Coastal transportation between the Port of Busan and the Port of Incheon started in 1996 when 80 000 TEU were transported. It peaked in 1999, with 132 000 TEU. However, cargo volumes decreased after 1999 and it stopped from 2006. Coastal transportation between the Port of Busan and the Port of Kwangyang started in 1998 and continued until 2004, peaking in 2001 with 43 000 TEU.

Table 3.5. **Coastal transportation of containers**

Thousand TEU

	1996	1998	1999	2001	2002	2003	2004	2005
Busan/Incheon	80	114	132	118	100	98	94	79
Busan/Kwangyang	–	38	25	43	39	38	6	–

Source: Busan Port Authority.

The cargo owners preferred road transportation to coastal transportation because the transportation time was shorter. Coastal transportation between the Port of Busan and the Port of Incheon takes about 47 hours, while road transportation and rail transportation between Seoul and Busan take about 13 and 19 hours respectively. Also, transportation by coastal shipping lost its competitiveness compared to ocean-going shipping and road transportation.

Recently, the Korean Government has established a plan for support to coastal transportation under the *National Plan for Low-Carbon Green Growth* and the *National Green*

Port Project. The Korean Government found that *i)* coastal transportation produces only 8% of the carbon emissions compared to road transportation, *ii)* the share of large vehicles is only 9.1% of the total number of vehicles but their share of road damages is 61.8%, and *iii)* the cost of coastal transportation to total national logistic cost share is only 1.0% while cost of road transportation share is 96.4 %.

Therefore, the Korean Government has decided to support private coastal shipping for coastal transportation, through *i)* exemption of port charges, *ii)* subsidy to fuel oil, and *iii)* a USD 20 cash incentive per TEU, with USD 10 coming from BPA and USD 10 from IPA. The coastal shipping industry claims that carrying one TEU results in a loss of USD 100. About 40% of the total loss is covered by the incentive under the government plan. In 2009, coastal transportation for containers between the Port of Busan and the Port of Incheon resumed under the support scheme described above, with 25 000 TEUs of containers transported. It is expected that more than 40 000 TEUs will be transported in 2010.

Notes

1. IMO MEPC 61/4. The average was 2.35% on a sample number basis, and the three year rolling average for 2007-09 was 2.38%.
2. See OECD (2010) for a further discussion of the impacts of ships' emissions on radiative forcing. It is important to keep in mind that the net cooling that international shipping could contribute to would largely take place take place on the open oceans, thus not alleviating any global warming impacts on human habitats.
3. Green Port, Issue 2, May/June 2008.
4. Green Port, Issue 2, May/June 2008.
5. San Pedro Bay Ports Clean Air Action Plan, *www.portoflosangeles.org/environment/caap.asp*.
6. POLA web page, *http://portoflosangeles.org/environment/etruck.asp*.
7. More information can be found at *http://portoflosangeles.org/environment/grants.asp*. Information on US EPA's National Clean Diesel Campaign can be found at *www.epa.gov/otaq/rfp.htm*.
8. *www.ccr-zkr.org/*.
9. *www.portofrotterdam.com/nl/actueel/pers-en-nieuwsberichten/Pages/05042007.aspx*.
10. *www.portofrotterdam.com/nl/actueel/pers-en-nieuwsberichten/Pages/20090406_02.aspx*.
11. See *www.ccme.ca/assets/pdf/1389_ci_kcac_e.pdf*.
12. Available at *www.portmetrovancouver.com/environment/initiatives/air.aspx*.
13. The 2005 inventory for the Fraser Valley and an update of the 2004 inventory for the Capital Regional District.
14. See McEwen (2010).

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Chapter 4

Energy Use and Emissions of Greenhouse Gases

This chapter describes energy use and greenhouse gas emissions related to port activities in a broad sense and discusses policy instruments applied to limit them, in the case study ports and elsewhere. The instruments range from many of those that (also) are applied to limit exhaust emissions (cf. Chapter 3), to several more specifically addressing GHG emissions, such as preparations made for carbon capture and storage. The chapter covers measures applied by the port authorities themselves, and measures taken by national, provisional or local political authorities.

Most of the energy consumed by shipping is used for propulsion, of which a tiny fraction for manoeuvring in ports where vessels usually operate for a short moment and at low speed. The largest scope for improvement regarding energy use thus is in voyage between ports.

A report prepared for the IMO in 2000 indicates a large potential for energy-efficiency improvement in shipping. Numerous technical opportunities are available, and some of them can be used not only in new-builds, but also in retrofitting of existing tonnage. Improved maintenance and operational measures, including slow-steaming (*i.e.*, reducing the speed of the ship), may also contribute significantly. The high price on bunker oil in recent years has made ship-owners aware of the importance of reducing fuel consumption. At current crude oil and bunker fuel prices, fuel makes up a significant share of the overall cost of most types of shipping. As a result, the strong trend towards faster vessels may have come to a halt. Design speed is probably the single most important parameter when trying to curb the hunger for fuel.

In the longer term, biofuels may begin to replace fossil fuels in the maritime sector. However, bioenergy is a relatively scarce resource, and may be more efficiently utilised elsewhere. Natural gas in the form of LPG is a more realistic option in the short to medium term. If LPG is to be used as a major marine fuel, a network of supply points would have to be created. This would require collaboration among the ports concerned.

Among non-CO_2 greenhouse gases, on ships, chlorofluorocarbons (CFCs) is the predominant medium used in container and cargo refrigeration, air conditioning and food compartment cooling, as well as for insulation around pipes. The annual leakage is (with the exception of the insulation) considerable. Halons are used in portable fire extinguishers and in fixed systems to ensure safety from fire.

4.1. Measures addressing energy use and greenhouse gas emissions – in general

In 2009, the Marine Environment Protection Committee (MEPC) of IMO "recognized the need to develop an energy efficiency design index" (EEDI) for new ships in order to stimulate innovation and technical development of all elements influencing the energy efficiency of a ship from its design phase.[1] The Committee also agreed to circulate guidelines for a voluntary use of the Ship Energy Efficiency Operational Indicator (EEOI).[2]

Where energy consumption and carbon emissions are concerned, a prime objective of ports is to clean up in their own premises. However, port authorities may have an additional role to play. The IMO has been requested by the UNFCCC to work together with, primarily, the industrialised countries in order to develop ways of reducing the climatic impact of international shipping. Some of the measures that have been under consideration, in particular a Maritime Emissions Trading Scheme (METS), proposed by some parties,[3] would rely on port state control.

Market-based instruments (*e.g.*, taxes, fees, charges and emission trading systems) can in general play an important role in addressing greenhouse gas emissions – although implementing such instruments to address maritime shipping can present some challenges. Such instruments allow the regulated parties to adapt the measures they take to comply to their own circumstances. They can be implemented locally – for example, by imposing variable fees designed to reward vessels with low-emissions – or internationally, for example through an emissions trading system.

The METS (based on Kågeson, 2007) would set a cap on the permissible emissions CO_2 from international shipping. The allowances allocated collectively to the shipping sector would be sold on auction, and in addition, ships would be allowed to purchase allowances from other trading schemes, as well as CO_2 credits from climate mitigation projects in developing countries. All ships above 400 grt would have to surrender CO_2 allowances or credits matching its real fuel consumption in order to be allowed to load/unload at participating ports. Fuel consumption would be declared by using the existing mandatory bunker delivery notes that all ships above 400 grt need to keep, according to MARPOL Annex VI. The IMO would create an authority for the administration of the scheme, and vessels would have to open a CO_2 account in the ship's IMO number. Ships belonging to an account that shows a deficit would be denied any services in participating ports.

Ports make use of buildings, including warehouses, and machinery, including vehicles owned by the port authority. Ports located in arctic and temperate climate zones may become more energy-efficient by improving insulation and heat recovery in buildings, while ports in sub-tropical and tropical areas have good reasons to choose efficient means for cooling and air-conditioning. Use of efficient lighting is essential regardless of location. Overall energy savings in the order of 30 to 40% might be achieved.

By developing routines that allow ships short turn-around times, ports may facilitate for ship-owners who want to reduce operational speeds without having to pay a high penalty in terms of capital cost (because of poor utilisation). Automated technologies for cargo handling may improve overall efficiency; reduce energy consumption and exhausts (if machinery is powered by diesel).

Most of the equipment used for loading and unloading ships, or for moving goods to and from warehouses, is for natural reasons subject to ever-changing engine loads. The scope for reducing fuel consumption by "eco-driving" is thus larger than for road vehicles and may in some circumstances exceed 30%. Varying load is also a prerequisite for cost-effective future investment in electric-hybrid power-trains. An additional opportunity lies in making software calculate the minimum movement required for handling the goods and the order that different containers are moved and loaded/unloaded.

The Port of Seattle has implemented a number of measures to cut waiting times and reduce idling, among them computer tracking systems at cargo terminals to quickly locate containers, alerted truck drivers to draw-bridge opening times, so they can plan routes accordingly, and new built overpasses and improved intersections for better traffic flow and reduced congestion.

Many ports are located in windy areas and an increasing number make use of these conditions to invest in wind-power. The ports of Amsterdam and Zeebrugge are homes to large wind turbine parks. Wind turbines have also been installed (for instance) at the ports of Liverpool, Marseille, Gothenburg and Freemantle. Solar energy is increasingly used for powering navigation buoys and may also be used as a supplement to the production of

fossil-based electricity in locations where solar radiation is relatively evenly distributed over the months of the year.

The Port Authority of New York and New Jersey has committed itself to make the ports carbon-neutral by 2010 by a combination of new capital investment and operational refinements and offsetting of the remaining emissions by investing in projects such as wind farms and methane capture facilities.[4]

4.2. Measures addressing energy use and greenhouse gas emissions – case study examples

Los Angeles and Long Beach

The issues related to global warming and climate change affect all nations of the world. California has committed to reducing state-wide greenhouse gas emissions to 1990 levels by 2020, about a 30% reduction from *Business-as-Usual*, and the state has adopted a goal of an 80% reduction below 1990 levels by 2050. The ports and goods movement activities overall are major sources of GHG emissions and therefore will be affected significantly by State and other programmes to address climate change.

The ports of Los Angeles and Long Beach and their parent cities are undertaking major efforts to address climate change. In addition to the Scoping Plan measures described below, both cities have *Climate Action Plans* in affect. For example, in May 2007, the City of Los Angeles adopted *Green LA: An Action Plan to Fight Global Warming*. Green LA directs the Port to develop an individual Climate Action Plan, consistent with the goals of Green LA, to explore opportunities to reduce GHG emissions from municipal operations. In December 2007, the POLA presented a staff Climate Action Plan. As part of that plan and its numerous GHG reduction measures, the POLA began reporting annual emissions inventories in 2008 and thence quarterly status reports.[5] Similar actions have been taking by POLB and both ports are following the adopted *San Pedro Bay Ports Clean Air Action Plan*.

Since 2006, many new state laws, policies and regulations to reduce GHGs have been enacted that greatly affect the two ports. They include the Scoping Plan under the *California Global Warming Solutions Act* of 2006 (AB 32) and adopted in December 2008; SB 375, a bill passed on in September 2008 that implements the transport portions of AB 32 through GHG emission reduction targets and better land use planning; the SCAQMD's December 2008 adoption of interim GHG significance thresholds; and the Southern California Association of Government's (SCAG) *Compass Blueprint*. The most immediate and far-reaching impacts of climate change strategies are contained in the Scoping Plan under AB32. Table 4.1 identifies several of the more relevant measures affecting the ports. In some cases, the measures were consciously adopted by California to reduce both conventional air pollutants and GHG emissions.

In addition to the greenhouse gas emission reduction goals and planning requirements that are in California law, Governor Schwarzenegger, by Executive Order S-13-08, ordered State agencies to develop the California *Climate Adaptation Strategy* (CAS), and this was issued in December 2009.[6]

Rotterdam

The Rotterdam Port Authority (PoRA) and the Dutch State are well aware of the impact of the port and port related activities on greenhouse gas emissions. To address the

Table 4.1. **Scoping plan measures to reduce GHG emissions related to ports**

Measure	Status	Implementation date	Notes
Ship Electrification at Ports[1]	2007	Phase in 2010-20	The regulation requires most container, passenger, and refrigerated cargo ships to shut off their auxiliary engines while at dock and receive power from the electrical grid.
Port Drayage Trucks[1]	2008	2010-13	Phase 1 requires all pre-1994 model year drayage trucks to be replaced or retired with newer model year trucks. Phase 2 requires all engines to meet or exceed the 2007 California and federal engine emission standards by 31 December 2013.
Clean (green) Ships	Not yet pro-posed	TBD	Reduce fuel consumption and associated CO_2 emissions through a variety of technologies and strategies that improve the efficiency of oceangoing vessels.
Vessel Speed Reduction[1]	Pro-posed	2010 or later	ARB would evaluate emission reduction benefits of a VSR measure for vessels entering and leaving California ports and vessels travelling along the California coast within 24 to 40 nautical miles.
System-wide Goods Movement Efficiency Improvements	2009-12	2012-15	Ports and agencies will develop and implement programmes to achieve system-wide reductions in GHG emissions from goods movement activities. These programmes will be in addition to existing measures for goods movement sources, and be developed over time through a public process.
Maintenance and Design Efficiencies for Commercial Harbour Craft Operators	2009-11	2010-11	Educate harbor craft owners to reduce GHGs by vessel speed optimization, optimized scheduling, regular engine maintenance, improved hull surface smoothness, and reduced hull fouling (seaweed and barnacles)
Cargo Handling Equipment[1]	2010	2010-11	For cargo-handling equipment at ports and intermodal rail yards, ARB will develop a new measure to restrict unnecessary idling, which will reduce fuel consumption and associated greenhouse gases, criteria pollutants, and toxic air contaminants.
Regional Transportation-related GHG Targets	Sept. 2010	2011-16	Implement SB 375 for local entities and regional governments by developing and implementing various transportation and land use strategies to reduce vehicle GHG emissions.

1. Measures adopted by California to reduce both conventional air pollutants and greenhouse gases.

problem, they are taking action to limit the emission of the greenhouse gas CO_2. The PoRA stimulates other actors to address the problem as well.

First of all, the PoRA is involved in the *Rotterdam Climate Initiative*. This initiative is one of the guiding initiatives in the Rotterdam Area. Within this initiative, a number of important actors joined together to try to limit the CO_2 emissions in the Rotterdam area, including those from port and port-related activities in co-operation. The *Rotterdam Climate Initiative* was founded by the PoRA, the municipality of Rotterdam, the environmental protection agency of the Rijnmond area (DCMR) and Deltalinqs (an industry platform). The goal set by this foundation is a 50% reduction by 2025 compared to the CO_2 emission level in 1990.[7]

The port should develop into a so called energy port. Within this initiative, a number of preventing mechanisms are in place as they want to develop the port to become:

- The energy port for low-CO_2 energy sources and products for Northwest Europe.
- A hub for carbon capturing transport and storage (CCS).
- The most energy efficient port and industrial cluster in the world.

In July 2008, Rotterdam hosted the C40 *World Ports Climate Conference*. This conference was a co-operation between the Clinton Foundation's Climate Initiative and the C40 Climate Leadership Group. The conference resulted in a statement and an action plan of 55 ports to combat climate change: the *World Port Climate Initiative* (WPCI). Rotterdam is one of the 55 ports that committed itself to the World Port Climate Initiative.

The mission of the *World Ports Climate Initiative* is to:[8]

- Raise awareness in the port and maritime community of the need for action.
- Initiate studies, strategies and actions to reduce GHG emissions and improve air quality.
- Provide a platform for the maritime port sector for the exchange of information thereon.
- Make available information on the effects of climate change on the maritime port environment and measures for its mitigation.

Several projects have been defined under the WPCI. Current projects include: Carbon footprinting; intermodal transport; lease agreement template; cargo-handling equipment; environmental ship index; and on-shore power supply.

Rotterdam is one of the leading ports in WPCI, and task-leader for the Environmental Ship Index project. The PoRA works together with the International Association of Ports and Harbors (IAPH), the European Sea Ports organisation (ESPO), the Clinton Climate Initiative and the ports of Antwerp, Bremen, Le Havre, Hamburg and Amsterdam (PoR, 2009a).

Another initiative of the PoRA that impacts the level of CO_2 emissions is the start of a sustainability index for its own activities relating to "planet". The index covers a number of issues, with CO_2 as one of the most important. This index includes a CO_2 footprint, sustainable building, green purchasing and sustainable tendering (PoR, 2009a).

First of all, the PoRA has calculated this CO_2 footprint for its own activities, like mobility, building energy consumption and energy management, including emissions from subcontractors (PoR, 2009a). The footprint has been a co-development of the port of Oslo and the PoRA. This footprint methodology has been presented and was launched to the public at the World Ports Climate Conference in 2008. The CO_2 footprint provides insight into the direct CO_2 emissions (not the whole supply chain) from the activities of the Port Authority, including those of its contractors.

The CO_2 footprint can be used as a tool to identify areas where emission reductions can be achieved. The PoRA uses this tool in trying to achieve its goal to become climate neutral in 2012. In 2011, they will try to reach a sub-goal of 35% reduction in the footprint compared to the level in 2007 (PoR, 2009a).

The CO_2 reduction ambition has resulted in (PoR, 2009a):

- Sustainable lighting and heating (green label).
- Fuel savings for the own fleet of ships (81 000 litres in 2008).
- 70% of the company cars with a green energy label.

The PoRA has also included sustainable buildings under its sustainability index. They have agreed upon the RCI guidelines goals to limit the climate impact of buildings, by signing an intention declaration. The reduction target is a reduction of 25% in CO_2 emissions in 2009 in comparison to the national building standards (PoR, 2009a). A 50% reduction should be achieved over the next five years. This reduction does not only account for the exploitation phase but the whole building cycle.

These use of these standards have resulted in the application of innovative technologies like low-temperature floor heating, using ground and river sources (PoR, 2009a). Another sustainable technology that found its way to these projects is a thermal storage system. This project uses surface water from the port. In this project the water is used as an energy medium. Two of the buildings linked to this system in the latter project are being developed by the PoRA itself.

Another way the PoRA uses its index to stimulate more sustainable practices at other organisations is based in its tendering processes (PoR, 2009a). As the PoRA is the governing body of the port area, it can decide what type of organisations, and under what conditions, they will accept to the port. Through the use of such extra sustainability conditions in tendering processes, the organisation promotes enhanced performances on a variety of practices. Different sustainability conditions are set for various sectors. For some sectors, energy use can play an important role in the tendering process. The PoRA has already been applying sustainability conditions in most of their tendering processes since 2008. However, it is still developing its final set of criteria.

An innovative joint initiative is under development. The PoRA and the company Stedin en Visser and Smit Hanab have developed a business case on a steam pipeline in the port (PoR, 2009a). Eight organisations are interested in the development of the steam pipe as they have expressed their support in 2008 via letter of intent. Organisations that produce steam (*e.g.* petrochemical companies) as a (waste) product will be linked to organisations that use steam in their processes. In case the steam is a waste product from another company, this accounts for efficient use of energy. By using such waste products, the use of fossil fuels is limited and the emissions of CO_2 as well. A separate firm – *Stoompijp b.v.* – should be responsible for the pipeline and the first customers were expected to be contracted in 2009 (PoR, 2009a).

The RCI is also active in the development of wind power. Currently, 150 MW has been installed in the port of Rotterdam, the largest share of this production capacity is located at the *Maasvlakte* area.[9]

This capacity is the result of the intention declaration of 2001 between the PoRA, the province, surrounding municipalities and the NGO Milieufederatie Zuid-Holland for the realisation of 120 MW in 2010. As the goal has already been reached, the RCI now wants to more than double the current production capacity. In the port itself, a doubling should be possible. Up-scaling will be possible due to the placement of new turbines on the *Maasvlakte 2* area and the existing port areas and by replacing older turbines.

Next to land-based development options, locations at sea are also being considered. For enlargement, the RCI has investigated possible locations for the development of a near-shore park in front of the *Maasvlakte* area.

CO_2 sequestration

Carbon Capture and Storage (CCS) is one of the main measures that are developed to reduce the emissions of CO_2 in the port area, under the RCI framework (RCI, 2009). A pilot project for the storage of CO_2 is underway in Barendrecht (PoR, 2009a). However, it is uncertain if this innovative project will be executed. The municipality and community of Barendrecht have resisted against the proposal to store the captured CO_2 in empty gas fields underneath residential areas.

In order to understand the challenges in the up-scaling of the capture and transport of CO_2, a business case has been developed by OCAP (*Organic Carbondioxide for Assimilation of Plants*), Wintershall, DMCR and the PoRA. The outcome of the business case is that the Rijnmond area should be able to capture and store 5 million tonnes of CO_2 by 2015 if development starts soon. The project would be economically feasible, under certain conditions. The business case concluded that it should be possible to upscale the transport and capture of CO_2 to 20 million tonnes in 2025 (PoR, 2009a).

At the *Maasvlakte,* a power plant will be equipped with an experimental carbon capture and storage facility (PoR, 2009a). The facility will be able to capture a small portion of the CO_2 emissions from the power plant. This facility is a development of E-on and TNO to test CCS. New methods for the post-combustion capturing will be tested in this facility. Within the CATO programme,[10] Dutch research organisations and industrial parties develop methods to capture and store CO_2, subsidised by the Dutch government. Next to the current plant E-on started the construction of a new coal fired power plant.

Shell is already active in capturing and transporting CO_2 (170 ktonne) to greenhouses, from their plant in Pernis to the Westland area (PoR, 2009a). The captured gas is transported via a pipeline network for use in greenhouse facilities in the neighbouring Westland area. In greenhouses, fossil fuels are being burned to obtain CO_2 for the growth of crops. Now that the waste product (CO_2) of the petrochemical installation is used, greenhouses do not need to combust fuels anymore to solely obtain CO_2.

Vancouver

Port Metro Vancouver is updating its annual corporate emissions inventory and developing a GHG reduction plan, including targets and metrics for ongoing measurement, to provide information needed to make appropriate environmental management decisions, and so that it may be ready for future reporting requirements. The *Air Action Program,* described in Chapter 3, includes measures to address energy use and greenhouse gas emissions.

The *Air Action Program* focuses on the development of a data baseline and progress tracking, improvements to operational efficiency, technological innovation and supporting regulatory change. The programme includes initiatives being undertaken by the Port, terminal operators, other industries and regulatory agencies, which all help to reduce port-related air emissions. Port Metro Vancouver has established air emission baselines and maintains databases for specific port sites. The port also works in partnership with government agencies through local environmental action programs such as the *Burrard Inlet Environmental Action Program* and the *Fraser River Estuary Management Program*, which include efforts to reduce greenhouse gas emissions.

The *Northwest Ports Clean Air Strategy*, part of the *Air Action Program*, identifies specific emission reduction strategies with defined performance metrics and reporting requirements. The *Northwest Ports Clean Air Strategy* is a partnership among three major West Coast ports, including the Port Metro Vancouver, and the ports of Seattle and Tacoma. The strategy is geared to reduce port-related diesel and greenhouse gas emissions in the Georgia Basin-Puget Sound air shed via voluntary and collaborative means.

The *Western Climate Initiative* is a collaboration of independent jurisdictions, including British Columbia, that work together to identify, evaluate and implement policies to tackle climate change at a regional level. This is a comprehensive effort to reduce greenhouse gas

emissions, spur investment in clean-energy technologies and reduce dependence on imported oil. The Province of British Colombia has also signed a Memorandum of Understanding with the State of California on *Pacific Coast Collaboration to Protect Our Shared Climate and Ocean*. This agreement commits British Columbia and California to work together to cap and trade greenhouse gas emissions and to develop and use clean technologies.

The Port strives to implement programmes to reduce energy use and emissions, obtain electricity and other energy from a renewable energy sources (either directly by generating it or by selecting an approved green energy provider), and by using low-carbon alternative fuels (*e.g.* such as sustainable biofuels and H_2). The port also participates in a responsible carbon project, whereby emissions that cannot be avoided or generated from renewables are offset by purchasing certified verifiable carbon credits. Furthermore, as the Official Supplier of Port Service to the Vancouver 2010 Olympic and Paralympic Winter Games, Port Metro Vancouver partnered with VANOC and off-setters to voluntarily offset carbon emissions created by the Games-time activities. By offsetting all of the port's operations during the Vancouver 2010 Winter Games, the port was able to contribute to carbon-neutral Games.

Port Metro Vancouver was also a recipient of a Vancouver 2010 Sustainability Star for its contribution to the BC Hydrogen Highway initiative. By showcasing the development of hydrogen and fuel cell technology, the port joined other collaborators, including the Government of Canada, Province of BC, City of West Vancouver, and BC Hydro, in realising a clean energy future for transportation and logistics.

To mitigate the environmental impact from the trucking industry serving the port, an approved Truck Licensing System license is required by any party wishing to access Port Metro Vancouver's property for the purposes of draying marine containers to or from any of the terminals under the jurisdiction of Port Metro Vancouver. All container truckers, including long-haul truckers, who access port container terminals must hold a valid licence. The Truck Licensing System includes a number of environmental requirements for port-related trucking contributions to both air quality and climate change and aims to phase out older, more polluting trucks.

Busan

In February 2009, a *Presidential Committee on Green Growth* was established under the control of the President to implement the national project of "Low-Carbon, Green Growth", presented as a national vision by President Myeong-Bak Lee in August 2008. In July 2009, the *Presidential Committee on Green Growth* finalized the *Five-Year National Plan for Green Growth* (2009-13), which includes the following three objectives and ten policy directions for a Green Growth Country.

- Mitigation of climate change and energy independence.
  1. Effective mitigation of greenhouse gas emissions.
  2. Reduction of the use of fossil fuels and the enhancement of energy independence.
  3. Strengthening the capacity to adapt to climate change.
- Creating new engines for economic growth.
  4. Development of green technologies.
  5. The "greening" of existing industries and promotion of green industries.

6. Advancement of industrial structure.
7. Engineering a structural basis for the green economy.

- Extension of R&D for ocean energy.

8. Greening the land, water and the building for the green transportation infrastructure.
9. Bringing the green revolution into our daily lives.
10. Becoming a role-model for the international community as a green growth leader.

In December 2009, the Korean government enacted the *Basic Act for Low-Carbon Green Growth*, which will be the basic and strong support to the Five-Year National Plan for Green Growth (2009-13).

Based on this act and the *Five-Year National Plan for Green Growth*, all the relevant ministries are establishing action plans. In 2008, Ministry of Land, Transport, and Maritime Affairs (MLTM) also established the *Comprehensive Plan for Response to Climate Change in National Land and Ocean*, which includes five parts, such as *i)* buildings, *ii)* transportation, *iii)* national land and cities, *iv)* ocean, *v)* water resources. The Ocean part of the Comprehensive Plan includes:

- Extension of R&D for ocean energy.
  - Development of practical technology for ocean energy, such as ocean current, tidal current and wave energy.
- Development of technology for disposal of CO_2 in oceans.
  - Collection of CO_2 generated at power plants and iron mills and storing in ocean sedimentary rocks.
- Development of technology for absorption of CO_2 by seaweed.
- Enhancement of fuel oil efficiency and reduction of CO_2 emissions from ships.
  - Setting assessment methodology of CO_2 and development of CO_2 reduction technology.
  - Establishment of a system for CO_2 emission statistics.
  - Analyses of CO_2 generation mechanisms and establishment of a reduction plan for CO_2 emissions from ships.
  - Development of technology to collect CO_2 emissions form ships.
  - Development of energy-saving ships.

MLTM is also establishing an action plan for the *National Plan for Green Growth*, one of which is the *National Green Port Project*. The *National Green Port Project* will:

1. Establish low-carbon hinterland transport systems, through enhanced rail and coastal transport from and to ports.
2. Promote a transfer to low-carbon energy-efficient ports, through a reduction of carbon emissions, transformation of engine-power-systems from fuel oil to electricity, and use of renewal resources.
3. Establish resource recycling port systems, through eco-friendly management of marine debris, dredging materials, etc.
4. Enhance the use of port space, through securing of water fronts, public access, etc.
5. Establish a response system for climate change and ocean disasters.
6. Enhance R&D for Green Growth and Green Growth Industry.

In particular, MLTM indicates that a plan for Alternative Maritime Power and high energy-efficiency will be established in 2010 and that the project for a rail transportation system for container to/from Busan Port and Kwangyang Port will be completed in 2011.

As all the ministries are trying to establishing action plans for the *National Plan for Green Growth*, the relevant institutes are also carrying out studies to support the action plans. In 2009, the Korea Maritime Institute (KMI), a government-owned and operated ocean-related institute, carried out a *Study on Response to Climate Change in Port Area* to support MLTM in establishing the *National Green Port Project*.

The study assessed that total CO_2 emission from Korea ports were 1 890 000 tonnes CO_2 in 2008, of which ships' share was 34.8%, vehicles' share 33.9%, and cargo handling 31.3%. And the study indicated that CO_2 emission from ports are set to increase to 2 760 000 tonnes CO_2 in 2020; so 830 000 tonnes CO_2 should be reduced to reach a target of 30% reduction compared to Business-as-Usual in 2020.

Finally, the study recommended the following alternatives to reach a target of 30% emission reduction by 2020, which will give much influence to MLTM in establishing the *National Green Port Project*:

- Reduction of vessel speed in port area.
- Supply of Alternative Maritime Power to vessels at berths.
- Conversion of rubber-tired gantry cranes' oil-based engine systems to electric engine systems.
- Establishment of a prevention system of truck idling.
- Education and training of port-related labourers.
- Establishment of a real-time operating system.
- Establishment of a public notice system of CO_2 emissions.

Many of the measures described in the section on air emissions will also have an impact on CO_2 emissions. For example, Busan Port Authority (BPA) estimates that converting of the engines in 94 rubber-tired gantry cranes (RTGC) reduces CO_2 emissions by 28 000 tonnes, and saves USD 16 million in operating cost, annually. The reduction in CO_2 emissions was calculated taking into account the CO_2 emission caused in the production of the electricity. The share of nuclear power generation to total electricity is more than 40%. BPA estimated that the operating cost of an RTGC is USD 18 000 per month in a case with an oil price of USD 1.2 per litre; however, the operating cost of an e-RTGC is estimated to be USD 2 000 per month.

BPA also estimates that the new capacity systems used at Busan New Port will reduce CO_2 emissions by 300 tonnes per year. BPA will spend five per cent of the total cost of every new construction project in new renewal capacity systems from now on.

Table 4.2. **Plan of construction of a renewal energy system at the Busan New Port**

	Until 2009			After 2010
	Phase 2-1	Supporting Buildings	Phase 2-2	Int'l Ship Chandlers Centre
System	Geothermal	BIPV Solar	BIPV Solar	BIPV Solar
Energy	90 RT	19.8 kW	49 kW	over 80 kW (estimated)

Source: Busan Port Authority. RT: Refrigeration Tonne (3 320 kilocalories per hour). BIPV: Building Integrated Photovoltaic System.

In addition, BPA has decided to change all of the old lighting systems of the Port of Busan to Light Emitting Diode (LED) systems. The total of lighting systems number to be changed is more than 22 700 (inside buildings: 22 450; outside buildings: 273). BPA estimates that the old lighting system consumes one unit of energy to produce 10% of lighting and 90% of heat; however, a LED system consumes one unit of energy to produce 70% of lighting and 30% of heat, hence the energy savings from using LEDs are 60% compared to the old lighting system. And the life-span of an LED system is about ten times longer than the old lighting system. However, the price of one unit of LED is around USD 50 to 80, while that of the old lighting system is around USD 0.3.

BPA estimates that changing the old lighting system to LED will reduce CO_2 emissions by 2 000 tonnes and save electricity worth USD 370 000 annually.

Table 4.3. **Plan of changing the old lighting systems in the Port of Busan to LED systems**

	2009	2010	2011	2012	after 2012	Total
Inside buildings	1 598	2 225	3 196	1 915	13 516	22 450
Outside buildings		49	28	78	118	273

Source: Busan Port Authority.

Notes

1. See *www.imo.org/includes/blastDataOnly.asp/data_id%3D26405/681.pdf*.
2. See *www.imo.org/includes/blastDataOnly.asp/data_id%3D26403/684.pdf*.
3. Submissions to the First Intersessional Meeting of the MEPC's Working Group on GHG Emissions from Ships in Oslo in June 2008 by respectively Germany, France, Norway and INTERFERRY.
4. Green Port, Issue 2, May/June 2008.
5. The plan is available at *www.portoflosangeles.org/DOC/REPORT_Climate_Action_Plan.pdf*.
6. The California Climate Adaptation Strategy can be found at *www.climatechange.ca.gov/adaptation/*. Several other climate change related programmes are discussed in Chapter 3.
7. *www.rotterdamclimateinitiative.nl/nl/50_minder_co_sub_2_sub/over_het_programma/over_het_programma_50_minder_co_sub_2_sub*.
8. *www.wpci.nl/about_us/mission_statement.php*.
9. *www.portofrotterdam.com/en/News/newsletters/Port-in-action/Documents/HaveninBedrijf_juni09_tcm26-60646.pdf*.
10. CATO (2008).

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Chapter 5

Other Environmental Problems Related to the Port Activities

This chapter discusses a number of different environmental problems related to port activities – such as noise; water pollution stemming from ballast water handling, oil spills and antifouling of the ships; waste; hazardous cargos; etc. – and highlights a number of different policy instruments applied, in the case study ports and elsewhere, to limit the problems. The chapter covers measures applied by the port authorities themselves, and measures taken by national, provisional or local political authorities.

5.1. Noise

Noise in port areas is caused by many sources; ship engines, fans, cranes, tractors and trucks. The extent to which noise from harbour activities is perceived as a nuisance depends on the sound pressure and frequency, the distance to local communities and also, to some degree, on topography and meteorology (humidity and prevailing wind direction). However, compared to aviation and the land-based modes of transport, few citizens are affected by noise from shipping, as the grand part of any voyage takes place far from human settlements.

A large part of the noise would disappear if ports switch to electric port vehicles and machinery and allow shore-side electricity to replace power produced onboard. Eco-driving will also contribute towards lower daily equivalent and maximum sounds. Lower speed-limits and/or better enforcement of such limits can cut noise levels in the port area itself and even more on the roads leading to and from it. Porous asphalt may also have a role to play in reducing the tire-to-surface noise which dominates the noise from heavy vehicle traffic at speeds above 70 kmh. Where reduction at source is not possible, the construction of noise barriers or noise screens can be a supplementary measure.

Measures addressing noise in ports – in general

Many ports are actively involved in trying to reduce noise and vibrations from ships and rolling stock, as doing so is a prerequisite for port expansion or for co-existence with adjacent communities. Where cities want to explore part of their water-fronts for housing projects or recreational areas, making the remaining port activities less noisy is often an essential part of the plan.

Comtois and Slack (2007) provide examples of ports developing systematic plans for noise prevention. They include the Port of Amsterdam that applies the concept of a "noise zone", where special noise standards apply, the Port of Auckland, which has established a "noise liaison group" with neighbouring residents, and the Port authority of Hay Point, Australia, that monitors noise levels during three periods a day and develops monthly statistics of noise events and complaints to identify exactly what they relate to in order to prevent future occurrences.

Measures addressing noise in ports – case study examples

Los Angeles and Long Beach

There are many sources of noise at the two ports during normal operations, including rail car wheel squeal, slamming containers, the operation of cargo handling equipment, locomotive operation and train assembly, vessel whistles and heavy-duty truck traffic. Additional noise occurs during construction activities associated with port improvements and expansion. Nearly all types of construction equipment produce high levels of noise with such equipment as pile drivers and rock drills standing out.

These impacts are dealt with in several ways. First, citywide noise laws or "ordinances" are imposed by the cities of Los Angeles and Long Beach. They limit noise-producing activities depending on the time of day and the day of the week. These ordinances effectively limit major construction activities to the 7 am through 9 pm periods on most days, and prohibit it altogether on Sundays and national holidays. Maximum ambient noise levels are capped for residential, hospital and school zones at all times. Second, the project-level reviews conducted for the *National Environmental Policy Act* (NEPA) and the *California Environmental Quality Act* (CEQA) typically include noise measurements, noise modelling and, in situations where noise impacts are considered "significant", the use of mitigation. Examples of mitigation measures include further reducing operating hours, using noise suppression technologies, constructing noise barriers and other actions. CEQA guidelines define thresholds of significance that vary by time of day and what kind of land use is affected.

Public input is routinely obtained from Community Advisory Committees, which provide a forum to discuss and address both routine noise issues and the adequacy of mitigation during construction activities.

Rotterdam

To manage the sound levels in the industrial areas in the Rijnmond area, the area is divided into several zones. These zones have been granted an average specific sound emission per m^2 for industry noise. The Rotterdam Port Authority (PoRA) is free to differentiate the noise emission levels in contracts with clients, as long as the average level is maintained. Through this process, the PoRA can strategically divide the noise emissions on the basis of their preferences. As the permitted sound level is stricter during the night, the standards present an obstacle on some locations and therefore 24 hour operation is not possible. The industrial noise emission levels agreed with PoRA are defined in an environmental permit, and compliance is monitored by the Environment Protection agency of the area, DCMR.

Noise limits have been defined to improve living and working conditions. The noise limits seemed to be an obstacle for the development in an area where the room for expansion was limited. Therefore, in 2000 DCMR, Rijkswaterstaat Zuid-Holland and the PoRA formed a knowledge-centre focused on knowledge sharing and stimulation of the application of existing sound reducing techniques (DCMR, 2009).

Due to technological advancements and the promotional activities as described above, sound emissions in the port area have decreased in the last years. The extra "space" that is created by the application of quieter techniques was granted to the industry up to 2010. It is being discussed whether the extra available "space" that could be created by further reductions from 2010 onwards will be granted to the industry or will be taken out of the system.

The construction of the *Maasvlakte 2* area is also under special attention. At the moment, monitoring of the noise effects of the construction of the *Maasvlakte 2* on its surroundings is taking place. These monitoring activities were required to obtain a construction license for the *Maasvlakte 2* area. In order to determine the effects of the construction of the *Maasvlakte 2* on cetaceans, the preconstruction noise level was determined and developments will be monitored (PoR, 2009a).

One option recently applied that affects the emission of noise, is the installation of shore-side electricity for inland shipping barges. As ships switch from their auxiliary engines to the electricity grid, the noise generated by the auxiliary engine is eliminated. For barges, the use of their auxiliary engines has been banned at several locations where these power outlets are available. The project is currently limited to the Waalhaven, but will be expanded to all other berths for inland barges in the next years.

Vancouver

The City of Vancouver administers a Noise Control Bylaw that establishes limits of noise levels for weekdays and weekends. Port Metro Vancouver has identified noise as a corporate social responsibility issue, is developing a noise and nuisance (dust, traffic, odour, light, etc.) management and monitoring plan and is proactively pursuing solutions to existing noise issues. The latter includes monitoring at a number of locations in the port and working with noise generators to resolve their noise issues. In addition, Port Metro Vancouver is a member of the Waterfront Industrial Noise Control Committee, which aims to develop solutions to the identified noise problems within the port and its terminals.

Noise, dust and visibility is formally managed by Port Metro Vancouver for construction and expansion/maintenance projects (often as criteria expressed in project permits) and informally managed for nuisance issues (complaints). For example, the East Vancouver Port Lands planning area, which is an area attached to downtown Vancouver that experiences relatively high levels of trucking and rail activity, has its own "Area Plan" that was developed with the local stakeholder groups (which included the City of Vancouver and the Burrardview Community Association). For this area, a set of locally sensitive land-use principles and actions were developed and the key environmental issues of concern were studied (the available land-use base, visibility and views from the residential areas, existing noise levels and associated port policies and air quality) among additional issues of concern, such as safety.

Two noise studies were recently conducted on major truck routes that parallel the Canadian Pacific Rail mainline. Both studies link the container, grain and break bulk terminals in the Port with the regional road and rail networks and operate 24 hours a day. The studies monitored noise levels from waterfront activities at various points in the Burrardview neighbourhood, identified noise sources, evaluated the feasibility and potential impact of various noise barrier options; and recommend measures to address the noise issues.

The *Environmental Programs Department* has a response programme for nuisance issues where occurrences of excessive noise, dust and visible stack plume are investigated by port staff to identify the cause and discuss viable options to minimize the issue with the tenant, ship or other source where feasible. For example, the port responds to excessive ship exhaust opacity to ensure a quick remedy is applied (such as a change in engine operation). In addition, Port Metro Vancouver has established a "community complaint" telephone number and e-mail address

Busan

Many of the measures described in previous sections have been motivated by a concern for noise problems – and will contribute to their alleviation. This includes, among others, the decision to develop the Busan New Port.

BPA estimates that the electrification of rubber-tired gantry cranes (RGT) reduces noise levels from 85 dB to 65 dB, and the breakdown rate of an electric RGT is about half of a fuel-powered RTGC. Following BPA's electrification, the Incheon Port Authority, the 2nd largest port in Korea, will also convert the engines of their RTGCs.

5.2. Ballast water

Ships use ballast water to control draught and centre of gravity (in relation to the cargo carried) in order to insure stability at sea. Ballast tanks are filled (and emptied) with seawater to enhance large vessels' stability when traveling with light cargo and fuel loads and to improve vessel trim, manoeuvrability and stability. Ballast tanks are also filled to offset off-loading of cargo and use of fuel and to facilitate travel through shallow waters. Ballast water acquired in one region may contain invasive aquatic species which, when discharged in another part of the world, may thrive in a new environment and disrupt the balance of the marine ecosystem. Such exotic species have already caused considerable harm when displaced. Examples of this include the zebra mussel (*Dreissena polymorpha*), the quagga mussel (*Dreissena bugensis*), the round gobie (*Neogobius melanostomus*) and also some plants such as the Euroasian water-milfoil.

Measures addressing ballast water – in general

In 2004, the IMO adopted the *International Convention for the Control and Management of Ships' Ballast Water and Sediments*, according to which the Parties shall undertake to adopt stringent measures to prevent, reduce and eliminate the transfer of harmful aquatic organisms and pathogens from ships' ballast water and sediments. The convention describes ballast water exchange standards and ballast water performance standards. Depending on the ballast water tank size and the year of construction, different dates have been set for meeting the ballast water performance standard. The convention describes where and when ballast water discharging is allowed to take place. The different programmes describe how the ballast water exchange has to be conducted from a number of pumping cycles to a number of organisms still present in the ballast water.

This convention is not in force, as not enough countries have yet ratified it. Currently, around 25% of the world tonnage is covered; however, 35% of the world tonnage is needed for enforcement (IMO, 2009).[1]

In 1996, the US congress decided on the introduction of a nationwide ballast water management programme, including a voluntary mid-ocean exchange of ballast water. In 2004, this programme became mandatory. However, there is still no mandated ballast water discharge standard enforced by the US Coast Guard.[2]

New technologies are being developed to treat ballast water in order to destroy any living organisms contained in the water. Trials involving several different options are currently carried out in different parts of the world.

Measures addressing ballast water – case study examples

Los Angeles and Long Beach

In March 2005, a US District Court[3] ruled in favor of the Northwest Environmental Advocates in a lawsuit that asserted that under the US *Clean Water Act* (CWA), the US EPA could not exclude discharges incidental to the normal operation of vessels from the National Pollutant Discharge Elimination System (NPDES) permit requirements. The

US EPA's response to that decision significantly altered the regulation of discharges from vessels into ocean waters in California and the rest of the US

In response to the Court's action, in December 2008, the US EPA issued the 2008 Vessel General Permit (VGP).[4] The VGP, which is implemented by the US EPA, will affect nearly 100 000 vessels using US ports, including the San Pedro Bay ports.[5] Before the VGP can be effective in a state, that state must certify that the VGP conditions are sufficient to protect the quality of the state's waters and to comply with its water quality standards, or waive certification. The EPA has approved California's certification, thereby providing for full implementation of the VGP in the State.

The VGP establishes effluent limits for 26 vessel discharge streams, including ballast water and gray water discharges and effluents from various ship processes (but not including sewage). Discharges covered by the VGP are aquatic nuisance species in ballast waters, substances typically found in wastewater (such as solids and organic matter), metals, nutrients, pathogens and toxic pollutants.

Large vessels can have ballast capacities of over one million gallons. Although that entire capacity is not typically discharged into port waters, ships calling on California ports can carry large quantities of water containing non-indigenous species (NIS) from far distant seas. These NIS may be invasive or nuisance organisms. As of 2005, 267 non-indigenous marine and estuarine animals were reported in California waters, some of which (such as the Chinese Mitten Crab) pose serious threats to the ecology and infrastructure of California's waters.

California's current regulatory approach to managing ballast water and reducing the introduction of NIS consists of ballast exchange requirements that currently apply in California coastal waters, and ballast water discharge requirements that phase in between 2009 and 2020. California's requirements tend to be more specific and stringent than those of other US states and of other countries.

Ballast exchange is flushing biologically rich water loaded at another port with less biologically active water from the open ocean. This technique may reduce the organism content of ballast water by 70 to 99%,[6] and most vessels can implement this management technique without structural alteration.

California has two ballast water exchange requirements, one that applies to vessels traveling within the Pacific Coast Region, and another for all other vessels.[7] In order for ballast water to be discharged into port waters, it must have been exchanged in waters at least 200 meters deep, and at least 50 nautical miles from land for Pacific Coast Region vessels, or waters at least 200 meters deep and 200 nautical miles from land for other vessels. The purpose of the Pacific Coast Region rule is to recognise that the organisms contained in ballast water picked up by vessels traveling between West Coast ports are not particularly foreign to California, and to avoid requiring such vessels to go 200 nautical miles offshore to do exchanges. California ballast water regulations are applicable within California's territorial boundaries, which extend three nautical miles beyond the State's coast.[8]

California's phase-in of ballast water discharge requirements begins with interim requirements that ballast water be treated or disinfected so that it meets specific biological requirements.[9] These requirements limit the numbers of organisms (micro and macro) per water volume; for example, the water may contain no more than 0.01 living organisms of sizes between 10 and 50 micrometers per millilitre of water and no more than

1 000 bacteria per 100 millilitres. These interim requirements became applicable on 1 January 2009 for vessels constructed after that date and having ballast capacities of less than 5 000 metric tonnes. There are progressively later effective dates through 1 January 2016 for vessels constructed before 1 January 2009.

The final regulations, which become effective after 1 January 2020, require that ballast water discharged into waters under California's jurisdiction be treated to contain *no* (zero) detectable, living organisms. Until the above-described requirements become effective, ballast water management relies primarily on ballast exchange.[10]

Rotterdam

The Netherlands signed the IMO Ballast Water Convention in 2005. The PoRA has not set any additional measures to control ballast water discharges in the port area.

Vancouver

Transport Canada operates the *Canadian Ballast Water Program*[11] in response to significant national concern with the introduction of alien invasive species by international shipping. The programme includes management for five Canadian regions – Arctic, Atlantic coast, St. Lawrence Seaway, Great Lakes and Pacific coast. Concern may be greatest for the Great Lakes, as over 170 aquatic alien invasive species have been established in the region. Of these, over 70% are thought to have been introduced through ship ballast water.

The Canadian programme has undertaken studies and actions supportive of the IMO *Global Ballast Water Management Programme*, supporting local investigations and information sharing. Canada ratified the IMO Ballast Water Convention on 8 April 2010, and Transport Canada is currently working on these regulations under *Canada Shipping Act, 2001*. Given the shared water resources with the United States, collaborative studies have been active with related US agencies. Until recently (2006), Canada had voluntary guidelines for ballast exchange. All ships entering Canadian waters were expected to exchange ballast water outside of the Exclusive Economic Zone (EEZ), with some exceptions during heavy seas. Currently, the *Ballast Water Management Program* has a mandatory ballast management requirement with four allowed options for ship ballast:

- Exchange at sea (outside of the Exclusive Economic Zone).
- Retain onboard.
- Pump ashore to treatment.
- Use on-board treatment to IMO standards (which are set in the Canadian regulations).

Transport Canada currently has an enforcement programme at the national level. Ship inspections occur for approximately 25% of ships arriving to coastal ports and 100% of ships entering the Great Lakes (a shared responsibility with the US Coast Guard and the Canadian and US Seaway Corporations). Inspections include record checks as well as sampling of ballast for salinity to verify the water had been exchanged at sea. Transport Canada enters this information to a database to prioritise future inspection activities.

The port's *Ballast Water Management Program* was one of the first programmes of its kind internationally when it was introduced (1997). The programme had a mandatory requirement for mid-ocean ballast exchange, even while a voluntary programme existed

elsewhere in Canada. This programme is now replaced with the current mandatory national programme, which was based in part on the port's local programme.

Busan

The case study does not mention any particular measures as regards ballast water.

5.3. Sewage, sludge and oil spills

Sewage and wastewater are generated onboard all ships, sometimes in large quantities. Some originates in bathrooms and galleys, while bilge water includes water that accumulates in the bottom of a vessel's hull and originating from deck runoff and leakage. When highly contaminated by residual machinery oil, the latter is called sludge. Discharges of these wastes into port waters may include organic, biological, chemical and toxic pollutants.

Measures addressing sewage, sludge and oil spills – in general

According to an IMO regulation, the discharge of sewage is allowed when the ship is more than 12 nautical miles off the coast. Under certain circumstances, disinfected sewage can be discharged as close as three nautical miles from land.

Passenger ferries produce large quantities of wastewater and some ports have developed facilities for taking care of stored wastewater. The Port of Stockholm operates treatment plants at its ferry terminals in order to prevent toilet and kitchen wastewater from being rejected into the sensitive brackish water system of the Baltic Sea.

An agreement signed in 2004 between the Port of Seattle, the Washington State Department of Ecology, and the Northwest Cruise Ship Association set strong standards for wastewater treatment and discharge in Washington waters, exceeding the federal requirements that ordinarily apply to cruise ships. This agreement, which was extended in 2006 to include the entire *Olympic Coast National Marine Sanctuary*, prohibits all untreated cruise ship wastewater discharges.

Deliberate discharge of oily machine room water remains a problem in shipping despite the IMO's adoption in 1983 of MARPOL Annex 1, that provides guidelines for the prevention of pollution by oil. A control made by the Port of Gothenburg revealed that 90% of the ships calling at Gothenburg did not have well-functioning oil separation systems (Göteborgs Hamn, 1999). MARPOL Annex 1 demands the establishment of appropriate technologies for retaining oily waste on board, and requires the Parties to provide reception and treatment facilities at oil terminals and ports. Ships are prohibited from discharging oily machine room waste containing more than 15 ppm of oil. Operational oil discharge from tankers is allowed outside special geographical areas, at more than 50 nautical miles from land, provided that the rate does not exceed 30 litres per mile travelled.

Several ports have designed systems for recycling of motor oil and oil filters, among them the port of Newport (Oregon) and terminals operated by Hutchison Port Holdings.

Bunkering of fuel in port or at sea may also result in oil spills unless carried out in a safe way. The ports of Gothenburg and Stockholm use a concept called "green bunkering", which includes a number of safety measures to reduce the risk of accidental spills.

Storm-water management is employed in many ports to minimize runoff from the sites into the harbour.

The Clean Shipping Project in western Sweden includes the promotion of best practices in the use of (among other parameters) bilge water separation, lubricants (engine oils, cylinder oils, gear oils, hydraulic fluids, lubricant grease, stern tune oil, etc.) and cleaning agents (Clean Shipping Project, 2007).

Large accidental oil and chemical spills may occur as a result of collisions involving tankers, the largest of which can carry several hundred tonnes of crude oil. Amendments to MARPOL Annex 1 require new tankers to have double hulls or alternative designs having similar properties. Ports in different parts of the world have differentiated port fees to stimulate early introduction of double hulls.

In Finland, the *Oil damage levy* has different rates for ships with and without double hulls. For oil transported in vessels without a double bottom, the tax rate is EUR 3 per tonne. For oil transported in vessels with a double bottom, the tax rate is EUR 1.5 per tonne.

Measures addressing sewage, sludge and oil spills – case study examples

Los Angeles and Long Beach

Liquid waste discharges are controlled by a complex combination of California and US EPA regulatory provisions. The California *Clean Coast Act*[12] prohibits the discharge of wastewater from oceangoing vessels (cruise ships and vessels of 300 gross registered tons or greater) within the State's three-mile zone, providing the vessel either has sufficient holding tank capacity or it is berthed near an onshore sewage reception facility, and the ship has the means to discharge to that facility. Wastewater is defined as treated and untreated sewage and other liquid wastes including sewage sludge, hazardous wastes and oily bilge water. If a vessel that has adequate holding capacity or access to an onshore facility discharges sewage into state waters, that discharge must be reported and the operator is subject to a penalty. Vessels that have neither adequate holding capacities nor access to onshore facilities may discharge sewage into the waters and are not required to report it.[13]

The federal *Clean Water Act* (CWA) prohibits the discharge of untreated sewage from vessels greater than 65 feet in length into navigable waters of the US, which includes territorial seas within three miles of shore.[14] In order for sewage to be discharged, it must be treated with an approved, Type II marine sanitation device. A Type II device is a system that, by maceration and disinfection, produces an effluent containing less than 200 faecal coliform bacteria per 100 millilitres and not more than 150 milligrams of suspended solids per litre. The US Coast Guard enforces the CWA's prohibition on discharging untreated sewage. The Coast Guard also enforces the prohibition of *any* sewage discharge into no discharge zones (NDZs). There are 10 estuarial, NDZs in California, although neither Los Angeles nor Long Beach harbours are among them.[15]

The CWA further provides that no state may require more stringent control of sewage (black water) discharges unless the Administrator of the US EPA approves. Because California's discharge requirements could be more stringent than CWA requirements in some situations, the California State Water Resources Control Board submitted an application to the Administrator of the US EPA seeking approval for California's implementation of the California *Clean Coast Act* provisions that apply to sewage.[16] The application states:

> The State Water Board requests that it be granted authority to regulate these (sewage and sewage sludge) discharges in order to preserve and protect water quality for the

many beneficial uses of all of the State's coastal waters, and to maintain conformity with applicable water quality standards established in statewide and regional water quality control plans and policies.[17]

The US EPA interprets the CWA to provide that the appropriate mechanism for a state to impose more stringent requirements on the discharge of sewage from vessels is through the creation of NDZs rather than by state law. Accordingly, the Water Resources Control Board and the US EPA now consider the State's application for EPA approval to be a request for the EPA to establish additional NDZs in California waters.[18] The US EPA is currently in the rulemaking process to approve this request. It appears that the practical difference between the Administrator approving the State's enforcement of the *Clean Coast Act* provisions and approving the State's request for NDZs is that California would enforce the former, and the US Government (Coast Guard) would enforce the latter.

Because the CWA requirement for EPA approval applies only to sewage (black water), the discharge prohibitions of the California *Clean Coast Act* which apply to gray water (wastewater from sources such as shower, laundry and kitchen wastes), bilge water, hazardous wastes and other wastes (medical wastes, dry cleaning wastes and photography laboratory chemicals) are in effect. The California Toxics Rule[19] establishes receiving water standards to protect aquatic life from acute and chronic consequences of the discharge of toxic substances.

In summary, California has sought to impose stringent liquid wastes discharge limits on ocean-going vessels. Except for sewage, state law prohibits liquid waste discharges in California coastal waters unless vessels are unable to either store or offload wastes. Federal law prohibits discharging untreated sewage into US waters and California is working with federal authorities to create NDZs in which all sewage discharges would be prohibited.

Rotterdam

To facilitate and promote safe and environmental friendly disposing of waste products from ships, waste reception facilities have been installed by the PoRA. It is obligatory for ships to discard their waste products at the port designated waste reception facilities.

The availability of waste collection points in the port is the result of a European directive (2000/59/EC) to minimise environmental damage to the marine ecosystem caused by waste products from sea ships. For oil waste products, a ship pays a fee on every port call and receives a subsidy upon the disposal of oil. The system promotes (frequent) disposal of oil at waste reception facilities for further processing (PoR, 2009b) and thereby discourages the illegal dumping of effluents at sea.

To make sure the ships hand in their effluents, all ships have to notify the port authority on the waste on board (substance, quantity) and their capacity for waste storage (PoR, 2009b). Ships are only exempted from their duty of obligatory disposal if they still have enough remaining capacity for waste storage.

The water quality can also be heavily affected by activities in the port. One such example is spills of mineral oils that lead to pollution of water and sediments. The PoRA activities are directed at the prevention and the control of oil spills. In case oil spills occur, PoRA will try to keep the environmental damage to a minimum. An example of how PoRA tries to prevent spills is through the Bunker checklist. Ships engaged in tanking procedures have to adhere to a number of precautionary measures to reduce the risk to a minimum,

controlled by the port master. This Bunker checklist describes the necessary precautionary actions to be taken prior to bunkering.

Compliance with these prevention regulations is monitored (inspections) by a number of organisations, including PoRA.

As spills still occur, PoRA takes action to minimise the environmental impacts of occurring spills. PoRA employs a number of ships that are capable to fight oil spills. Recently, the port has taken a new ship into service that is specially adapted to fight oil spills (PoR, 2009a). PoRA's policy works both preventatively (inspections) as well as correctively (prosecution). In the event of a spill, the responsible party will be held accountable for the costs of cleaning.

Vancouver

Oil spill preparedness and response is an additional national concern in Canada that has held a strong focus over the last two decades. A defined framework has been in place since 1995, backed by legislation and mutual agreements between government agencies and industry. The national oil spill management framework has been updated very recently, consistent with international strategies and agreements between countries engaging in high levels of trans-oceanic trade.

Disposal of sludge, sewage and garbage, snow and rain water removal, use of anti-fouling paints and land use and resource conservation are regionally-oriented issues that CPAs deal with, often in collaboration with municipal or regional government officials.

Canada's *Marine Liability Act,* first introduced in 2001, is the principal legislation for managing the liability of ship-owners associated with passengers, cargo, pollution and property damage. This Act provides a means to manage oil and fuel spills by way of mandatory insurance requirements for ship-owners and maximum fines that can be applied in the event of an accidental release. Much of the Act was designed to support international strategies and agreements. Canada has been a member of the international *Oil Pollution Compensation Fund* since 1989. A *Supplementary Fund Protocol of 2003* provides an additional tier of compensation for damages due to oil spills from tankers (an increase from $500 million to $1.5 billion for a single incident). The *International Convention on Civil Liability for Bunker Oil Pollutions Damage, 2001* provides a framework for liability and fines associated with fuel spills (all forms of ship bunker) for all commercial ships other than oil tankers. The *Marine Liability Act*, updated in 2009, utilises a "polluter pays" principle and provides a complete framework for liability and compensation due to pollution damages from ships.[20]

The *Fisheries Act* prohibits the release of deleterious substances to waters frequented by fish. This prohibition is applicable to fuel spills as well as other substances and provides the basis for government to lay criminal charges in the event of negligent fuel releases to fish inhabited water.

The *Marine Liability Act* provides Transport Canada with the ability to manage all forms of fuel spills in a manner consistent with current international agreements and best practices. This is known by international shipping agencies, which likely influences which ships are active in Canadian waters (*e.g.*, this discourages use of older ships that may have a higher degree of risk for accidents). By requiring mandatory spill insurance for all ship-owners operating in Canadian waters, immediate spill response can be provided by the Canadian government without concerns related to costs.

For visiting ships, the Harbour Patrol of Port Metro Vancouver seals the engine room bilge discharge valve(s) with a tamper-proof seal. Hold washing discharges can be requested and these requests are treated on a case by case basis. Any accidental discharges must be reported to the port immediately. One Harbour Patrol craft has thermal imaging that can be used to identify oil in water.

The *Canada Shipping Act, 2001,* requires vessels to immediately report oil or fuel spills to the Canadian Coast Guard. The port has taken an informal "First Responder" role for any leak/spill issues and informs each vessel captain of the port's expectations and local communication protocol upon entry to the jurisdictional waters. In the event of an accident, the port is typically the first to respond and facilitate communication with the affected governmental agencies.

The port does not permit any discharge of problematic wastes (sludge, sewage, garbage) to the marine environment and discourages non-problematic discharges. Local suppliers are available to receive discharges from ocean going vessels, for limited volumes.

Busan

The ports' reception facilities for garbage and oily waste in large ports such as the Ports of Busan and Incheon have been installed by private companies. However, such facilities have been installed by the Korea Organization of Environment Management (KOEM), a government-owned and managed organisation, in small ports in Korea. There are 45 oily waste cleaning companies in the Busan Port, of which 22 companies also can clean oil spilled at sea. There are recommended prices for reception of oily waste; however, the private companies are competing for business of reception of oily waste. Between 2007 and 2009, a total of 107.6 million litres of liquid oil waste and 52.6 million litres of solid oil waste were collected from vessels in the Busan Ports.

Table 5.1. **Collected oily waste in the Busan Port**

(Thousand litres)

2007		2008		2009		Total	
Liquid	Solid	Liquid	Solid	Liquid	Solid	Liquid	Solid
39 850	18 143	34 555	19 206	33 166	15 218	107 571	52 567

Source: Korean Coast Guard, 2010.

Korea is a member of MARPOL, so single hull tankers of less than 25 years of age in 2010 were scheduled to be regulated according to MARPOL options. However, after the "Hebei Spirit" accident in December 2007, the Korean Government revised the *Marine Environment Management Act*, and accordingly, no single hull tanker will be allowed to enter Korean ports after 1 January 2011.

With industrialisation, population growth, and dense activity in coastal areas, large quantities of marine debris are generated, harming the marine environment and causing a large number of maritime accidents in Korea. Most of the land-based marine debris comes from rivers, such as the Han River, the Keum River, the Youngsang River, the Seomjin River and the Nakdong River during flooding in the summer when more than three fourths of the yearly precipitation occurs in Korea. The origin of land-based marine debris is in large cities. Also, the fishing industry is active in the coastal waters of Korea, and a huge

quantity of marine debris is generated at sea. Currently, the aquaculture industry is very dense in coastal areas, and large quantities of Styrofoam buoys, nylon ropes, and nets are generated.

The *Marine Environment Management Act* stipulates that the Korea Government should establish a National Marine Debris Management Plan and local governments should establish local marine debris management action plans. Based on those plans, the MLTM office in Busan operates 4 vessels for marine debris collection and removal in the Port of Busan area. In 2009, a total of 246 tonnes of marine debris were collected and removed and 12 derelict vessels removed. And 20 organisations joined in the coastal cleaning of Busan coastal area under the campaign of *One Company, One Coastal Cleaning*.

After the "Sea Prince" accident in 1995, the Korean Government established a National Contingency Plan (NCP) and Regional Contingency Plans (RCP), which are essential for effective oil spill response. The NCP is a national oil spill response plan, by which all personnel and equipment of related government agencies and the private sector can be mobilised in the case of a big oil spill accident. The RCP is an action plan, by which the actual oil spill response is conducted at the oil spill site. Without a NCP, the Korean Government did not have a plan to manage large oil spills in the coastal waters in Korea.

After the "Sea Prince" accident, the Korean Coast Guard (KCG), as the responsible agency for oil spill response, established the NCP in 2000, and RCPs for twelve major coastal waters were established from 1999 to 2002. Also, the KCG planned to maintain resources for oil spill management capable of responding to a large oil spill of 20 000 tonnes. The Korean Government also ratified the OPRC Convention in 2000 and has tried to co-operate with neighbouring nations through the Northwest Pacific Action Plan to respond a large oil spill accidents.

The Busan coastal area is biologically very productive, but the risk of oil spills from vessels is very high because of the dense vessel traffic. Therefore, KCG has established a RCP of the Busan coastal area and secured resources for effective oil spill responses. Also, the *Marine Environment Management Act* stipulates that a *Shipboard Oil Pollution Emergency Plan* should be onboard the vessels and an *Oil Pollution Emergency Plan* should be established for marine facilities such as oil refineries. Usually marine facilities have a contract with the Korea Marine Environment Organization for cleaning oil spills in case of accidents.

5.4. Garbage

Routine operations of crew and passengers create solid wastes from activities such as food preparation and ship operations, and from cargo-related activities, such as spillage and disposal of packing materials. Disposal of these wastes into port waters may include organic, biological, chemical and toxic pollutants.

Ships can limit garbage problems by predominantly using recyclable materials and by collecting, sorting and possibly treating waste on board (in compactors and comminutors). On-shore reception systems can be integrated with municipal recycling and waste management systems.

Measures addressing garbage – in general

MARPOL's Annex 5 provides rules for the prevention of pollution by garbage. It bans any disposal of plastics into the sea and restricts the discharge of other garbage from ships into coastal waters. The Parties to the Annex must ensure the provision of reception

facilities for different types of waste at ports and terminals. The annex also requires ships to carry a Garbage Record Book where the date, time, position of the ship, description of the garbage and the estimated amount incinerated or discharged garbage must be logged and signed. This is, of course, particularly important for large passenger ferries and cruise ships that generate significant quantities of organic waste.

The EU Directive 2000/59/EC goes one step further by addressing in detail the legal, financial and practical responsibilities of the different operators involved in the delivery of ship-generated waste and cargo residues in European ports.

Many ports have well designed systems for the reception of ship waste, where debris is integrated into the local or regional system for recovery and recycling. Examples of this can be found in the ports of Portland, New York and New Jersey, as well as in Stockholm and Gothenburg. Presumably good practices exist in many places elsewhere.

Measures addressing garbage – case study examples

Los Angeles and Long Beach

The federal *Clean Water Act* and the *Marine Plastic Pollution Research and Control Act* regulate solid waste disposal in US waters. These laws implement the protocol of 1978 relating to the International Convention for the Prevention of Pollution from Ships, 1973 (MARPOL). This convention prohibits any vessel from jettisoning plastic wastes overboard within 200 miles of the US shoreline or garbage within three miles of the shoreline. The US Coast Guard enforces these requirements.

The POLB has a comprehensive recycling and solid waste management programme.

Rotterdam

To facilitate and promote safe and environmental friendly disposing of waste products from ships, waste reception facilities have been installed by the Rotterdam Port Authority, PoRA. It is obligatory for ships to discard their waste products at the port designated waste reception facilities.

The availability of waste collection points in the port is a result of the EU Directive 2000/59/EC to minimise environmental damage to the marine ecosystem caused by waste products from sea ships. Under this directive, in the Port of Rotterdam, ships are obliged to pay a fee for waste disposal, whether they do or do not make use of the waste reception facilities. The height of this fee is dependent on the engine size. In exchange, the ship is allowed to dispose garbage (household garbage, plastic, small chemical) to a limit of 3-6 m^2 free of charge (dependent of engine size). If more garbage is handed in, the ship owner will be will charged for the additional costs (PoR, 2009b).

Vancouver

The port does not permit any discharge of problematic wastes (sludge, sewage, garbage) to the marine environment and discourages non-problematic discharges. Local suppliers are available to receive discharges from ocean going vessels, for limited volumes.

Busan

Port reception facilities for garbage have been installed by private companies in large ports such as the Ports of Busan and Incheon. However, such facilities have been installed

by the Korea Organization of Environment Management (KOEM), a government-owned and managed organisation, in small ports in Korea.

5.5. Dust

In ports dust can be released from transport of materials and from handling of bulk cargo. In addition, some substances transported and stored may create risks of spontaneous combustion or fire. Coal terminals are known to be a major source of dust, unless dust lift-off is prevented by cover or by using water spray to dampen stockpile areas.

Construction activities and industrial services located to the port area may also produce dust. Ship maintenance is a third potential source of dust. Repair activities, such as sand-blasting and welding, may create problems in the neighbourhood. Covers, guards and shields might be used for reducing the risk of spreading hazardous dust.

Dust emission control measures at port sites are generally part of the local or regional jurisdiction that monitors ambient air quality and regulates air pollution.

Measures addressing dust – in general

In 2002-03, the Port of Queensland invested in a noise and dust monitoring plan. The programme involves reducing stockpile heights, to lessen the potential for wind impact, and the use of water spray during drier conditions. The port authorities of Gladstone and Newcastle, both in New South Wales, also water bulk stockpiles by automatic sprinklers to reduce dust emissions. In addition, these ports have planted green border corridors between bulk cargo terminals and neighbouring areas (Comtois and Slack, 2007).

Measures addressing dust – case study examples

Los Angeles and Long Beach

The case study does not mention any particular measures in this regard in the two ports.

Rotterdam

The storage and transhipment of coal can significantly influence local air quality (DCMR, 2009). To limit the emission of dust, measures have been taken. The Rijnmond Environmental Protection Agency determines which technical and behavioural measures a company involved in dry bulk handling has to implement (DCMR, 2009). Technical measures to decrease the emission of transhipment include closed transhipment, or the use of suction filters. To prevent dust emissions from the storage of dry bulk outdoors (ore, coal), surfaces are kept wet or are covered under a crust of cellulose or latex materials.

Also behavioural codes for handling dry bulk have been set (DCMR, 2009). In these codes, for example, conditions for material handling with machinery are described. The codes also include factors such as the maximum wind speed under which handling is allowed to take place.

A monitoring network has been created around the major dry bulk terminals. The digital network provides these organisations with information on when dust is emitted. The DCMR also uses the network to check compliance with regulations. Without these networks, it would be very difficult to check the compliance of regulations (DCMR, 2009).

Vancouver

Infrequently, dust can be a source of complaints by community members near marine terminals. At times, dust from minerals and grains handling can be liberated. Dust controls, such as water application and elevated sprays, are required for terminals that handle large volumes of materials that can cause dusting and these requirements are expressed in their lease agreements. In some cases, a dusting event may be caused by lack of adherence to a documented dust management programme; the port's response to a dusting event includes contacting the operation to ensure that a resolution is being worked on whenever possible. A detailed port assessment of fugitive dust emissions (*e.g.*, an emissions inventory) is often very difficult to develop compared to an inventory of engine exhaust emissions. Although emission factors are available from the US EPA and other sources, significant variability in potential rates is often possible, depending on the specific commodity attributes for the minerals or grains handled at a terminal. In addition, available emission factors usually relate to "normal" operational practices, and not the atypical conditions that tend to lead to dusting events.

Busan

The case study does not mention any particular measures in this regard.

5.6. Hazardous cargo

Hazardous cargo poses a special danger to the surrounding environment and community. The volume of dangerous and polluting goods carried by sea is increasing and will most likely continue to increase.

Many different types of hazardous cargo are transported by ships and handled and stored in ports, including substances such as caustic soda, sulphuric acid, nitric acid, phosphoric acid, ammonia, coal and tar products, and many petrochemical products.

Measures addressing hazardous cargo – in general

An amendment to MARPOL Annex 2 refers to the international IBC code for the construction and equipment of ships carrying dangerous chemicals in bulk, which identifies more than 250 noxious liquid substances. Annex 2 provides guidelines for the design, construction and operational requirements of chemical tankers, as well as the discharge conditions for noxious liquid substances as a result of shipping activity and tank cleaning. It also contains procedures for the prevention of accidental discharge at sea and measures for the control, treatment and disposal of wastes from chemical tankers at port.

The International Maritime Dangerous Goods Code (IMDG), adopted by the IMO, lists hundreds of specific dangerous goods. MARPOL Annex 3 regulates the prevention of pollution by harmful substances carried by sea in package forms by providing detailed rules on standards on packaging, marking, labelling, documentation, stowage and quantity limitations.

According to a survey by Comtois and Slack (2007), advanced training of crew aboard ships and port personnel is essential.

Ports may have several reasons to develop emergency plans. Accidents involving the handling and storage of hazardous substances are one. Toxic spills, explosions and fires may require the protection and evacuation of people in the port area, as well as in neighbouring communities. Emergency plans may also be needed in relation to natural

disasters, such as hurricanes and earthquakes. According to a survey conducted by the IMO in 2004, only 11% of ports had by then submitted a security plan in compliance with the International Ship and Port Facility Safety Code (ISPS Code).

The Port of Auckland employs an emergency management programme targeting specific environmental problems. Components of the programme focus on fire-fighting exercises, spill response procedures, regular response training of port personnel, in partnership with civilian authorities and shipping lines (Comtois and Slack, 2007).

The *Dangerous Goods Advisory Council*, which was incorporated in 1978, is an international, non-profit, educational organisation dedicated to the promotion of the safe transportation of hazardous materials/dangerous goods. DGAC and its staff accomplish this goal by providing education, assistance, and information to the private and public sectors.

Measures addressing hazardous cargo – case study examples

Los Angeles and Long Beach

The container cargo that is handled at the two San Pedro Bay ports includes items such as fireworks; industrial chemicals (gases, liquids, and solids); solvents; petroleum products; paints; cleaners; and pesticides. Hazardous materials that are transported in containers are stored in individual containers specifically manufactured for storing and transporting the material. In addition, shipping companies prepare, package, and label hazardous materials shipments in accordance with US statutory requirements. All hazardous materials in containers must be properly manifested. Hazardous material manifests for inbound containerised hazardous materials are reviewed and approved by the Port Security and the City's Fire Department before they can be unloaded.

In addition to container cargo, the ports handle numerous liquid bulk cargos, some of which that are potentially hazardous. The two ports receive and export refined and partially refined petroleum products on a large scale. The POLA, for example, has approximately 150 liquid storage tanks on site. The region surrounding the Port (the Los Angeles Basin) also contains a number of oil and gas production fields, which have been operating for nearly a century. These petroleum production facilities include storage vessels, pipelines, processing activities and truck activity. Although these facilities and pipelines are engineered according to various safety standards and undergo extensive environmental review prior to their approval, they nonetheless handle materials that pose risks to people, the environment, and property in the vicinity.

In addition to port requirements, there are a number of city, State and national requirements that apply to protect workers and the public, including the requirement that facilities that store or handle hazardous material prepare a Risk Management Plan. Risk Management Plans were first required by California in 1986 and have since been supplemented by a parallel federal government requirement. A Risk Management Plan contains a hazard assessment of potential "worst-credible" accidents, an accident prevention programme, and an emergency-response programme.

The risks associated with expanding port activities and their interaction with non-port operations in the vicinity of the ports are also dealt with during project-level reviews conducted for NEPA and CEQA, the two environmental disclosure laws discussed earlier.

Rotterdam

Almost all commercial ports are confronted with the handling of dangerous substances. Handling these substances requires special care due to the risks involved for the general environment and also for the workers handling such transhipments. To prevent damage to the environment and the health of the workers, the PoRA has introduced rules for operations involving dangerous cargo. In general, rules have been introduced for the following situations:[21]

- *The use of petroleum ports*

  Describes the rules for loading, unloading and bunkering in petroleum ports.

- *Berthing*

  Describes the rules as to where tankers carrying hazardous cargo are allowed to take berth. Next to this, it also describes the situations in which a ship is allowed to berth elsewhere in the port. It also describes where the container and general cargo vessels containing hazardous cargo are allowed to take berth.

- *Cleaning of cargo tanks*

  Describes the locations where cleaning, washing and ventilating of tanks are allowed to take place. It also describes the procedures to obtain permission for such activities or permission for these procedures in different locations.

- *Repairs*

  In the PoR it is not allowed to conduct major repairs to ships except in a shipyard. It also describes how ships can apply for an exemption.

- *Decontamination of cargo and degassing of spaces*

  Describes the rules on degassing and decontamination of spaces. Such procedures are only allowed under special conditions and prior permission from the harbour master is necessary.

In the Netherlands, dangerous goods need to be transported via dedicated links, depending on the safety category. At the same time, there are conditions for building directly around this infrastructure. The authorities use a standard of one in a million per year for the risk on fatal accidents.

Vancouver

Environmental response programmes for the port are in place and, for the most part, are managed by the terminals and cargo handlers. Port Metro Vancouver Operations personnel monitor and assist port's tenants as appropriate. Notices of incidents are circulated to a list of responders and mandated agencies, including the port, by the Provincial Emergency Program as they are reported.

Crude oil cargos. With respect to tanker traffic, the former Vancouver Port Corporation commissioned a "Risk Analysis of Tanker Traffic in the Port of Vancouver" in 1990 and implemented its recommendations to ensure safety. Since then, the Port has actively managed movement of crude oil, petroleum and chemical products by tankers and tanker barges to ensure safety in Burrard Inlet and approaches. In that regard, the Burrard Inlet Second Narrows are designated a Movement Restricted Area. Port Metro Vancouver is now receiving proposals for a similar study to address proposed tanker traffic on the Fraser River (such traffic has so far not been permitted there).

Dangerous goods cargos. Dangerous goods are substances regulated under the *Canada Shipping Act*, 2001 or under the *Transportation of Dangerous Goods Act*. Transport Canada is responsible for the coordination of work while promoting public safety as related to the transportation of dangerous goods. There are certain requirements and systems that shipping agents and other port community members must be aware of, which apply specifically to Port Metro Vancouver.

The port established an Advance Notification Requirement, where the Harbour Master requires pre-notification of the movement of dangerous goods into the port's areas. A minimum of 24 hours advance notification is required for all dangerous cargoes entering port waters or the port area. Applications for Containerised Dangerous Goods Authorization are submitted and processed online at the Pacific Gateway Portal (PGP) website. Notification and authorization also applies to cargo in transit (retained on board a vessel).

Time and quantity limitations apply to containerised explosive and radioactive cargoes, respectively International Maritime Dangerous Goods Class 1 and Class 7. Quantity limitations for International Maritime Dangerous Goods Class 1 vary by terminal. Such shipments are not permitted to be stored on the dock, but are restricted to being immediately loaded on the vessel or removed by the inland carrier as the case may be.

Busan

The case study does not mention any particular measures in this regard.

5.7. Antifouling

The surfaces of vessels under the waterline are prone to fouling; hence, antifouling is needed for reducing the friction between ship hulls and the surrounding water. An adequate coating will improve ship efficiency, save fuel and reduce running and maintenance costs. Antifouling paints prevent parasites from attaching to the hull under water and may play a role in preventing invasive aquatic species from being transported from one part of the world to another. The antifouling substances leach into the water and subsequently the bottom. This leaching process presents danger, as a number of these compounds are found to be highly toxic, such as biocide antifoulings. Historically, antifouling products have contained heavy metals, such as copper and tin. As these compounds constantly leach into the water, they present a real environmental risk, with possibly severe adverse effects on oysters, whelks, shell-fishes, sea mammals and fish. Next to the leaching process, the compounds can also be released into the environment through ship maintenance (sanding and grinding).

Biocide antifoulings are not the only antifouling types that have negative side effects. Other substances still used also affect the environment, for example the ones that use heavy metals, such as copper. Despite the ban on the use of antifouling containing biocide, already applied substances can still impact nature.

TBT (organotin tributylin) has been widely used by the shipping industry as an antifouling product. TBT is not only a problem in large commercial ports, but also in leisure boat marinas. Research carried out in Sweden shows the concentration of TBT in the top layer of the sediments of some natural harbours frequently visited by leisure boats to be three times higher than the concentration found in the sediments of the Port of Rotterdam and 3 000 times that of the ambient limit value. The concentration was 10 times higher in

the top-layer of the sediment compared to lower layers, indicating that TBT is still leaching to the natural environment, despite the fact that almost 20 years have passed since the ban on TBT for application on boats shorter than 25 metre.[22]

Measures addressing antifouling – in general

On an international level, some action is taken to reduce negative impacts of antifouling products on the environment. In 2001, the IMO adopted a convention addressing the control of antifouling systems used on ships. As the toxicity of the various used substances became apparent, the use of antifouling containing biocides was banned in 2003.[23] Antifouling containing biocides already applied on ships were to be removed by 2008, or alternatively be encapsulated with other coats of paint to prevent the substances for leaching.

Some shipping companies, notably Leif Höegh, Norway and Wallenius Lines, Sweden, use silicon paints, while Nippon Paint Marine Coatings has developed a TBT-free antifouling paint technology (Comtois and Slack, 2007).

Measures addressing antifouling – case study examples

Los Angeles and Long Beach

California is concerned with non-indigenous organisms such as worms, crabs and amphipods that attach themselves to the submerged portions of vessels. On the other hand, hull cleaning to remove such organisms is also of concern because it can introduce toxic substances into the water.

California requires[24] that hull fouling be regularly removed according to the following:

- before the expiration date (or extensions thereof) of a vessel's full-term safety certificate,
- before the expiration date (or extension thereof) of a vessel's US Coast Guard certificate of inspection,
- within five years of a vessel's last out-of-water, dry-docking.

Commercial vessels operating in California waters must submit annual hull husbandry reports.[25]

In-water hull cleaning is not allowed in the Los Angeles or Long Beach harbors because they are listed as "impaired"; that is, in need of remediation.[26] This prohibition applies only to underwater cleaning operations, not to deck and hull washing above the water line.[27] The Vessel General Permit (discussed above) prohibits all in-water hull cleaning after 2011 in California (except for propeller cleaning) unless it is conducted using the best available technologies that are economically feasible (as required by Section 401 of the *Clean Water Act*), as determined by the California State Lands Commission and the State Water Resources Control Board.

The ports' direct responsibilities regarding hull fouling are limited to the ports' general housekeeping activities.

The Port authority of Los Angeles has, however, contributed towards the development of environmentally benign substitutes for antifouling by a pilot-project aimed at coating ship hulls with Teflon-based material containing no toxic chemicals.

Rotterdam

PoRA does not impose extra rules on the type of antifouling used. It has, however, banned the mechanical cleaning of ship hulls in the water, as this would result in extra emissions of the active substances to the water.

Vancouver

Canada ratified the IMO Convention on the Control of Harmful Anti-fouling Systems on Ships in 2009. Under the *Canada Shipping Act 2001*, the *Regulations for the Prevention of Pollution from Ships and for Dangerous Chemicals* include provisions for anti-fouling systems and apply to all ships in Canadian waters and to all Canadian ships everywhere. In Canada, the sale and use of products such as organotin paints are regulated by Health Canada. The Pest Management Regulatory Agency (PMRA) indicated in a Special Review Announcement that all registrations and use of organotin-based anti-fouling paints ceased to be effective 31December 2002. The PMRA maintains a list of currently registered anti-fouling paints that may be imported, sold or used in Canada.

Furthermore, Port Metro Vancouver manages some aspects related to antifouling coatings, such as hull polishing requests, discharges from maintenance facilities and decommissioning tide grids..

Busan

The case study does not mention any particular measures in this regard.

5.8. Dredging

Every year, one hundred million cubic metres of marine sediments are dredged worldwide to maintain or improve waterways (Comtois and Slack, 2007). These sediments are sometimes heavily contaminated by numerous poisonous substances that have settled onto the underwater floor. However, most dredged material is clean sediment and should be recognised as a resource. In many cases, the sediment from dredging is put into productive use for shore stabilisation or residential, industrial and infrastructure projects. Sometimes uncontaminated or low-contaminated sediments are used for agricultural and forestry purposes or in park development.

Measures addressing dredging – in general

Dredging is regulated by the London Convention of 1972, amended by the IMO in 1996 with guidelines for the prevention of marine pollution by the dumping of wastes. Sediment disposal may take place in land dumps or in approved areas of the sea bed.

The disposal of dredged material is usually controlled through permits provided by national legislation which sometimes originates from international conventions for the protection of the sea, such as the OSPAR Convention (for the North-East Atlantic), the Helsinki Convention (the Baltic Sea) and the Barcelona Convention (the Mediterranean Sea).

Among the examples of port action mentioned in Comtois and Slack (2007) is the Port of Boston that has excavated a number of underwater cells at a depth of 20 metres, removed the uncontaminated sediments and replaced them with dredged contaminated sediments and capped the latter with a one metre layer of clean sandy material. The Port Authority of New York and New Jersey forwards all sediments resulting from dredging to a

site located on an off-shore platform where dredged material is screened to separate debris from sediments. Uncontaminated sediments are pumped to an on-shore site where they are mixed with cement kiln dust to enhance their compressive strength. This sediment mixture was used for the construction of a parking lot of 24 hectares at the Jersey Gardens mall in Elisabeth, New Jersey.

A similar solution has been developed by the Port of Brisbane that used a two kilometres long pipeline to transport dredged materials to the local airport to meet expansion needs, and the Port of Geraldton, also in Australia, used dredged materials essentially composed of limestone to build off-shore artificial reefs in partnership with the local lobster industry. The Port of San Diego, California, has built a small-scale reprocessing plant for recycling of copper from heavily contaminated sediments, and in Copenhagen, a new beach park was built on the island of Amager with artificial lagoons and beaches.

The Port of Oslo has recently started the Oslo Harbour Remediation Project "Oslo Fjord Clean Up". The aim is to remove 0.5 million m^3 of contaminated sediments from the harbour basin, thereby preventing the dispersal of environmental toxins in the inner Oslo Fjord, improving navigation depth and contributing to urban renewal. The project aims at demonstrating techniques for separating contaminated sediments to be stored in a natural depression in the seabed, at 60-70 metres depth, capped by a layer of non-contaminated material. Hydraulic dredging will be used in order to cause only limited suspension.[28]

The Port of Antwerp runs a project, subsidised by the EU, for completely removing TBT (tributyl tin) from dredging spoil. The Port Authority is developing and testing different treatment techniques for removing TBT so that the dredging spoil can be reused.

The International Association of Dredging Companies (IADC), an umbrella organisation for contractors in the private dredging industry, has published Environmental Aspects of Dredging (jointly with CEDA).

Measures addressing dredging – case study examples

Los Angeles and Long Beach

The Port of Long Beach's goal is to remove all of the contamination that has been identified in the port's land and sediments by 2010 and at the same time protect workers, the public and natural systems in the port.

Rotterdam

Due to the natural process of sedimentation in rivers and the coastal seas, dredging needs to take place to keep the waterways in the Port of Rotterdam at proper depth for shipping. The main waterways passing through the port are under the jurisdiction of the state (Rijkswaterstaat). The state is responsible for dredging in these areas. As the port basins fall under the jurisdiction of the PoRA, the dredging in these areas is being carried out by this organisation. Combined, in Rotterdam, 20 million m^3 of sludge is being dredged each year.

The quality of the dredged sludge in the PoR is improving; however, still 1.5 million m^3 of contaminated sludge (metals, PAC, PCB) is being dredged each year.

In the past, all sludge, including the contaminated part, was disposed at sea. With the creation of a depot called "Slufter", this situation changed in 1986. Now only clean sludge is disposed at sea. The basin was created by the PoRA in co-operation with the Dutch state;

the PoRA manages the basin. The basin is primarily used to store the contaminated sludge from dredging activities in the port and the waterways leading to the port.

As the largest part of the sludge is not contaminated, it can still be disposed in the North Sea. As the quality of sludge is increasing, more and more sludge will be disposed at sea. The obligatory separation of clean particles from the contaminated sludge also helps (PoR, 2007). These developments have prolonged the capacity of the storage basin for contaminated sludge.

The PoRA has set itself the goal for 2015 to improve the quality of the sludge to a level so that the sediments can be reused in, for example, infrastructure projects or disposal at sea.

Contamination of the waste and sludge is not only caused by port activities. Activities taking place upstream have also a significant influence on the sludge quality in the port. To tackle the problem of upstream pollution, PoRA has signed a covenant with industries upstream the rivers to reduce their levels of pollution.

A number of old contaminated basins have been covered with a clean layer of sand. This prevents the further spread of the contamination.

Next to these damage-preventing measures, PoRA and Rijkswaterstaat are active in a pilot project to improve the biodiversity in the water and the overall water quality in the harbour by installing hard substrate for algae and shellfish (PoR, 2009a). Through their water filtering capabilities, these organisms are expected to improve the water quality in the harbour.

Vancouver

The *Canadian Environmental Protection Act* provides a wide range of tools to manage toxic substances and ensures that the most harmful substances are phased out or not released into the environment. Environment Canada administers and enforces regulations that have been made under this act, such as a *Disposal at Sea* programme for the management of dredged materials.

Port Metro Vancouver has developed a project review process with a unique Environmental Assessment Procedure (EAP). All proposed projects involving physical work and potentially problematic activities (*e.g.*, discharges) on port property require approval through EAP. This would include new structures on land or water, additions or modifications to existing structures, demolitions, dredging or land grading and recreational docks. The EAP and project review process establishes consistency in assessment procedures and provides defined expectations for proponent requirements.

The EAP requires a description of all potential environmental impacts associated with a project's construction and operation. Development of a local environmental baseline is required if a suitable baseline assessment has not been prepared in the past. A description of the methods that a project proponent will use to avoid or reduce environmental impacts is also required. Depending on the nature and size of the project, detailed site assessments and development of current and expected future activity levels may be required.

Busan

The Busan Office of the Ministry of Land, Transport and Maritime Affairs (MLTM) is dredging at the semi-enclosed bay of the Busan South Port to restore the marine ecosystem and improve the marine environment. The project period is five years from 2009 to 2014.

The area for dredging is about 367 000 m^2 and the volume of the sediment is 255 000 m^3. The total budget is USD 28.5 million. The dredged sediments are reclaimed at a designated area of the Busan North Port for development of berths and terminals.

Notes

1. *www.imo.org/Conventions/mainframe.asp?topic_id=247*.
2. American Association of Port Authorities (*www.aapa-ports.org*).
3. Northern District Court of California in *Northwest Environmental Advocates et al. v. EPA*, 30 March 2005. On 23 July 2008, the Ninth Circuit Court of Appeals upheld that decision.
4. *www.epa.gov/npdes/pubs/vessel_vgp_permit.pdf*.
5. The VGP applies to all vessels operating as a means of transportation, except that discharges incidental to the normal operations of recreational vessels are exempt (although non-incidental discharges are not exempt). All commercial fishing vessels and all other vessels less than 79 feet in length are subject only to the ballast water discharge requirements of the VGP.
6. 2009 Biennial Report to the California Marine Invasive Species Program, California State Lands Commission. January 2009.
7. California Code of Regulations, Title 2, Division 3, Chapter 1, Article 4.6, Sections 2280 et seq. and California State Lands Commission, Marine Facilities Division Publication: California's Marine Invasive Species Program, Ballast Water Management.
8. *www.waterboards.ca.gov/academy/courses/wqstandards/materials/water_us_ca/ca_water_042508.pdf*.
9. California Code of Regulations, Title 2, Division 3, Chapter 1, Article 4.7, Sections 2291 et seq.
10. Sylte, McGuire and Calkins (2009).
11. *www.tc.gc.ca/marinesafety/oep/environment/ballastwater/menu.htm*.
12. California Public Resources Code, Division 38, Section 72400 et seq.
13. This provision begs the question of whether the Act rewards vessels that do not invest in adequate holding capacities or equipment to allow them to discharge to onshore sewage reception facilities.
14. *www.epa.gov/region09/water/no-discharge/*.
15. *www.epa.gov/owow/oceans/regulatory/vessel_sewage/vsdnozone.html#ca*.
16. State Water Resources Control Board Clean Water Act Section 312(f)(4)(A) Application. *www.waterboards.ca.gov/publications_forms/publications/legislative/docs/2007/supplemental_leg_report_final.pdf*.
17. *www.swrcb.ca.gov/water_issues/programs/npdes/docs/sb771/cwa312epa_ap.pdf*.
18. *www.calepa.ca.gov/pressroom/Releases/2009/Feb25.pdf*.
19. *http://ci.santa-rosa.ca.us/doclib/Documents/ut_irwp_PEIR_Appendix_C_1_California_Toxics.pdf*.
20. See *www.tc.gc.ca/acts-regulations/acts/2001c6/menu.htm*.
21. *www.portofrotterdam.com/en/Shipping/inland-shipping/Pages/dangerous-noxious-goods.aspx*.
22. Miljöaktuellt, No. 3, 2008.
23. *www.imo.org/*.
24. California Invasive Species Program, Fouling Removal and Hull Husbandry Reporting, California State Lands Commission. 15 July 2009.
25. California Code of Regulations: Title 2, Division 3, Chapter 1, Article 4.8, Section 2298.
26. The "impaired waters" designation is made by the US EPA, based upon California's recommendation, as required by the CWA.
27. Pursuant to Section 303(d) of the *Clean Water Act*, the California State Water Resources Control Board has designated waters in parts of the Los Angeles and Long Beach harbours as not meeting water quality standards, *cf. www.swrcb.ca.gov/water_issues/programs/tmdl/docs/2002reg4303dlist.pdf*.
28. Green Port, Issue 2, May/June 2008.

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Chapter 6

Land Use, Hinterland Distribution and Feeder Traffic

This chapter addresses land use and the transport of goods to and from the hinterland of the ports, and highlights policy instruments that can be used to limit negative environmental impacts in this regard. The chapter covers measures applied by the port authorities themselves, and measures taken by national, provisional or local political authorities.

6.1. Land use

Ports often require large areas of land and water. For large ports, the spatial imprint may be in the order of several hundred hectares; including land used for road and rail infrastructure or by warehouses and port related industrial activities. The ever-expanding size of ocean-going vessels require port authorities to provide berths that can accommodate longer ships with greater draught and terminals that are large enough to house enormous quantities of goods. The average capacity of container ships has grown tenfold in the last 35-40 years. Only a limited number of ports are capable of handling ships with a capacity of 8 000-10 000 TEU.

Measures addressing land use – in general

Conflicts over critical sites in coastal zones are common, as port development may have a considerable negative impact on marine ecosystems and estuaries. Port expansion may come into conflict with international conventions for the conservation of nature (World Heritage Convention), wetlands (Ramsar), biodiversity (Rio Convention), migratory species (Bonn Convention) or endangered species (Washington Convention) or with regional regulations, such as Natura 2000 in Europe. In Europe, the inherent conflict between port expansion plans and Natura 2000, the Birds Directive (79/409) and the Habitats Directive (92/493) has led to proposals concerning the establishment of a coherent EU "network of strategic port areas". Port projects in these designated zones would benefit from the status of "overriding public interest" and thus escape some of the restrictions expressed in the bird and habitats directives.[1]

The European Sea Ports Organisation (ESPO) has adopted a Code of Practice on the Birds and Habitats Directives as well as a Guidance document for port development and nature protection.[2]

Another example of developing useful tools is the European Union's Interreg IIIB project "NewDelta", into which several Northwest European port authorities delivered their best practices. Similar to the ESPO Code of Practice, NewDelta aimed at focusing on practical experiences in finding a balance between ports and nature. NewDelta developed practical information for port authorities such as guidelines, a solution database and toolkits.

Integrated Coastal Zone Management (ICZM) is aimed at creating a strategic approach to coastal zone planning and management in order to achieve sustainable development. Unlike the Birds and Habitats Directives, ICZM does not specifically focus on nature and biodiversity protection, but also takes economic development in the coastal region into account. In 2002, the EU issued a Recommendation on the use of ICZM, which does not contain mandatory legal requirements, but provides a collection of principles which should preferably be considered by Member States when developing national strategies.

Ports in different parts of the world have developed biodiversity programmes and invested in the protection of habitats and endangered species, among them the ports of Houston, Auckland, Brisbane, Le Havre, Seattle, San Diego, Tampa, Antwerp and Ipswich.

Ports may also threaten existing or planned urban development as they expand into contiguous areas or they may be constrained from such expansion by surrounding urban development. Some ports have moved closer to the open sea or relocated to new sites outside city centres, old waterfronts have been restored as parks and/or new local communities. The transformation of attractively located waterfronts in London, New York, Boston, Seattle, San Francisco, Gothenburg and Oslo are among the many well-known examples of this.

Expansion and relocation of port activities require dredging, backfilling and building new infrastructure in water and on land. Soil contamination is an issue both in the context of port expansion and the transformation of old sites into parks or urban settlements. In addition to the examples mentioned in the section on dredging, Comtois and Slack (2007) provide details of measures to restore contaminated land in the ports of Long Beach, Seattle, Vancouver and Sydney. Their survey suggests biologically and chemically treatment of where contaminated soils before it is being recycled as construction materials or used on sites as fill – but does not address the question of costs.

Measures addressing land use – case study examples

Los Angeles and Long Beach

Land use in communities adjacent to many older seaports are generally unstructured and quite mixed in their composition. Industrial activities tend to be interspersed with older, residential areas, and they all are frequented with heavy truck, rail, and even air transfer facilities. Efforts to improve the communities often conflicts with the desire to expand the capacity of the port onto formerly residential and business areas. The ports of Long Beach and Los Angeles match the above description in terms of land uses, but they are attempting to increase the efficiencies of their current land uses to address some of these concerns. Ports often look to the US EPA and State programmes known as "brownfields", an approach that supports cleaning-up former industrial tracts of land that are both contaminated and abandoned. With very few large expanses of "greenfield" (uncontaminated) properties remaining in the near vicinity of the two ports, the brownfield concept is not only practical but also can use existing infrastructure such as utilities and potential funds for pollution clean-up. One such project is located within the POLA at the Southwest Marine Terminal Island Facility.

The POLB was one of the earlier implementers of brownfield remediation. In 1994, the Port acquired 725 acres that had been used for oil and gas production and disposing of contaminating materials. The contaminated area was remediated on-site by the Port. Contaminated soils were safely removed and used to create a 30-acre landfill. The port has a goal to remove, treat and render suitable for beneficial reuse other contaminated soils and sediments in the harbour. A major effort is underway to remove contaminated sediments from the West Basin and reuse acceptable material as structural material underneath the new Pier T terminal.

The POLB has developed a comprehensive land use plan that considers the need for commerce and recreation, consolidation of liquid bulk storage facilities, and includes an academic and government marine research lab.

Perhaps the most significant programme that affects expansion and modification of ports in the United States is the *National Environmental Policy Act* (NEPA) and, in California, its somewhat more restrictive counterpart, the *California Environmental Quality Act* (CEQA). NEPA applies to projects in which federal funding, permitting, or on-going oversight is involved. Because of these two important laws, the lead agency, usually a port or city, must prepare either an Environmental Impact Report (EIR) under CEQA, or a combined Environmental Impact Statement (EIS) under NEPA and an EIR before undertaking any significant project. The EIS/EIR must disclose all environmental impacts to decision makers and under CEQA, the lead agency must mitigate any impacts that are negative and significant.

The POLB has a highly regarded and detailed Environmental Protocol that provides guidance to agencies and consultants in preparing an EIR.[3] Some of the land use-related factors considered in an EIS/EIR are: areas of influence; significance criteria or thresholds; mitigation measures; cumulative impacts; and post-mitigation tracking. Although Greenhouse Gas emission (GHG) reductions are not currently addressed in detail in the Protocol, new guidelines and threshold levels from the State will certainly apply to future project reviews.

The requirement to mitigate significant impacts has increased the attention the ports pay to adjacent communities. In some circumstances, the lead agency has the option of reducing impacts (air quality/water quality) at a location offsite from the proposed project. This may be more cost-effective than expensive changes onsite and yet can provide equal or greater protection of the environment.

As noted above, in 2006, with assistance from the South Coast AQMD, the California Air Resources Board (CARB), and the US EPA, the two ports adopted a very comprehensive plan (CAAP) to improve air quality in both the port area as well as the rest of the South Coast Air Basin.[4] While the CAAP is essentially an air pollution reduction strategy, the CAAP can also affect land use and transportation issues. For example, manufacturing sources currently located in the port region will need to add additional pollution controls. Some sources may either not be able to afford the changes or decide to relocate to other areas of the air basin. The composition of the truck and rail transportation system may be altered by the CAAP, as considerable funds are provided to clean-up or reduce diesel-powered equipment or vehicles. Finally, state bond money for transportation projects may accelerate an improvement of the traffic system of the region.

The expansion of the two ports during the past thirty years has undoubtedly induced growth of industry, business and residential areas in the immediate vicinity of the ports, as well as the rest of the Los Angeles basin and the hinterlands. There are both positive and negative impacts from this growth. Traffic on various highways exiting the port region has become more congested despite infrastructure improvements. This is especially true on Interstate Highways 405, 110, and 710. Increased truck and rail traffic in the streets of the adjacent communities of Wilmington, San Pedro and Long Beach has been detrimental to the fabric of those locales. On the positive side, the economy of the South Bay has been stimulated by the rapid expansion of the ports. Terminal improvements have removed obstacles to domestic and international trade and thus provided economic expansion in the basin. Environmental documents (EIS/EIR) on port expansion projects must consider their growth inducement impacts.

Various State agencies have adopted, or are in the process of developing, programmes that will support the Scoping Plan and the SB 375 process in relation to greenhouse gas emissions. These include new, State CEQA guidelines for global warming at the programme and project level; the California Transportation Commission's January 2008 guidelines for addressing climate change requirements in Regional Transportation Plans (RTP); and the Attorney General's guidance to ensure regional planners and local governments address climate change in their plans and decisions. These various programmes will have major impacts on future development of the ports and their ability to meet environmental requirements.

California's climate change legislation (AB 32) asks local governments, such as the Cities of Long Beach and Los Angeles, to play a key, partnership role in implementing the Scoping Plan. Land use planning and urban growth decisions will have very large impacts on future GHG emissions, particularly in the years after 2020. The Air Resources Board will soon assign each region of the state GHG emission reductions targets for the transportation sector. SB 375, a *sequel* to AB 32, provides guidance on how local governments can meet the Air Resources Board's targets. The guidance focuses on reducing emissions from autos and light-duty trucks and is therefore a complement to the measures in the Scoping Plan that address trucks, rail and ships.

Finally, the SCAG Compass Blueprint has many provisions that are directly related to future port development. "Blueprints" are broad-scale regional development plans that have or are being developed for most of the urban regions of California. The SCAG blueprint's current emphasis is the *Two Percent Strategy*, which focuses on the priority 2% of the region's land area. The ports are included in the Two Percent Opportunity Areas with the POLA in the Los Angeles City South area and the POLB in the Gateway Cities area.

Rotterdam

As space for growth is limited in the Rotterdam area, and as the PoRA wants to minimise the impact of developments on the surroundings, they focus on their land use. Therefore, in existing port areas, they actively stimulate efficient use of the scarce space. The PoRA managed to intensify the land use in the port due to the re-development of 200 hectares that had come into disuse in the period up to 2008 (PoR, 2009a). As an example, PoRA reclaims land in port basins no longer being used. Another method they used to intensify business on existing land is by reducing the size of the land reserves owned by companies for future growth purposes. The PoRA also redevelops old port areas to meet the current standards. By redeveloping areas, PoRA limits the need for additional land (PoR, 2009a).

Another way in which the PoRA states it has kept its expansion to a minimum is by choosing a compact design for the *Maasvlakte 2,* given the projected activities in the area (PoR, 2009a).

Vancouver

Port Metro Vancouver has a comprehensive land management programme. Leases have provisions for baseline and exit surveys and, where appropriate, periodic surveys during tenancy. Tenants are required to remediate contamination they are responsible for before lease termination (and during tenancies, if appropriate, if contamination is discovered). Soil, sediment and groundwater contamination potential is considered in project assessments, and surveys and mitigation are required as appropriate during project

implementation. Port Metro Vancouver has an ongoing assessment programme for untenanted lands, and conducts appropriate due diligence surveys during land acquisition. These issues are well described on the port's website, which includes guidance documents available to prospective tenants and the public.

There has been concern expressed about the landside infrastructure developments that will be necessary to support increased rail and truck container traffic for Port Metro Vancouver. In Metro Vancouver, the planned developments are encompassed within the *Gateway Program* and include development of several rail overpasses and, more contentiously, an additional highway corridor. These developments introduce concerns for environmental issues such as noise, dust and land use conservation. Recognising these concerns, the federal Government of Canada and the province of British Columbia have been working with various public and private stakeholders on the *North Shore Trade Area* study, which was completed in the fall of 2008. The findings of this study were used as the basis for the development of an implementation plan that includes a package of transportation infrastructure projects along Burrard Inlet on the North Shore. These projects will enhance rail and port operations, accommodate anticipated growth in rail and road traffic while providing local quality of life and environmental benefits, including reduced congestion on the local road network and reduced noise pollution, such as train whistles at road/rail crossings and rail shunting.

Busan

Together with the development plan for the Busan New Port, the Korea Government and Busan Port Authority (BPA) established the Plan for Redevelopment of Coastal Ferry Terminal, International Passenger Terminal, and Piers No. l, 2, 3 and 4 of the Busan North Port. These berths are situated at the very downtown of Busan City, where there is no space for public access to the water front. Especially, Piers No. 1, 2, 3 and 4 are berths for general cargoes which cause heavy traffic jams and air pollution. Therefore, BPA decided to develop general cargo berths at other areas, such as the Gamcheon Harbour, which is in the south of Busan City.

The Korean Government and BPA will redevelop the area as a heart place of international marine tourism and creating a waterfront for Busan citizens. The area of the Redevelopment Plan of the Busan North Port is about 1 525 000 m^2 and the project period is 2008-15. A total of USD 8.5 billion will be invested, of which USD 2.4 billion in infrastructure and USD 6.5 billion in superstructure.

6.2. Hinterland distribution and feeder traffic

The environmental impact of hinterland distribution of goods is affected by the efficiency of the transport chain, the choice of mode and the standard of the fuels and vehicles used. Generally, transportation by rail, in-land waterways and short-sea shipping require less energy per tonne transported than transport by road and cause fewer emissions of greenhouse gases. However, where emissions of NO_x, SO_x and PM_{10} (or $PM_{2.5}$) are concerned, the choice of fuel and exhaust-treatment systems may be more important.

Measures addressing hinterland distribution and feeder traffic – in general

There are, as a response to climate change, some signs of ports trying to make clients contribute to a modal shift away from road transport. The port of Gothenburg has over the last decade years worked systematically with freight customers to increase the share of

containers transported by train. As a result, the volume carried on rail from the port to different destinations in Sweden and Norway has more than tripled. In 2007, 38% of the container goods arrived by rail shuttles connecting the port to 22 towns in the hinterland.

The Port of Antwerp is trying to raise the proportion of freight carried by rail. Two important elements in this strategy are reactivating the "*Iron Rhine*" and construction of a rail tunnel.

A problem in the context of short-sea shipping and hinterland distribution by barges is that there is a strong tendency in the port industry to lease or sell terminals to large companies that, for commercial reasons, give priority to large capacity users. This translates to delays in berthing for smaller vessels that may have to wait for hours. According to Comtois and Slack (2007), this is particularly problematic for container feeder services.

To promote the use of short-sea shipping, the Port Authority of Antwerp has modified the port dues so that they no longer form a significant part of the total transport cost, with discounts for regular short-sea services. The proportion of freight carried by barge in the Port of Antwerp is growing rapidly, with container freight in the lead. Nearly one third of the container volume passing through Antwerp now travels by barge.

Measures addressing hinterland distribution and feeder traffic – case study examples

Los Angeles and Long Beach

The landside transportation links from the two ports can have a major impact on the adjacent communities, depending on whether they quickly carry freight through the area or cause serious congestion to local streets and highways. The San Pedro Bay ports are attempting to accommodate the increased activity through developing a transportation infrastructure to minimise impacts on those communities while accommodating the increased demands. While ideally the incoming freight on ships could be trans-loaded onto rail or trucks for specific destinations, the reality is that there is very limited space at the ports for large trans-loading operations and goods must be loaded onto drayage trucks, with their consequent environmental impacts. Several recent studies commissioned by the ports provide some insight on dealing with this problem.

San Pedro Bay rail study. To assist the ports in finding ways to increase and enhance the rail proportion of transport, an update of earlier rail studies was completed in December 2006.[5] This study was also a complement to the earlier described CAAP. The ports engage in three types of rail loading: 1) on-dock rail yards that load cargo onto trains in the marine terminal, thus eliminating any truck trips on local roadways, 2) near-dock rail yards that are within five miles of the terminal and can serve both ports, and 3) off-dock rail yards, usually located 25-50 miles from the terminal, such as in downtown Los Angeles.

The study found that any cargo that is moved by train from the port benefits the overall transportation system by reducing the truck trips, total truck mileage, and their associated impacts. It further found that each on-dock, a double-stack, *through* train could eliminate 750 truck trips and can be at least twice as fuel-efficient and clean as trucks on a ton per mile basis. The report found that where docks have limited space, on-dock rail service can interfere with other terminal traffic flows and reduce overall terminal efficiency. Nevertheless, they are considered the preferable option from an environmental

perspective and the ports are pursuing on-dock rail as a high priority. The goal is to increase the percentage of container cargo handled by on-dock rail from 24% in 2006 to 30% by 2030.

Near-dock has the advantage of combining cargo from various terminals and building trains that can go anywhere in the nation with that cargo. However, there is only one near-dock facility serving the ports – the Intermodal Container Transfer Facility which handles eight per cent of the ports' cargo.

As on-dock capacity increased, the off-dock share of the ports throughput has declined to less than 11%. Current off-dock rail yards are located in downtown Los Angeles, and are operated by Union Pacific (UP) and by Burlington Northern-Santa Fe (BNSF). Moving cargo by truck to these off-dock facilities results in additional congestion on the region's roadways.

To accommodate future growth of the ports, two new, on-dock rail and two near-dock rail facilities are planned. The Rail Study Update also examined several non-traditional rail concepts. One option was an *inland* shuttle train, which would serve as an inland port for use to distribute local cargo. The second option was an inland rail yard to sort trains. This concept would allow creating multi-destination trains by block at the on-dock rail yard, then block-swap (the organisation of trains headed to the ports into terminal specific trains) at the inland yard to create single destination trains. Similarly, in-bound trains to the ports could be sorted out at these inland rail yards.

Regional transportation plans and goods movement policy. The Southern California Association of Governments (SCAG) has overall regional and transport planning responsibility for most of Southern California. Major planning programmes affecting transport near ports are the 2005 Goods Movement Policy Paper, the 2008 Regional Transportation Plan (RTP) and the 2004 Compass Blueprint process. While most of their programmes are advisory to the local cities, they can be a major player in transport funding and land use decisions.

The 2008 RTP contains a major supplement document on Goods Movement and a sub-section in that document on Maritime Activity.[6] This report is a source of cargo forecasts, future on-dock rail plans and rail network capacity forecasts. Truck-related activities are also included. The share of California's containerized cargo handled by the two ports is expected to remain essentially the same through 2030 – slightly less than 87%. Total cargo (general, liquid bulk and dry bulk) is expected to be roughly equal between the two ports – 52% at POLA and 48% at POLB. Freight rail, as well as passenger rail, is projected in the RTP to see major increases over the next 30 years due to rapid expansion of the ports and greater use of passenger commuter rails in the basin. In 2000, a key crossover point 65 miles northeast of the ports handled 121 freight trains daily. This traffic is projected to climb to 266 freight trains per day in 2025, a situation that will result in severe congestion on the crossover, as well as on a mountain pass leading to the desert and points east.

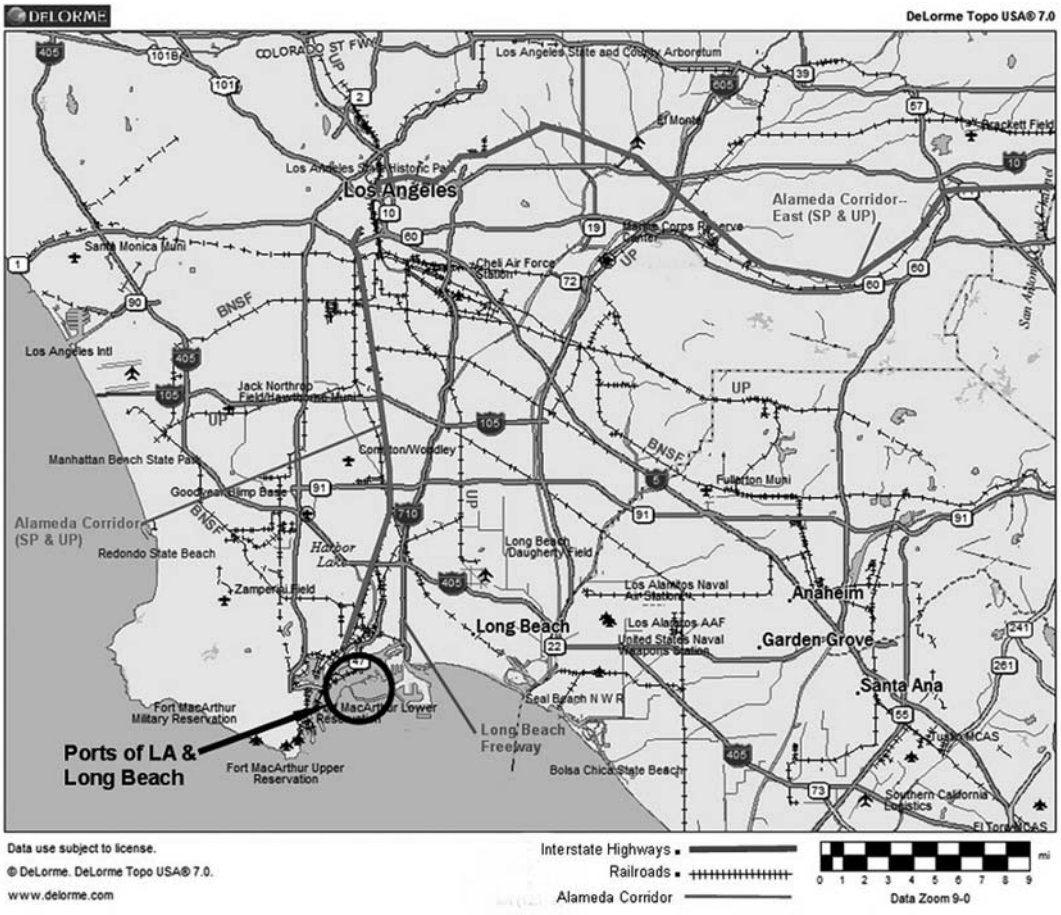
The ports' projected growth overwhelms the ability of on-dock rail capacity enhancements to provide relief. After completing all planned on-dock enhancements at the two ports (more than a five-fold increase between 2005 and 2030), the ports will still have 2.2 million TEUs that could be moved by on-dock rail if it was available. This will necessitate development of additional near-dock or off-dock intermodal yards in the region.

The SCAG Goods Movement report discussed the impacts of port-related trucking in some detail. The largest truck traffic appears to be between the marine terminals and intermodal yards further into the basin. However, the vast scattering of manufacturing facilities throughout the basin generates secondary truck trips that affect the many freight corridors of the region. There is also a significant amount of truck movement to return the empty containers from the off-dock, intermodal yards to the port terminals. The RTP examined the two major corridors that carry the largest concentration of port truck traffic volumes in the basin – Interstate 710 (Long Beach Freeway) and State Highway 60 (Pomona Freeway). With its proximity to the ports, I-710 carries a great amount of the truck traffic. Over 17% of all vehicles in freeway segments closest to the port are trucks, and 94% of those trucks are port trucks. The total heavy-duty truck traffic along I-710 is projected to double by 2025, accounting for over 35% of all vehicles travelling the high-volume portions of I-710. State Highway 60, which is located much farther from the ports, had a truck volume 8.8% of all vehicles in 2003 and port trucks comprised only 6.7% of the total truck volume. With the projected increases in truck volume, especially on I-710, the development of dedicated truck lanes, perhaps limited to clean technology trucks, is earning serious consideration.

Alameda and Alameda-East corridors. The model programme for reducing rail transport congestion in Southern California was the creation of the Alameda Corridor. The project addressed the extreme congestion that developed along the twenty-mile corridor between the ports and downtown Los Angeles. SCAG initiated the project with the creation in 1981 of a Ports Advisory Committee (PAC) to examine both highway and rail access to and from the ports. Phase one, which dealt with highway/truck access, recommended a cost-effective set of highway improvements, such as street widening and freeway enhancements. Phase two, the rail access study, was completed in 1984 and focused on the impact of train traffic on the various cities between the ports and downtown Los Angeles. After reviewing several routing alternatives, the PAC recommended consolidating all trains onto an up-graded right of way. SCAG created an Alameda Corridor Task Force that developed plans for a consolidated, below ground-level rail corridor and created in 1989 the Alameda Corridor Transportation Authority (ACTA).[7] The Alameda Corridor opened in April 2002, *cf.* Figure 6.1. Total cost of this facility was USD 2.4 billion, with nearly half of that sum from revenue bonds, see Agarwal, Giuliano and Redfearn (2004). The railroads agreed to pay a container-based user fee for access to the Alameda Corridor, which is being used to retire the revenue bonds. The ACTA clearly stated that "the Alameda Corridor project was intended to consolidate train traffic and eliminate at-grade conflicts, which it did successfully. It never was aimed at removing the truck traffic from the freeways".

The project is notable for its *Mid-Corridor Trench*, a below ground, triple-tracked rail line that is 10 miles long, 33 feet deep and 50 feet wide. The Alameda Corridor allows trains to bypass 90 miles of early 20th century branch rail lines and avoiding more than 200 at-grade railroad crossings where cars and trucks previously had to wait for long freight trains to pass slowly. An important use of the corridor is to take cargo containers to and from the ports. The corridor has a maximum speed of 40 miles per hour, has reduced air pollution from idling cars and trucks by 54%, and cut travel time to 45 minutes from two hours between the ports and downtown Los Angeles. A study was performed in 2005 to analyse the air pollution impact of the Alameda Corridor.[8] Cumulative NO_x and PM_{10} emission reductions from improved rail efficiency in 2002-04 were estimated to 732 and 28 metric tonnes per year, respectively. Likewise, cumulative emission reduction benefits from traffic

Figure 6.1. **Major ports-related transportation facilities in the Los Angeles Basin**



delay elimination from NO_x and PM from 2002 to 2004 were estimated to 330 and 16 metric tonnes per year, respectively.

However, Agarwal, Giuliano and Redfearn (2004) notes that the researchers "were unable to find any independent performance reviews or studies that pass any conclusive judgment on the Corridor's performance. It would be premature and overly simple to accept it as a complete success or to write it off as a complete failure. It may be partially both: a success of public-private partnership in financing and building an infrastructure mega-project and a failure of a mega-project in living up to the mega-expectations generated during its development (particularly regarding reduction in traffic congestion)."

The relative success of the Alameda Corridor, along with the need for similar congestion relief between the terminus of the corridor in downtown Los Angeles and important routing of those freight trains eastward toward the San Bernardino and Riverside counties and on to the hinterlands, has resulted in planning for the Alameda Corridor East, *cf.* Figure 6.1. A construction authority, known as the Alameda Corridor East (ACE) Construction Authority, is overseeing numerous safety upgrades and traffic signal control measures. The project is currently under construction and will grade separate many of the crossings along Union Pacific's main east-west lines through the San Gabriel Valley. Many of these crossings, which are currently at grade, tie up traffic on north-south

streets for long periods, multiple times a day, as the long freight trains pass on their way to and from the massive Union Pacific yards in the cities of Vernon and Commerce. Included as part of the Alameda Corridor East project is the half-billion dollar San Gabriel Trench, which will submerge the track through the cities of Alhambra and San Gabriel. The project will connect the ports to the transcontinental rail network and greatly improve distribution of cargo by 2020. Importantly, over 200 metric tonnes of air pollutants will be eliminated annually from the air basin.

Regional strategies to improve goods-movement from port activities. The 2008 RTP identifies several regional truck and rail strategies for addressing the growth in goods movement, especially from the POLB and POLA, over the next 25 years. Several are already underway or completed, but the vast majority will need additional analysis, policy support, and sources of funding to succeed. These strategies generally have a dual benefit – reducing both air pollutant emissions and relieving future congestion.

Truck Strategies: The majority of goods movement in the Los Angeles Metropolitan region is by on-road trucks. Trucks account for at least one trip segment in 75% of the port-related movements. Although trucks consist of only 15% of the total vehicles on the highways, they consume up to 40% of the total roadway capacity. Proposals include:

- Dedicating freeway lanes for clean technology trucks. Consideration is being given to I-710, I-15 (Cajon Pass) and an east-west corridor through the San Gabriel and Pomona valleys. A study of the I-710 freeway with a dedicated truck way indicated that it would return USD 4.66 for every dollar invested.[9] The benefits included less accidents, congestion, vehicle operating costs and air quality.
- Truck climbing lanes. Reduces congestion by allowing other vehicles to move at faster speeds and reduce lane weaving.
- Extend hours and have five additional off-peak shifts per week, thereby shifting 40% truck activities. The existing Pier Pass programme, which collects USD 20 per TEU from all importers or exporters, would be refunded in part to containers that leave/arrive at the terminal in these new off-peak hours. The off-peak shifts might occur on weekends during the day, or possibly after 5 pm on weekdays (which may have a noise impact on nearby residents).
- Create a "virtual container yard" which would be an internet-based matching service for empty containers. This would reduce the number of vehicle miles travelled associated with the movement of empty containers.

Rail Strategies: Additional operational enhancements for rail transport that could be considered include:

- more efficient and increased use of on-dock rail yards;
- shuttle train pilot project to transport containers currently being trucked to warehouses in San Bernardino and Riverside counties by a short-haul rail line to an inland rail yard and thus reduce truck transfer distances;
- additional rail-highway grade crossing separations;
- track and signal improvements throughout the harbour area;
- new intermodal rail yards;

- construct a High Speed Rail Transport system that would use a shared guide way with passenger trips, following the Alameda Corridor/I-710 corridor to Union Station in downtown Los Angeles, then east as freight-only to San Bernardino.[10]

Rotterdam

The Port of Rotterdam has a diverse range of hinterland connections. Products and goods can be distributed further into land by five different modalities (road, rail, inland shipping, short seas shipping and pipeline).

Traditionally, the different types of goods have been transported by specific modalities. For example, dry bulk products, such as ore and coal, have commonly been transported with barges. From an accessibility and air quality point of view, the PoRA wants to increase the share of inland shipping. As the port is expected to grow, additional pressure will be put on the existing hinterland connections. To maintain accessibility levels, the PoRA deems a modal shift as needed.

In the modal split of container transport in 2007, road transport accounted for almost half (49%) of the hinterland distribution (PoR, 2009a). Inland shipping held the second place with a share of 37%, to be followed by rail transport with a share of only 14%, see Figure 6.2.

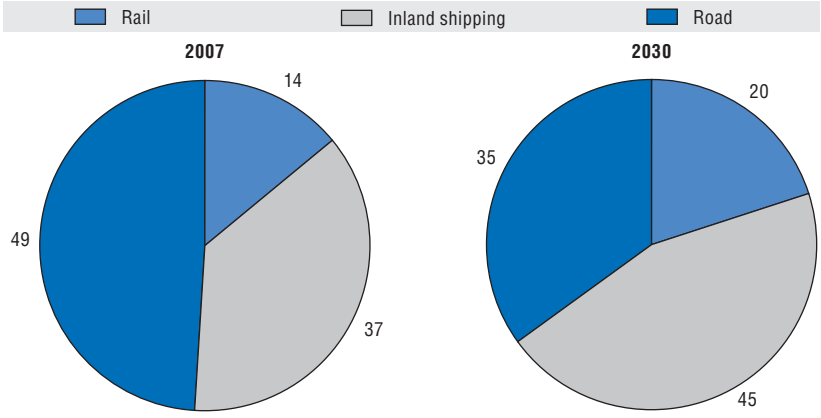
To reduce the levels of congestion of the truck routes to and from the port, and to increase the energy efficiency of its operations, the PoRA set the goal to ship more goods over water and railways, and less by the road. For 2030, the objective is 35% by road, 45% by inland barges and 20% by rail (PoR, 2009a).

To be able to create such a big modal shift, the PoRA has made binding agreements with container terminals at *Maasvlakte* 2. The container terminals are bound to the modal split presented above in the contracts between the PoRA and the container terminals.

The PoRA does not only try to guide the modal split in the *Maasvlakte* 2 area; it also tries to create a modal shift in the existing port areas. However, their influence here is limited. One can, for example, not expect a modal shift from road to rail or inland shipping if there is no access to these modes.

Figure 6.2. **Modal split in 2007 and the Port of Rotterdam's goal for 2030**

Based on the number of containers, percentage



Next to these activities to secure a modal shift trough the contractual terms, the PoRA is promoting the use of inland shipping as it (PoRA, 2009a):

- Creates more loading capacity for inland barges.
- Limited the increase of port dues for inland barges (1% in 2008 and 2009).
- Optimises the service to inland barges (wait times, safety improvement).

The situation of rail transport has also been improved with the completion of the *Betuweroute* rail line in 2007. With the creation of this railway, a dedicated link for electric rail cargo transport between the *Maasvlakte* and the Ruhr area in Germany has been created. The port rail link will be equipped with modern technologies so that the connection with the *Betuweroute* is optimal (PoR, 2009a). To increase the share of rail in the modal split, more rail infrastructure will be created in the next decade.

Other activities to prevent congestion focus on traffic management. In order to guarantee the accessibility and a good traffic flow on the roads in the vicinity of the port, the PoRA, in collaboration with "Rijkswaterstaat" (Ministry of Transport), the Municipality, and the city region, created the "*Verkeersonderneming*" (PoR, 2009a). This organisation tries to reduce the traffic flow on the A15 motorway during rush hours by 20% by guiding the supply and demand of traffic on the A15.

To achieve this reduction in traffic, a variety of actions are taken, from traffic management initiatives to more behavioural oriented initiatives (PoR, 2009a):

- (Dynamic) traffic management.
- Avoiding rush hours (Road users are financially compensated for not using this particular highway during rush hours).
- Collective company transport.

The PoRA is also investigating the idea to enhance the flow of goods by the creation of a container terminal downstream in the Drechtsteden region, with a capacity of 200 000 TEU. A letter of commitment has been signed with twelve important partners in the container logistics (PoR, 2009a).

Vancouver

The Port Metro Vancouver is an important player in the development of the Pacific Gateway. The Pacific Gateway[11] is a multimodal network of transportation infrastructure in Western Canada, focused on trade with Asia. The federal and provincial governments are collaborating with ports and other service providers to improve the Pacific Gateway's system performance, efficiency and reliability. Through the Asia-Pacific Gateway and Corridor Initiative, the federal government has partnered with the private sector to invest in transportation infrastructure and technology, which will relieve traffic congestion and reduce air emissions. Recent initiatives by Port Metro Vancouver include:

- Sustainability – Port Metro Vancouver emissions reduction programmes have received international acclaim, having been awarded the Globe 2010 ecoFreight Award for Sustainable Transportation. The Port has also been credited for its Air Action Program, having been nominated for the International Sustainable Shipping Award. The Port has also improved incentives for cleaner ships to call at the port, and together with government and industry, brought shore power to Canada Place, making 2010 the first eco-friendly cruise season.

- Collaboration – Port Metro Vancouver's first Collaboration Agreement with CN has been a catalyst to CN's recent announcement of service agreements with terminal operators, with CP also entering into similar agreements. These agreements are important steps toward more reliable and efficient service.
- Capacity – Through the *Gateway Infrastructure Program*, in partnership with the Government of Canada, Municipal governments, First Nations, business and stakeholders, Port Metro Vancouver commissioned the Deltaport Third Berth project and commenced construction of the Lynn Creek/Brooksbank Rail Underpass project.

Short sea shipping and inland waterway projects in B.C. Short sea shipping and the improved use of inland waterways could make moving international trade through Canada's Asia-Pacific Gateway more efficient and improves air quality, reduce traffic congestion and noise pollution generated by trucking and rail. In 2008, the federal government announced five regional short sea shipping/inland waterway projects, including the Fraser River Shuttle, Mountain View Apex Container Terminal, Deltaport Shortsea Berth, Southern Railway of B.C. Barge Ramp and Vanterm Shortsea Berth. The Southern Railway of B.C. Barge Ramp project was implemented and became fully operational in January 2010.

These projects would establish a network of complementary short sea shipping services (including the use of inland waterways) in the Lower Mainland that will contribute to the integrated and efficient movement of international trade. These services will help reduce road congestion between river terminals and deep-sea terminals, increase throughput capacity at marine terminals, develop new transportation options, and increase overall system capacity for trade between Asia and North America.

Traffic management centre and smart corridors strategy. The Traffic Management Centre, based in the Lower Mainland of B.C., is an example of how the Pacific Gateway is advancing Intelligent Transportation Systems to improve traffic flows, reduce emissions and improve quality of life in communities through which increasing trade volumes move.

Trucking. Trucks, entering port facilities, must comply with the Port Metro Vancouver's Truck Licensing System (TLS), which aims to phase out older, higher-polluting truck engines and includes environmental requirements that are designed to help reduce port-related trucking contributions to both air quality and climate change.

Other Canadian programmes are also supporting the reduction of air emissions from trucking. For example, Green Fleets BC, an independent, non-profits programme, helps fleets in British Columbia to become more efficient and reduce environmental impact from trucking. SmartDriver, a federal government programme offered by Natural Resources Canada, is aimed at commercial fleets to improve fuel efficiency and reduce greenhouse gas emissions.

Rail. Port Metro Vancouver offers extensive scheduled rail service, with 3 Class I rail companies using on-dock rail facilities at the port's container and cargo terminals. Loading and unloading on-dock reduces cargo transit time, as well as additional trucking traffic.

Canadian Pacific Railway offers clean, efficient and reliable rail service of the port's cargo. Installing anti-idling devices in over 80% of its locomotive fleet has reduced

emissions generated by rail operations, where stop/start fuel-saving devices have reduced fuel consumption by 40 million litres a year.

Canadian National Railways, serving the intermodal terminal at Port Metro Vancouver, invested significant capital to acquire more than 100 new fuel-efficient, high-horsepower locomotives in 2007 and 2008. The new units produce 40% less nitrogen oxides and are at least 15 to 20% more fuel-efficient than the locomotives being replaced.

Through the *Asia-Pacific Gatewayand Corridor Initiative*, improvements will be made to the Roberts Bank Rail Corridor, where a road/rail grade separation projects will be done along the 70-km rail network. The project will contribute to more efficient road and rail operations and enhance the quality of life for residents along the rail corridor.

Provincial programmes and initiatives. In the regional district of Metro Vancouver, there has been considerable public attention applied to commercial marine emissions of both GHGs and CACs during the last several years. This is due to two main reasons, both of which are associated with the well-publicised expectation that the port will greatly increase its level of container handling during the next decade: aggregate emissions from ships are expected to increase both at the port and offshore, and large-scale infrastructure projects will be required to facilitate the additional land-based traffic (rail, trucking). To address these concerns, the region and Port Metro Vancouver actively support a number of regional programmes and initiatives addressing emissions from transportation sector. These initiatives are described in Chapters 3 and 4.

Busan

As described above, the present Busan North Port is in a residential area and the many containers are carried to off-dock-container yards in the downtown, which creates heavy traffic jams, air pollution and noise. However, the Busan New Port is designed to carry container cargoes by dedicated railways and roads which are in the suburb of Busan City, so there will be no traffic jams, air pollution or noise.

The “Hinterland Road 1”, with a length of 23 km between the Busan New Port and the Chojeong interchange, which connects to the Seoul-Busan Expressway and the Namhae Expressway, was completed in 2009. The “Hinterland Road 2” with length of 17 km between the Busan New Port and the Jillye interchange, which also connects to the Seoul-Busan Expressway and the Namhae Expressway, will be completed in 2011. The “Hinterland Railway”, with length of 39 km between the Busan New Port and the Samrangjin, which connects to the Seoul-Busan Expressway, will be completed in 2011. All the three hinterland roads start from the Busan New Port, run through non-residential areas, and connect to the Seoul-Busan Expressway and the Namhae Expressway.

The “Port Hinterland Road”, with length of 25 km between the Busan New Port and the Busan North Port, will be completed in 2011. The “Port Hinterland Road” runs through the South Port Bridge (already completed) and the North Port Bridge (will be completed in 2011), before arriving at the Busan North Port, and runs through the Gwangan-Daero Bridge after the Busan North Port and connects to the Seoul-Busan Expressway. The “Port Hinterland Road” is designed to run outside of the Busan City by construction bridges over the seas to avoid traffic jams and air pollution.

Notes

1. European Commission, *Port Policy Consultation 2006-07*.
2. *www.espo.be/downloads/archive/d4fd1c39-99dc-478a-a307-4bee791fc8ae.pdf*.
3. The POLA also has a refined and detailed environmental review process.
4. *www.portoflosangeles.org/environment/caap.asp*.
5. *www.portoflosangeles.org/DOC/REPORT_SPB_Rail_Study_ES.pdf*.
6. *www.scag.ca.gov/rtp2008/pdfs/finalrtp/reports/fGoods_Movement.pdf*.
7. *www.acta.org*.
8. Alameda Corridor Air Quality Benefits, Final Report, Weston Solutions, Inc., 10 June 2005.
9. *Southern California Regional Goods Management Policy Paper*, SCAG, February 2005, page 5.
10. Final 2008 Regional Transportation Plan: Making the Connections, SCAG, *www.scag.ca.gov/rtp2008/pds/finalrtp/f2008RTP_Complete.pdf*.
11. *www.pacificgateway.gc.ca/index2.html*.

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Chapter 7

Other Port-related Environmental Issues

This chapter addresses a few other port-related environmental issues, such as systems for environmental permits, port-induced incentives to clean shipping, the use of port-state authority to promote higher environmental standards, and unilateral environmental demands on voluntary port calls. The chapter covers measures applied by the port authorities themselves, and measures taken by national, provisional or local political authorities.

7.1. Environmental management and environment permits

Environmental assessment, environmental management systems and certifications are ways of making the environmental work more systematic and to promote improvement.

Environmental management and environment permits – in general

Several ports have had their operations certified according to ISO 14001 developed by the International Standards Organisation (ISO) or to the Eco-Management and Audit Scheme (EMAS), created in 1993 by the European Union. There are in addition some simplified systems or tools that have been developed for the shipping and port industry. Some ports have developed systems of their own. However, according to the survey by Comtois and Slack (2007), only 11% (85) of 800 ports had an environmental management system (of any sort) in operation.

However, in a 2009 review of environmental management, policies and plans in European ports,[1] the European Sea Ports Organisation (ESPO) *i.a.* found that of the ports:

- 72 % had an environmental policy;
- 62% make it available to the public;
- 58% aim through their policy to improve environmental standards beyond those required under legislation;
- 69% provide environmental information through their website;
- 43% produce a publicly available Annual Environmental Review or Report;
- 69% have their own environmental specialist(s);
- 48% have a form of Environmental Management System;
- 77% carry out monitoring within the port area;
- 60% have identified environmental indicators;
- 36% publish factual data by which the public can assess the trend of its environmental performance;
- 33% measure or estimate their carbon footprint;
- 51% take measures to reduce their carbon footprint;
- 57% have a programme to increase energy efficiency;
- 20% produce some form of renewable energy.

The International Association of Ports and Harbors (IAPH) has compiled best practices and experiences gained by member ports into the *Guidelines for Port Planning and Design* (2nd edition, 2001) and also developed the *Tool Box for Port Clean Air Programs*.

In 2003, ESPO adopted its *Environmental Code of Practice*.[2] It reiterates the port sector's collective commitment to contributing to sustainable development in its three dimensions

– social, economic and environmental – and demonstrates how the port sector is improving its environmental performance.

The EcoPorts Foundation is a network established in 1999 by European ports for the benefit of ports and port communities.[3] It has developed several tools:

1. The *Self Diagnosis Methodology* (SDM) is an environmental self-audit.[4] It can be used to establish the position and status of a port's environmental management programme for the initial development and implementation of an Environmental Management System (in a non-prescriptive way), and/or as a periodic auditing tool to establish performance over time, either against the port's own baseline or in relation to European benchmarks.
2. The *Port Environmental Review System* (PERS) has been developed specifically for ports.[5] PERS defines a standard of good practice for reviewing and reporting significant aspects of a port's environmental management. It may be considered as a first step in a phased programme to implement an Environmental Management System. PERS includes the option of a voluntary application for a Certificate of Verification by an independent auditor. So far 33 ports have been certified, 19 of them in the United Kingdom.
3. An *Environmental Management System*. This is a standard environmental management scheme which can be applied in port communities all around Europe. The main focus is on environmental relationships within the port community, *i.e.* the port authority, the industrial facilities located within the port area and companies exploiting the port's terminals. It also consists of an integrated environmental port area management module, bringing together those information streams that can help to strengthen the effects of environmental management on both port administrations and operators. It can also be of assistance in environmental improvement programmes, notably by monitoring and measuring the results of these programmes by using standard environmental indicators.

Important in the context of the tools developed by the *EcoPorts Foundation* is that the port shall identify the significant environmental aspects of its activities, products and services, that it can control and over which it can be expected to have an influence (*e.g.* tenants, agencies, sub contractors, port users).

The American Association of Port Authorities (AAPA), with 150 members in North, Central and South America, has developed a guide for environmental management, the *Environmental Management Handbook* (EMH).[6] This guide offers information on:

- The environmental issues associated with port development.
- Practices and techniques of environmental management.
- Public relation programmes.
- The means to implement an EMS programme.

Hutchison Port Holdings Group, the world's leading port investor and operator, has adopted an environmental policy covering all aspects of port development and operations, and developed an environmental management system.

With the goal of integrating environmental considerations into the business, the Port of Portland's environmental programmes focus on executing the port's *Environmental Management System* (EMS). The EMS consists of ten programme areas, such as water resources and waste management, which seek to control the port's environmental aspects and impacts. Each programme includes a programme manager and team with detailed

goals and priorities, and in its five years of implementation, the port's EMS has enhanced local air quality, reduced hazardous waste generation and conserved water.

The Port of Sydney has created a set of *Green Port Guidelines* with the aim to encourage port developers, operators and tenants to adopt sustainable business strategies and to promote innovation in design and operation. The guidelines cover ten key areas.[7]

The *Sustainability Policy* authorised by the Port Authority of New York and New Jersey encourages tenants and patrons to conduct their business in a sustainable fashion.[8]

The Port of Brisbane regularly commission independent experts to report on various aspects of the environment in which it operates. These reports form the basis for informed decision-making and implementing environmental management.

The Port of Marseille has initiated the *Sustainable Development Advisory Committee* (CCDD), which is hierarchically independent of the port authority. The CCDD alone defines its strategy, implementation, operation and calendar, as part of its responsibilities.

Many countries require ports to acquire an exploitation permit when expanding or establishing new terminals. Sweden has gone a bit further by demanding all ports to acquire such permits for their pre-existing operations. To obtain a permit to continue operations, ports must complete a comprehensive environment impact assessment of all maritime activities related to the port and to identify the measures by which they intend to improve environmental performance.

Since 1999, every port area in Flanders has to draw up a *Strategic Plan* and a *Land Use Plan* that guarantee maximum protection of the surrounding residential areas, build up the "ecological infrastructure" inside and outside the port area, and make efficient use of space. This means that economic expansion of the ports can no longer be interpreted as taking up additional space at the cost of agricultural land, natural areas or existing residential areas.

Environmental management and environment permits – case study examples

Los Angeles and Long Beach

To reduce the port's impact on the environment, the Port of Long Beach developed the *Green Port Policy*. The policy consists of five principles for port environmental protection efforts, including protecting the local environment from harmful port impacts and employing technology to minimize them. Implementation of the *Green Port Policy* has achieved significant environmental benefits, such as the *Vessel Speed Reduction Program*, which reduces emissions from ocean-going vessel main engines, and the *General Soil Cleanup Program* that ensures contaminated soils are safely handled and are re-used or disposed of in an environmentally responsible manner.

Rotterdam

The case study does not mention any particular measures in this regard.

Vancouver

Port Metro Vancouver is committed to conducting operations in a responsible and sustainable manner that safeguards and promotes continual protection of the environment. In line with this commitment, Port Metro Vancouver is currently documenting and upgrading its Environmental Management System.

The *Canada Port Authorities Environmental Assessment Regulations*, promulgated pursuant to the *Canadian Environmental Assessment Act* (CEAA), establish a process that allows Canadian port authorities to carefully consider proposed projects in order to ensure that they do not cause significant adverse environmental effects, taking into account activities undertaken during the construction, modification, operation, decommissioning and abandonment of the project, and recommending appropriate mitigation measures.

Furthermore, the Port Authorities Operations Regulations under the *Canada Marine Act, 2001* prohibit anyone from doing anything that will or is likely to, amongst other things, adversely affect air, land or water quality unless otherwise authorized by the port. In accordance with environmental legislation, the port may conduct environmental assessments for proposed projects. Port Metro Vancouver works closely with regulators (Environment Canada, Ministry of Environment, etc.) as appropriate in conducting such assessments.

Port Metro Vancouver is, for example, managing noise, dust and visibility in connection with construction and expansion/ maintenance projects, often as criteria expressed in project permits.

Busan

The case study does not mention any particular measures in this regard.

7.2. Port-induced incentives to clean shipping

A few ports in different parts of the world have developed incentive schemes in order to make customers contribute to a good environment.

Measures promoting clean shipping – in general

The environmental differentiation of port dues in Swedish and some Finnish ports mentioned above is one way of promoting cleaner shipping.

The *Green Award Foundation*[9] is a pioneer in the field of promoting a maritime, environmental and safety-conscious culture, and has been the inspiration for later similar initiatives, including the *Qualship 21* initiative of the United States Coast Guard.

The *Qualship 21* Initiative (Quality Shipping for the 21st century) came into effect in January 2001 and was introduced by the US Coast Guard to eliminate substandard shipping by providing incentives to encourage quality shipping. Before the introduction of *Qualship 21*, vessels were examined no less than once each year, regardless of their performance. This provided no incentives for the well-run quality ship. Therefore the US Coast Guard implemented an initiative to identify high-quality ships of all flags and provide incentives to encourage quality operations. A quality vessel is associated with a well-run company, is classed by an organisation with a quality track record, registered with a flag state with a superior Port State Control record, and has an outstanding Port State Control history in US waters. Approximately 10% of the non-US-flagged vessels that call in the USA qualify for this initiative. Incentives for quality vessels include a *Qualship 21* certificate, and vessel names are posted on the US Port State Control website. With a *Qualship 21* certificate, a quality freight ship will be subject to fewer Port State Control inspections for a period of two years.

Measures promoting clean shipping – case study examples

Los Angeles and Long Beach

The *Green Flag* programme run by the Port of Long Beach rewards ships and vessels operators for voluntarily slowing ship speeds in the harbour to reduce air pollution. This programme provides reduced docking fees to vessels that comply with a voluntary speed limit of 12 knots in Southern California waters.

Rotterdam

In 1994, in collaboration with the Port of Rotterdam, the *Green Award Foundation* launched the *Green Award* programme, which is designed as an incentive to large vessels to improve safety and environmental protection. Crude oil tankers, product tankers and bulk carriers with a minimum deadweight of 20 000 tonnes may apply for inspection and certification. Worldwide, about 1 500 tankers and 1 500 bulk carriers are operational in the categories for which the *Green Award* in principle is available. Today, more than 30 ports in eight different countries offer reduced port dues for tankers and bulk carriers that carry a *Green Award Certificate*. Most of them offer discounts of 5 or 6% on port dues. Around 200 ships have been certified. Most of these vessels are larger than 50 000 DWT and not used in short-sea shipping.

The certification procedure consists of audits of crew and management procedures and technical provisions. The emphasis is on safe and environmentally friendly management and crew competence. A certificate is valid for three years. In addition, the ship-owner must demonstrate environmental and safety awareness in a number of areas affecting management and crew competence, as well as technical provisions. They include manning, maintenance systems, tank and hull arrangements, oil leakage prevention, vapour emission control, accidental oil pollution prevention, spill collection, bilge water treatment, waste disposal, tank cleaning and exhaust emissions. For each element, a certain minimum score must be obtained in order to be granted a *Green Award*, and a certain minimum total score for the entire ranking list must also be obtained. Criteria related to air emissions can contribute a maximum of 10% of the total number of ranking points available. Points are awarded for NO_x emissions of no more than 17 g per kWh, the use of low-sulphur fuel or alternatively SO_2 emissions below 6 g per kWh. The assessment procedure is carried out in absolute confidentiality, which means third parties are not offered any insight.[10]

Vancouver

Port Metro Vancouver operates an ecoAction programme, formerly known as the *Differentiated Harbour Dues Program*. The programme encourages environmentally sound ships operations by offering a differentiated hotelling fees schedule. Under this programme, harbour dues are differentiated according to three levels – gold, silver and bronze, as described in Section 5.6.3.

In 2010, Port Metro Vancouver instituted a recognition programme, called the Blue Circle Award, which is a financial incentive for shipping lines that reduce emissions of their ocean-going vessels. Under the EcoAction Program for Shipping, vessels that qualify will be eligible to receive the Blue Circle Award, a recognition reserved for only the highest emissions reduction achievements consistently attained. The Blue Circle Award recognizes participants in the EcoAction Program, based on efforts to reduce air emissions, depending

on the quality of fuel used and overall emission reductions. Vessel operators can apply for the program at each call or provide an annual declaration for their vessels.

Busan

The case study does not mention any particular measures in this regard.

7.3. Use of port-state authority

The growing use of port-state control reflects the wish of States to improve the protection of their waters and ecosystems. Port authorities have the right to inspect any ship for IMO compliance, so long as they voluntarily entered the port. A number of regional agreements have been made to make sure that States actively exercise their powers in this respect.

Examples of use of port-state authority – in general

The *Paris Memorandum of Understanding on Port State Control* (Paris MoU) consists of 27 participating maritime administrations and covers the waters of the European coastal States and the North Atlantic basin from North America to Europe. The aim is to eliminate the operation of sub-standard ships through a harmonized system of port State control. Annually over 20 000 inspections take place on board foreign ships in the Paris MoU ports, ensuring that they meet international safety, security and environmental standards, and that crew members have adequate living and working conditions. From the website of the Paris MoU, the monthly lists of detentions of the last two years can be downloaded.[11]

In May 2009, a "New Inspection Regime" (NIR) under the Paris MoU was agreed to, entering into force on 1 January 2011. The new regime was developed in parallel with the EU's 3rd Maritime Safety Package. The NIR is a risk-based targeting mechanism, which will reward quality shipping with a smaller inspection burden and concentrate on high-risk ships, which will be subject to more in-depth and more frequent inspections. The NIR makes use of company performance and the IMO audit for identifying the risk profile of ships. The past inspection record of the ship, as well as the ship's age and ship type, will influence the targeting.

Similar memorandums of understanding exist in seven other regions concerning other seas and contracting States.

Examples of use of port-state authority – case study examples

Los Angeles and Long Beach

The case study does not mention any particular measures in this regard.

Rotterdam

To ensure that activities in the port of Rotterdam are being conducted according to the applicable regulations, a large number of organisations conduct environmental and other inspections. The PoRA itself also plays an important role in the control of the behaviour in the port. Inspectors of the port mainly focus on the disposal of waste and waste products. Port state control is responsible for the inspection with respect to international environmental regulations.

The port State control in the Netherlands is a member of the Paris Memorandum on Port state control. Through co-operation, these maritime authorities are actively trying to

eliminate sub-standard ships and increasing their effectiveness. The Netherlands has to some extent the possibility to enforce stricter environmental standards than internationally agreed, but does not make use of this option, perhaps for international competition reasons.

Vancouver

The *Canada Shipping Act, 2001* (CSA) is the principal legislation governing protection of the marine environment in Canada. The CSA applies to all vessels in waters under Canadian jurisdiction and to Canadian vessels everywhere. The CSA includes Canadian provisions related to pollution from ships and additionally implements Canada's obligations under international conventions, such as the MARPOL Convention.

Port Metro Vancouver Marine Operations Department targets 100% of ocean going vessel arrivals for: boarding; inspections of overboard discharge and engine room logs; and informing ship's officers of the Port's environmental and other rules and procedures. For logistical reasons, actual boardings run at about 98% of arrivals.

Busan

Korea is a member of the Tokyo Memorandum on Port State Control (PSC) and is actively trying to eliminate sub-standard ships for maritime safety and marine environment protection. In 2009, the Korean Government carried out port state control of 2 852 ships, with faults detected at 2 497 ships. 274 ships were banned from leaving the ports due to serious faults. In 2010, the Korean Government will carry out port state control of about 3 000 ships, which will meets the goal of a 32% of inspection rate. The inspection rate has increased annually; 26.7% in 2008, 30.3 % in 2009, and 32% in 2010. In order to increase the rate of port state controls, the Korean Government will increase the number of control officials from 35 officials in 2010 to 56 officials in 2014.

The PSC is carried out based on a *Ship Targeting System* that is focused on the sub-standard ships. Until 2009, ships with a targeting factor (TF) of 100, which considers ship's age, numbers of faults, numbers of bans of leaving ports, etc., got a PSC inspection every three months in Korean ports. However, in 2010, ships with a targeting factor of 80 get a PSC inspection every three months. And the ships with a targeting factor of 40-79 will get a PSC inspection every six months. The ships with a targeting factor of less than 40 will get a PSC inspection based on the individual port office's discretion.

Table 7.1. **The plan for increasing numbers of PSC officials in Korea**

	2010	2011	2012	2013	2014
Inspection rate (%)	32.0	39.1	42.6	45.1	47.3
PSC officials	35	46	50	53	56

Source: MLTM, 2010.

7.4. Unilateral environmental demands on voluntary port calls

Port states have a wide discretion under the *United Nations Convention on the Law of the Sea* (UNCLOS) and are allowed to make voluntary port calls conditional on unilaterally enforced standards if they consider this necessary for the protection of their environment.[12] However, the requirements must be proportional to the subject pursued and non-discriminatory. They can be enforced on all vessels, regardless of flag.

States have on many occasions used the opportunity to enforce higher standards on ships calling at their ports. Examples of this are the United States *Oil Pollution Act*, the European Union's early ban on single-hull tankers, the 1996 Stockholm agreement on stability requirements for Roll-on-Roll-off ferries, the US ballast water requirements, the European Union's regulation on the highest permissible sulphur content in fuels used by ferries, the Community's requirement on ships not to use fuel containing more than 0.1% sulphur while at berth, and the requirement by the Swedish city of Helsingborg that ferries must have installed SCR as a condition for entry into port.

Notes

1. ESPO/EcoPorts Port Environmental Review 2009, *www.espo.be/downloads/archive/5b1261d2-35e9-42f6-bed4-39037ecec3e4.pdf*. This is an update of similar reviews carried out in 2004 and 1996.
2. *www.espo.be/downloads/archive/85817e87-5a24-4c43-b570-146cb7f36b68.pdf*.
3. *www.ecoports.com*.
4. *www.ecoports.com/page.ocl?pageid=29&mode=&version*.
5. *www.ecoports.com/page.ocl?pageid=30&mode=&version*.
6. *www.aapa-ports.org/Issues/content.cfm?ItemNumber=989*.
7. Green Port, Issue 1 March/April 2008.
8. Green Port, Issue 2, May/June 2008.
9. Initiated by the Rotterdam Municipal Port Authority and the Dutch Ministry of Transport and Water Management.
10. A list of the ships certified under the Green Award is available at *www.greenaward.org/defaulthome.htm*.
11. *www.parismou.org*.
12. See OECD (2010) for further discussion.

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American Association of Port Authorities (AAPA), *www.aapa-ports.org*.

Association of Australian Ports and Marine Authorities, *www.aapma.org.au*.

China Ports and Harbours Association, *www.port.org.ch*.

Dangerous Goods Advisory Council, *www.hmac.org*.

EcoPorts Foundation, *www.ecoports.com*.

European Sea Ports Organisation (ESPO), *www.espo.be*.

INTERFERRY, *www.interferry.com*.

International Association Cities and Ports (IACP), *www.aivp.org*.

International Association of Classification Societies (IACS), *www.iacs.org.uk*.

International Association of Dredging Companies (IADC), *www.iadc-dredging.com*.

International Association of Independent Tanker Owners (INTERTANKO), *www.intertanko.com*.

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Port Authorities

The web addresses of many port authorities can be reached via *www.portfocus.com*.

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(97 2011 02 1 P) ISBN 978-92-64-09682-0 – No. 57835 2011

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Further reading

Globalisation, Transport and the Environment (2010)

Please cite this publication as:

OECD (2011), *Environmental Impacts of International Shipping: The Role of Ports*, OECD Publishing.
http://dx.doi.org/10.1787/9789264097339-en

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97 2011 02 1 P