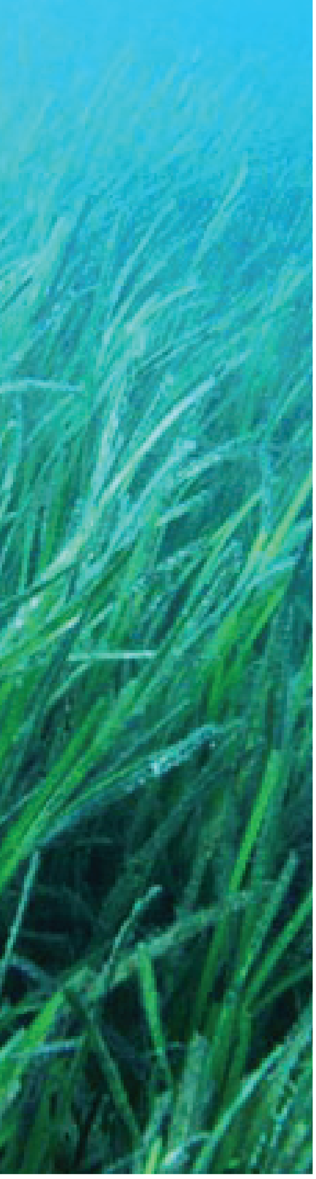
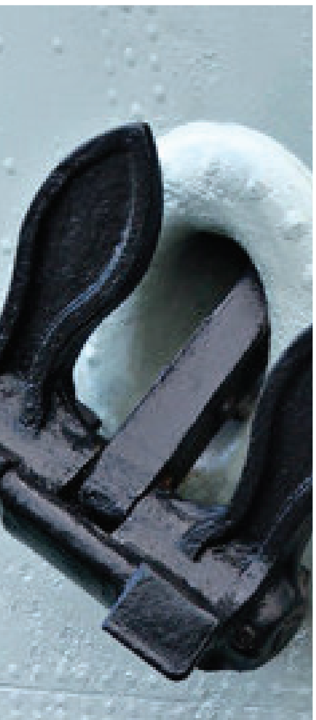


Environmental Best Practice Port Development: An Analysis of International Approaches

Report prepared for
Department of Sustainability, Environment
Water, Population and Communities

July 2013



GHD

Disclaimer

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Executive summary

Context and methods

The Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) commissioned GHD with the support of Sprott Planning & Environment Pty Ltd to investigate and identify best practice environmental management standards relevant to the planning, development and operation of seaports internationally. The primary purpose of this work is to better understand international management benchmarks and their potential application in an Australian context.

This study forms one of a number of research projects being conducted by SEWPaC to support the comprehensive strategic assessment of the Great Barrier Reef World Heritage Area and adjacent coastal zone, and the management of environmental impacts associated with ports and shipping. This report may be used by SEWPaC in conjunction with other research to help inform assessments of ports under the *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act) and dredge spoil disposal activities under the *Environment Protection (Sea Dumping) Act* 1981.

This report focuses on activities that could generate environmental threats which are directly controlled or influenced by ports and have the potential to significantly impact on matters of national environmental significance under the EPBC Act. To identify how these potential impacts are managed internationally, a literature review and analysis of relevant case studies was conducted to identify best practice examples in environmental management. For the purpose of this report best practice was defined as the application of measures or combination of measures that demonstrably shows results superior to those achieved with other means based on international experience and that is issued as a benchmark. Stakeholders from Commonwealth and Queensland government, industry experts and port authorities were then consulted to help benchmark current Australian practices and consider the application of the identified best practice examples to an Australian context.

International ports are diverse in their locations, surrounding environments, activities and regulatory regimes. Many are located in sensitive coastal and marine environments and are faced with the challenge of minimising impacts particularly to avoid causing long-term and irreversible damage. Australia is unique in that it is one of few countries with several ports in and adjacent to World Heritage Areas. The settings of ports and the environmental risks involved are varied and so require a wide range of management responses to avoiding, mitigating or offsetting impacts.

This report has largely drawn on examples of management responses in Europe and North America. Their regulatory regimes and the planning, development and operation of their ports are mature and the ports tend to engage more with their communities than may be the case in other regions. This means there is more information publicly available for review and evaluation. Limited information was uncovered about responses to environmental issues in areas outside these two continents.

This study found that best practice was primarily driven by three key factors:

- Strong regulation, policy environment and governance arrangements
- Consideration and avoidance of environmental impacts through rigorous site selection and master planning processes (incorporating strong stakeholder and community engagement processes)
- Adoption of a site specific and risk-based approach to selecting management options to avoid and mitigate environmental impacts.

Regulation, policy and governance

Most actions by international ports were in response to local environmental laws and regulations or were in response to particular environmental issues and approvals associated with port development activities. This was also common to Australian ports. Many international ports also have certified ISO 14001 Environmental Management Systems or similar governance processes which provide a robust environmental management framework. It is important therefore that regulation and approval conditions extend to include implementation mechanisms, such as management plans, monitoring programs with triggers for action and independent auditing to drive accountability and continuous improvement. Monitoring and auditing also enables the success or otherwise of actions to be captured and recognised and lessons shared to inform future projects.

Transparent stakeholder and community engagement, including with traditional land owners, can encourage data sharing, enable community concerns to be considered and addressed, and provide motivation and encouragement to ports to improve environmental performance. International organisations such as EcoPorts provide a forum for networking and sharing of information. In Australia, Ports Australia facilitates an Environmental Working Group, although this is restricted to industry representation from Australian ports. Most ports considered as part of this study had some information available on their website as to their approach to environmental management and upcoming or current projects; however only very few ports published details as to their ongoing environmental performance or monitoring results. In many cases, both internationally and in Australia, stakeholder engagement appears to be driven by regulation as part of approvals processes.

Site selection and master planning

Comprehensive and transparent site selection and master planning processes incorporating proactive stakeholder and community engagement principles are critical to enabling avoidance of long-term and prolonged legacy issues for port operations and the environment. Site selection, master planning and design are the stages in a port's development where there is the most opportunity to avoid and mitigate environmental impacts, especially impacts on coastal processes and hydrology, aesthetics and habitat. These processes need to consider a range of aspects including the regulatory setting, environmental values of the location, cumulative impacts, and operational requirements. This study highlighted a best practice example from the Port of Dublin, where a Strategic Environmental Assessment was conducted as part of the master planning process (instead of consequentially), enabling integration of environmental and stakeholder considerations into the broader decision making and governance framework. Many ports in Australia have developed master plans however these are often not publicly available due to commercial in confidence or other potentially sensitive material, and are not necessarily comprehensive in terms of their consideration of environmental issues. Depending on the port and nature of the master planning activity, inclusion of a strategic environmental assessment as part of port master planning could be applied in an Australian context.

Management of activities and environmental impacts

The study examined practices of international ports in managing particular environmental issues and activities. The range of issues assessed was based around the potential for impacts on matters of national environmental significance and considered practices to manage water and sediment quality, coastal processes and hydrology, noise and vibration, lighting, aesthetic impacts, direct ecosystem impacts, air quality and invasive species. The literature found that the most prominent environmental issues that international ports are focussing on are water quality (especially from dredging impacts), noise, and air emissions. Air quality from port operations is generally treated as a human health issue and has limited impacts upon matters of national environmental significance and so has not been considered in detail in this report.

Deterioration of water quality is one of the most serious potential impacts ports can have, because of its effect on a wide range of environmental values. Poor water quality can cause a range of environmental impacts including reduction in light, smothering, fouling of gills, reductions in visibility and, if sediments contain contaminants, toxic impacts on fauna. The literature review found that the level of impact on environmental values such as seagrasses and corals arising from turbidity and sedimentation was site-specific and dependent upon the species assemblage present and natural variability of local background turbidity.

Large scale dredging, a common port activity, is the largest potential cause of poor water quality. The study found that many issues associated with dredging can be considered during the site selection, master planning and design phase. It also found that a risk-based approach to management of a dredging program is the most effective process to match mitigation measures to potential impacts. This is consistent with the approach taken on recent Australian dredging projects such as the Port of Melbourne's Channel Deepening Project and maintenance dredging for Port Hedland Port Authority but there is an opportunity for it to be more widely practiced at Australian ports. There are a wide range of measures to control the impacts of dredging both at the site where material is being removed as well as at the disposal site. Other measures such as timing of dredging operations to avoid sensitive times of the year, for example when fish are migrating or when turtles are nesting, and real-time monitoring programs with trigger levels for action, can be used to further minimise impacts. This study has identified several best practice examples for dredging and management of dredged spoil; each of these was tailored to meet a particular circumstance, but could be considered, amongst other options, for application in an Australian context.

Water and sediment quality can also be affected by stormwater runoff, dust from stockpiles, spills of chemicals or cargo and the use of antifouling paints on ships. The latter three are heavily regulated through conventions of the International Maritime Organisation that are ratified by most countries. Australia has ratified conventions to control navigational and cargo handling issues as well as the management of waste at sea by ships. Oil spills are managed on a region wide basis but each port has its own responsibility for maintain and implementing oil response equipment within port limits. Stormwater is managed to meet local requirements for the management of discharges into waterways and there are methods such as the use of treatment ponds, on site treatment and recycling which have been employed by ports both internationally and in Australia to achieve required environmental outcomes. Stockpile dust is generally managed through spraying the material with water, sometimes with a dust suppressant added. Whilst Australia's approaches are consistent with those internationally, there are many different technologies available and there are opportunities to continue learning from other ports..

Port activities have potential to generate noise and vibration in both the terrestrial and marine environments. Terrestrial noise is generally well understood and was identified by this study as the primary environmental issue focussed on by European ports (particularly as a human health and nuisance issue). There is less knowledge around underwater noise. Until recently, most of the focus has been on the physical impacts of high intensity noise such marine piling, sonar and seismic surveys, with less information on the impacts of lower level noise from activities such as shipping. Noise impacts on fauna can include physiological damage, impacts on hearing sensitivity and behavioural changes. There are a range of techniques used internationally to mitigate underwater noise particularly from high intensity sources such as use of bubble curtains, coffer dams, piling caps and vibrational piling. Other techniques include timing of activities to avoid impacts on fauna that may not be present at all times and modifying the rate of the noise generating activity.

The literature review did not reveal any specific actions being taken by ports to reduce marine noise from shipping, although notes that this may be a by-product of actions such as speed restrictions which are implemented for other reasons, such as emission reduction, health and safety and to avoid collisions with megafauna. Similarly to international ports, Australian ports consider terrestrial and underwater noise as part of port development and operation and are implementing measures to minimise impacts.

Outcomes of this study

Overall this study has found that environmental performance of ports internationally is largely driven by regulation, policy and governance. The ability to avoid environmental impacts is greatest at the site selection, master planning and design stages of a port, and hence it is critical that these processes consider environmental and social values along with operational requirements. For port construction and operation activities there are many different technologies and environmental management solutions used internationally, each with its benefits and constraints, and so while there is evidence that environmental management practices and approaches employed by Australian ports are comparable to those internationally, there are opportunities for Australian ports to learn from international ports. Further consideration may also need to be given to the difference and potential gap between meeting best practice, and achieving best environmental outcomes.

This report has highlighted examples where the available literature indicates international ports have avoided, mitigated and offset environmental impacts as far as practical for their situation and hence could be considered to have achieved best practice. Each of these examples of technology or process could be considered for application in an Australian context. Most of the examples cited in this study were well tested responses to the issues faced, with standard approaches often preferred by ports because they involve proven technologies with low risk of failure. For this reason, it is important that ports monitor their performance and share knowledge around progression in technology and successes, as well as failures, to enable continuous improvement in environmental management.

Table of contents

Table index

Figure index

Appendices

Glossary of key terms

Abbreviation	Expansion
AAPA	American Association of Ports Authorities
ADPC	Abu Dhabi Ports Company
AFC	Anti-fouling Coating
AMSA	Australian Maritime Safety Authority
Benthic organisms	Those animals and plants that live on the sea floor either on hard or soft substrata.
BWM	IMO's International Convention for the Control and Management of Ship's Ballast Water and Sediments
CARP	Ports of New York and New Jersey Contaminant Assessment and Reduction Project
CSA	Canada Shipping Act, 2001
CCG	Canadian Coast Guard
CCME	Central Command for Maritime Emergencies
CDF	Confined disposal facility for dredged material
CEDA	Central Dredging Association
COAG	Council of Australian Governments
COLREGs	International Regulations for Preventing Collisions at Sea 1972: IMO regulations that essentially are the rules of the road for shipping.
CSD	Cutter Suction Dredge
DPC	Dublin Port Company / Port of Dublin
DP World	Dubai Ports World
EAD	Environmental Agency of the UAE
EC	Environment Canada
EIA	Environmental Impact Assessment
EMAS	European Union Eco-Management and Audit Scheme
EMP	Environment Management Plan
EMS	Environment Management System
EPA	Environment Protection Authority

Abbreviation	Expansion
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
ES	Environmental Statement
ESI	Environmental Ship Index
ESPO	European Sea Ports Organisation
ESTRUS	Enhanced and Sustainable Treatment for Urban Stormwater
EU	European Union
GBRMPA	Great Barrier Reef Marine Park Authority
Globallast	IMO's Global Ballast Water Management Program
GBRWHA	Great Barrier Reef World Heritage Area
I2S2	International Institute of Sustainable Seaports
IAPH	International Association of Ports and Harbours
IMDG	International Maritime Dangerous Goods Code
IMO	International Maritime Organization is the United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of marine pollution by ships
IMPS	Invasive Marine Pest Species
ISO 14001	ISO 14001 Environmental management systems – requirements with guidance for use
IUCN	International Union for the Conservation of Nature
LPoC	Last Port of Call
MARPOL	The International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes.
MNES	Matters of national environmental significance
MPRSA	US Federal Marine Protection, Research, and Sanctuaries Act 1972 – The Ocean Dumping Act
NAGD	National Assessment Guidelines for Dredging. Australia's guidelines for implementing Commonwealth legislation on sea dumping.
NGO	Non Government Organisation
NOx	Nitrous oxide
NPDES	National Pollutant Discharge Elimination System

Abbreviation	Expansion
NPS	National Ports Strategy
OEM	Office of the Environmental Monitor
OSPAR	OSPAR Commission established to implement the OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic 1992
PIANC	World Association for Waterborne Transport Infrastructure
PCB	Polychlorinated Biphenyls
PERS	Port Environmental Review System
Polychaete	Marine annelid worm
QPAR	Quarantine Pre-Arrival Report
RO-RO	Roll-on roll-off cargo / rolling stock
ROPME	Regional Organization for Protection of the Marine Environment comprising member states of Bahrain, I.R. Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates
SDM	Self-Diagnosis Method
SEA	Strategic Environmental Assessment
Sea Dumping Act	Commonwealth *Environment Protection (Sea Dumping) Act 1981*
SEWPaC	Australian Government Department of Sustainability, Environment, Water, Population and Communities
SWPPS	Stormwater Pollution Prevention Plans
teu	Twenty-foot equivalent units. A measure of container number based around the twenty foot container as a single unit.
TBT	Tributyltin an organotin component of many older antifouling paints. Now banned for all vessels since 2008.
TSHD	Trailer Suction Hopper Dredge
UAE	United Arab Emirates
UK	United Kingdom
UNCLOS	United Nations Convention on the Law of the Sea
UNESCO	United Nations Educational Scientific and Cultural Organisation
US	United States of America
USACE	United States Army Corps of Engineers
US EPA	United States Environment Protection Agency

Abbreviation	Expansion
VAS	Vessel Arrival System
WA	Western Australia
WHA	World Heritage Area
WRAP	Port of Los Angeles Water Resources Action Plan

1. Introduction

The Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) commissioned GHD with the support of Sprott Planning & Environment to investigate and identify best practice environmental management standards relevant to the planning, development and operation of seaports internationally. The primary purpose of this work is to better understand international management benchmarks and their potential application in an Australian context.

This study forms one of a number of research projects being conducted by SEWPaC to support the comprehensive strategic assessment of the Great Barrier Reef World Heritage Area and adjacent coastal zone and the management of environmental impacts associated with ports and shipping. This report may be used by SEWPaC in conjunction with other research to help inform *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) assessments of ports in the Great Barrier Reef region and more broadly around Australia and assessments of dredge spoil disposal activities under the *Environment Protection (Sea Dumping) Act 1981* (Sea Dumping Act).

The methodology for this report includes a literature review, analysis of relevant case studies, identification of best practice examples in environmental management, and stakeholder consultation to help benchmark current Australian management approaches and identify opportunities and constraints for implementing the best practice examples in Australia. It considers site selection, planning and design, construction and operational phases (including monitoring) of port development.

This report focuses on activities that could generate environmental threats which are directly controlled or influenced by ports, and have the potential to significantly impact on matters of national environmental significance (MNES) as defined in the EPBC Act. The report does not cover management of activities such as railways, roads and shipping operations that are external to the port. Decommissioning of ports was also not covered as the focus is on management of the environmental impacts of new or expanded ports.

1.1 Ports in Australia

Ports and associated infrastructure are of significant economic and social importance to Australia. They are an important gateway for industry, goods and services, and support the domestic, security and safety needs of the nation. There are over 70 ports on the Australian coastline, of varying size and scale. Environmental settings range from the tropical World Heritage Areas associated with the Great Barrier Reef; the remote regional locations of the northern Pilbara; and the large container port located in a heavily urbanised location such as Melbourne or Sydney. Locations are shown in Figure 1.

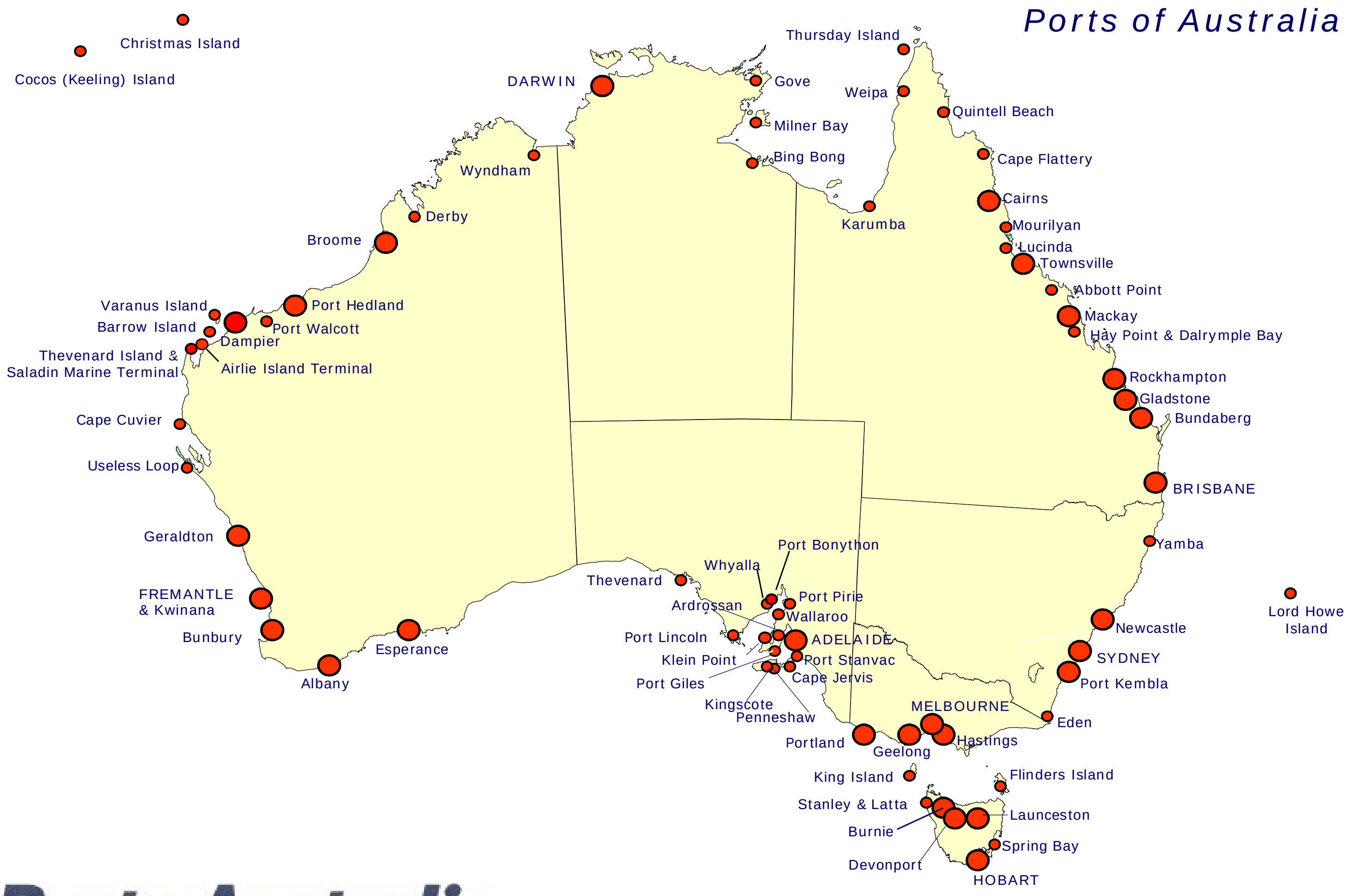


Figure 1 Ports of Australia (Ports Australia, 2013)

Many of these ports are experiencing continued growth. The National Ports Strategy (2012) states that Australia's bulk commodity exports and metropolitan container imports are both expected to double in size every 10 years. Examples are shown in Table 1 below.

Table 1 Expected trade growth through ports in Australia

Commodity	2011 export tonnage (Mt)	2025 forecast tonnage (low-high forecast (Mt)
Thermal coal	148	267-383
Metallurgical coal	133	260-306
Iron ore	439	885-1082
LNG	19	86-130

Source – Australian Bulk Commodity Exports and Infrastructure – Outlook to 2025 (July 2012), BREE

Demand for mineral and resource commodities is driving much of this expansion, particularly in Queensland and Western Australia. Many of Australia's ports, including those subject to significant development proposals, are located in sensitive environmental settings and have special needs and considerations in terms of fulfilling international commitments and obligations. For example, in Queensland several ports are located in or adjacent to the Great Barrier Reef World Heritage Area (GBRWHA). In Victoria the Port of Hastings is located adjacent to the Westernport Ramsar area and the Port of Melbourne channels are close to a Ramsar area.

1.2 Environmental management and regulation context

As ports are often located in sensitive environmental settings and can result in a range of environmental impacts, good design and sound environmental management of construction and operational activities is critical.

Sustainability is identified by ports around Australia as a key consideration in their overall management strategies. This includes environmental management of port, shipping and resource industries as a whole. Environmental impacts of port activities can extend beyond the bounds of the port itself. Significant improvements in environmental management have been made over many decades and it remains important to continually improve. This report provides international examples which may assist with this continued improvement.

The responsibility for environmental approvals and regulation of port development lies with various bodies across several levels of government. Assessing port developments that could have a significant impact on MNES is the responsibility of SEWPaC under the EPBC Act. The seven MNES protected under the EPBC Act that are of greatest direct relevance to port development and operations are:

- World heritage properties
- National heritage places
- Wetlands of international importance (listed under the Ramsar Convention)
- Listed threatened species and ecological communities
- Migratory species protected under international agreements
- Commonwealth marine areas
- The Great Barrier Reef Marine Park.

Dredge spoil disposal activities in the marine environment need to be assessed by SEWPaC under the Sea Dumping Act. These assessments examine impacts on the marine environment more broadly than just MNES. The outcomes of this study may inform SEWPaC's consideration of project referrals and assessments under both of these pieces of legislation.

2. Method

2.1 Overview

To identify international best practice environmental standards this report

- Defines best practice
- Reviews international literature to identify environmental management practices adopted by international ports and which of these meet the definition of best practice
- Analyses the practices adopted by a sample of international ports to identify further examples of best practice
- Considers how the identified international best practice examples compare to Australian practices and potential issues associated with the implementation of these measures in Australia, based on consultation with key stakeholders.

2.2 Definition of best practice

For the purpose of this report best practice is defined as the application of measures or combination of measures that demonstrably shows results superior to those achieved with other means based on international experience and that is issued as a benchmark.

In order to achieve superior results a practice should seek to achieve the best environmental outcome that is practically possible, which may include using new or innovative methods not commonly used for environmental management or extending beyond compliance with legislation. This should be demonstrated through the application of the hierarchy of 'avoid, mitigate and offset' to reduce environmental impacts. This hierarchy forms a key principle for environmental legislation and policy internationally, including for assessment under the EPBC Act in Australia, and the London Protocol on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter. In summary:

- **Avoidance of impact:** Avoidance is the primary strategy for managing the impacts of an action. Measures to avoid the creation of impacts from the outset include: spatial or temporal placement of project components, in order to completely avoid impacts on environmental values.
- **Mitigate:** Mitigation of potential impacts: take measures to reduce the duration, intensity and/or extent of impacts (including direct, indirect and cumulative impacts, as appropriate) that cannot be completely avoided, as far as is practically feasible.
- **Offsets:** are ''*measures that compensate for the residual adverse impacts of an action on the environment. Offsets provide environmental benefits to counterbalance the impacts that remain after avoidance and mitigation measures*'' (SEWPAC, 2012). Offsets can take the form of management interventions such as restoration of degraded habitat, weed removal, arrested degradation or averted risk, protecting areas where there is imminent or projected loss of biodiversity. Offsets do not reduce the likely impacts of a proposed action, but compensate for any residual significant impact.
- **Ongoing adaptive management:** ongoing adaptive management is a systematic process for continually improving management practices through learning from the outcomes of previous management, and facilitates maintenance and enhancement of environmental values over time.

In the context of this report, to be defined as best practice an approach or technique must clearly demonstrate environmental impacts have been avoided as far as practical given social, economic and technical constraints, then minimised and offset as required, and informed by ongoing monitoring and adaptive management.

Best practice will vary depending on the situation and the technology currently available and needs to incorporate continuous improvement and adaptive management strategies to enable management to be modified in response to new information.

2.3 Scope of study

2.3.1 Port activities

The study considered the following port activities to the extent that they are controlled or influenced by ports:

- **Site selection and master-planning** – includes best practice principles or approaches for selecting the location of new or expanded port developments and considers: master planning, integration of the port with land-based road and rail linkages, and potential conflicts and compatibility with other land uses.
- **Design and construction** – includes: port planning (as part of design once a site has been selected), functional requirements for the port or terminal, environmental impact assessment, the application of design codes and guidelines; the actual design and documentation of the various elements including shipping channels; and construction activities such as dredging and spoil disposal, land-use runoff, piling, reclamation and clearing of vegetation.
- **Operation** – includes activities such as maintenance dredging, shipping (manoeuvring and anchoring), ballast water discharge, vessel arrival, major incidents (including contingency planning for natural disasters and extreme weather), planning for long-term sea-level rise issues, traffic, lighting, land-use runoff, stockpiling of materials. Operation also includes social aspects such as community engagement/education programs aimed at maintaining transparency of port operations and strengthening relationships with the community.
- **Monitoring and continuous improvement** – includes implementation of Environment Management Systems (EMS) or Environment Management Plans (EMP), adaptive management approaches to inform future port development and operation and facilitate continuous improvement, and the collection and interpretation of data to monitor impacts of port development and operation. This can include regional networks established to share lessons across ports.

Decommissioning of ports is outside the scope of this review. The focus is on the environmental management of new or expanding ports.

2.3.2 Environmental impacts and risks

A preliminary scoping exercise identified potential sources of impacts on or risks to MNES. These are summarised in Table 2. Under the EPBC Act an action must be referred for assessment if it is likely to have a significant impact on MNES (significant impact is further detailed in the Australian Government's 'Significant Impact Guidelines 1.1'). Findings are described in Section 5 structured by environmental impact or risk.

Table 2 Potential sources of impacts and risks

Environmental impact or risk	Description	Potential sources of impact or risk: design and construction activities	Potential sources of impact or risk: operational activities
Water quality	The primary water quality impact from port activity is increased turbidity. Other impacts may include: • Increased pollutant contamination • Nutrient input • Disturbance of acid sulphate soils. Declines in water quality may have a significant impact on MNES by, for example, adversely affecting habitat critical for the survival of the species such as seagrass and corals; or altering species behaviours such as disrupting the breeding cycle of a population; or reducing the area of occupancy of the species. Note: the Sea Dumping Act takes a 'whole of environment' interest in relation to water quality impacts.	• Dredging and dredge spoil disposal • Erosion and runoff from earthworks • Pile driving • Potential leakage or spills of contaminants • Garbage • Reclamation • Land and marine based vegetation clearing • Dust (e.g. wind erosion of exposed areas; from the transport of materials)	• Stormwater • Turbidity caused by ship anchoring and ship movements (including prop-wash) • Maintenance dredging • Waste and effluent discharge (including ballast water) • Bilge water discharge • Antifouling paints • Sewage, sludge and oil spills • Garbage • Hazardous cargo • Dust from transporting, loading and storing materials (especially coal)
Noise pollution and vibration	Increased noise (variable or continuous) can disturb terrestrial and marine species and affect their behaviour, including breeding or foraging.	• Traffic • Equipment (generators, alarms etc.) • Pile-driving • Dredging • Reclamation	• Traffic (including ship engines) • Operation of machinery (including conveyors and alarms, fans, cranes, vehicles) • Maintenance dredging
Light pollution	Increased light sources can affect species behaviour (e.g. marine turtle nesting).	• Temporary lighting	• Permanent lighting, particularly on jetties/berths, conveyors and walkways • Increased vessel lighting
Aesthetic	Port infrastructure and activities may impact on the aesthetic values of an area. This is	• Design of on-shore port infrastructure (height and design	• Increased ship traffic • Offshore

Environmental impact or risk	Description	Potential sources of impact or risk: design and construction activities	Potential sources of impact or risk: operational activities
	particularly relevant under the EPBC Act if the port is in a World Heritage Area listed for its aesthetic values (e.g. Great Barrier Reef World Heritage Area).	of buildings, landscaping etc.) • Location– visibility from land/water • Off-shore port infrastructure (jetty/berth)	anchorages • Stockpiles of materials • Port lighting at night
Coastal processes and hydrology	Port infrastructure can result in barriers to riverine and estuarine flow, beach erosion and changes to sediment deposition, tidal flow and drainage. This can impact on MNES through barriers to species movement, alterations to habitat and changes to water quality.	• Construction of sea walls, breakwaters or other barriers • Trestles • Dredging • Reclamation	• Maintenance dredging
Air quality	In addition to dust, other air quality impacts may have an impact on human health and amenity and come from emissions from ships and port equipment. Note: Air quality has limited relevance to MNES.	• Emissions from construction equipment • Odours	• Emissions from port, waterfront industries and ships (diesel particulate matter, sulphur and nitrogen oxides etc.) • Volatile organic compounds from loading and unloading of petroleum products • Odours
Direct ecosystem impacts	Direct impacts on ecosystem functioning and integrity, including individual species (e.g. direct physical injury, removal or mortality)	• Dredging and dredge spoil disposal • Vegetation clearing • Reclamation • Habitat removal and fragmentation.	• Collision with vessels • Entanglement with infrastructure • Ship anchoring • Maintenance dredging
Invasive species	Introduction of new invasive species in marine or terrestrial environments could result in substantial impacts to MNES through competition for resources, predation or disease.	• Increased susceptibility of terrestrial areas to invasive species incursion due to vegetation clearing and edge effects	• Ballast water discharge • Biofouling.

2.4 Identifying best practice environmental standards

International best practice for managing the environmental impacts outlined in Table 2 was identified through a literature review and case studies of ports displaying advanced environmental management or standards.

2.4.1 Literature review

A literature review identified how environmental protection is approached by international ports. Some practices at Australian ports may match or surpass these examples; however in order to provide an impartial review that can be applied in Australia, Australian ports and practices were not considered as part of the literature review.

The review first considered how environmental issues are typically managed in ports and the standard approaches employed and results achieved. This assessment then enabled practices that went above and beyond standard practice to be identified and analysed as to whether they might constitute best practice.

Information on environmental management shows various levels of peer review, rigour and independence. Sources reviewed are listed below in order of their independence from individual port management:

- Internationally recognised and independent sources, including publications from the International Maritime Organisation (IMO), World Association for Waterborne Transport Infrastructure (PIANC), International Association of Ports and Harbours (IAPH) and Central Dredging Association (CEDA)
- Continent/country specific organisations, such as the European Sea Ports Organisation (ESPO) and the American Association of Port Authorities (AAPA)
- Technical and research papers presented as part of conferences or journals
- Publications, studies and websites commissioned or published by individual port authorities.

A full reference list is contained in Section 7.

The findings from the literature review provide an insight into the management framework required to enable best practice followed by detailed information on management practices for environmental issues and risks.

2.4.2 Case studies

A sample of international ports has been reviewed to identify examples of best practice. Initially twelve ports across Europe, Asia and America were selected for analysis based on their relevance to the study and similarities to Australian ports, including proximity to sensitive marine environments or World Heritage Areas, import or export of large quantities of commodities, and environmental credentials such as nominations for environmental awards or reported good practices. During the course of the literature review additional examples of best practice were identified and included in the case studies to enable analysis of a broader range of management practices used to address environmental impacts and risks. The international ports referenced in this study are:

- Port of Antwerp, Belgium
- Port Metro Vancouver, Canada
- Port of Helsinki, Finland
- Port of Saint-Nazariare, France
- Ports of Bremen/Bremenhaven, Germany
- Port of Hamburg, Germany
- Port Dhamra, India
- Port of Dublin, Ireland

- Port of Ashdod, Israel
- Port of Genoa, Italy
- Port of Yokohama, Japan
- Port of Le Havre, Netherlands
- Port of Rotterdam, Netherlands
- Port of Oslo, Norway
- Port of Doha, Qatar
- Port of Singapore, Singapore
- Khalifa Port, United Arab Emirates (UAE)
- Port of Dover, United Kingdom (UK)
- Port of Grimsby, UK
- Port of London, UK
- Port of Southampton, UK
- Port of Odessa, Ukraine
- Port of Baltimore, United States of America (US)
- Port of Bellingham, US
- Port Canaveral, US
- Port of Charleston, US
- Ports of the Columbia River, US
- Port Everglades, US
- Ports of the Great Lakes Ports Association, US and Canada
- Port of Houston, US
- Port of Long Beach, US
- Port of Los Angeles, US
- Manatee County Port, US
- Port of New Orleans, US
- Ports of New York and New Jersey, US
- Port of Portland, US
- Port of San Diego, US
- Port of Skagit, US
- Port of Seattle, US
- Ports of the US Navy, US.

Information reviewed as part of the examples has primarily been sourced from each port's website as well as published literature as a basis for analysis.

2.4.3 Analysis of best practice

Analysis of the practices identified in the literature review and case studies has considered:

- Why the standard or practice is considered to be international best practice. In order to answer this question, the analysis considered:
  - Has the standard or practice achieved the best environmental outcome that is practically possible?
  - Is there a system in place to continuously improve performance?
  - Has the hierarchy of avoid, mitigate, offset been applied when selecting the standard or practice?
  - Is the standard or practice appropriate for the situation?
- Potential issues and constraints (technical, financial, ecological and physical) in implementing the standard or approach in Australia or in particular types of ports
- Potential social and economic costs and benefits associated with implementing the best practice measure (including the identification of any alternative measures that may result in a similar environmental outcome at a lower cost). This was done qualitatively due to the range of factors that could influence the actual costs and benefits of the practices examined in this report.

2.4.4 Consultation

A number of key stakeholders were consulted in preparation of this report, including relevant Australian Government and state government departments, industry representatives including Ports Australia and several port authorities, as well as marine scientific experts. Consultation included a stakeholder workshop to discuss the report in detail, identify any additional examples of international best practice that should be included, benchmark current Australian management approaches against the international examples, and discuss the applicability of findings in the report to an Australian context.

Outcomes from the stakeholder consultation activities have been incorporated into this report, and are outlined in more detail in Appendix A.

2.5 Structure of this report

This study found best practice environmental standards are generally founded on three key themes, which the reported is structure around:

- A strong regulatory and policy environment and good governance of the port proponent/operator (this is explored in Section 3)
- Site selection and master planning showcasing early consideration of environmental values and issues (this is explored in Section 4)
- Leading environmental management approaches to particular issues and sources of impacts seen at several international ports (this is explored in Section 5).

2.6 Limitations of the study

A substantial body of literature exists regarding various environmental practices, however much of it can't be appropriately verified because the primary data is not publicly available or evidence of the results of the practice has not been available. The report sought to review and rely on recognised sources and those verified through direct industry contact.

This review has not been exhaustive and it is possible that other international practices may exist that are not mentioned in this report.

The Australian examples mentioned in this report represent a small sample of ports and practices in Australia. These were identified during stakeholder consultation for the purpose of considering how Australian practices compare to international practices, and the applicability of identified international best practice examples to an Australian context. Not all Australian ports were consulted. The focus of this report was on international best practice and a detailed review of best practice in Australia was outside the scope of this study.

Impacts associated with ancillary infrastructure, such as railways and roads, or that are not directly controlled or influenced by ports, such as shipping operations outside of port waters, have not been considered.

While this report is current now in its discussion on best practice, it is considered that the standard to meet best practice is likely to shift in the future, with for example, changes to port practices as a result of technological advancements.

3. Regulation, port policy and port governance

3.1 Overview

This section considers the role of regulation, port policy and port governance in influencing environmental performance. This has been considered in terms of the how best practice may be facilitated by:

- Regulation and policy set by regulators and inter-jurisdictional bodies
- Port governance and management systems
- Incentive programs and awards
- Stakeholder engagement and awareness
- Use of independent expert review.

3.2 Regulation, policy and guidelines

Governments and government authorities can facilitate best practice for environmental management through development of guidance documents, the setting of policy and requirements for the planning and development of ports; and through regulation of the minimum standards required for the assessment of environmental risks and impacts, and continuous improvement.

3.2.1 Inter-jurisdictional bodies

There are a number of inter-jurisdictional bodies who provide guidance on environmental management for ports. These include:

- **IMO** – the United Nations agency with responsibility for prevention of marine pollution by ships. The organisation administers over 20 environmental treaty instruments and is a technical authority in this field. Australia is a member state of the IMO.
- **CEDA** – an independent, international association focused on dredging and marine construction. CEDA provides independent technical and scientific advice, publishes a range of information including guidance notes and technical briefings, and facilitates seminars and training.
- **IAPH** – and NGO representing the world's port industry. It provides an opportunity to members to collaborate, share information and advance sustainable practices.
- **PIANC** – an international organisation aiming to provide expert technical advice on a range of waterborne transport infrastructure issues, including environmental issues, and to keep the international waterborne transport community connected.

Adoption of the guidance, treaties and other information provided by these organisations is voluntary and occurs on a regional or country-by-country basis. Information and guidance published by these bodies is available to Australian ports to consider and adopt where appropriate.

3.2.2 Strategic port policy

Direction provided by strategic port policy or legislation can provide clarity and certainty on the environmental management framework and requirements for ports. There are examples from the jurisdictions reviewed as part of this study where governments have embedded environmental management requirements into strategic policies on port development.

In the United Kingdom the British National Ports Policy Statement (2012) provides the framework for making decisions about port development. Section 4.1.1 requires decision makers when making decisions on port development proposals to take into consideration the Government's objectives for transport, including the need

'…to create a cleaner and greener transport system through improving the environmental performance of ports and associated developments, including transport, as well as to help changing to support infrastructure needed for green technologies…'

The policy statement also highlights the importance of sustainability considerations in the decision-making framework for ports, including that new port infrastructure should:

- Preserve, protect and where possible improve marine and terrestrial biodiversity
- Minimise emissions of greenhouse gases from port related development
- Be well designed, functionally and environmentally
- Be adapted to the impacts of climate change
- Minimise use of greenfield land
- Provide high standards of protection for the natural environment
- Ensure that access to and condition of heritage assets are maintained and improved where necessary.

Section 4.10 of the policy states:

'…. applying 'good design' should produce sustainable infrastructure sensitive to place, efficient in the use of natural resources and energy used in their construction and operation, matched by an appearance that demonstrates good aesthetic as far as possible'

'Good design is also a means by which many policy objectives in the NPS can be met, for example the impact sections show how good design and use of appropriate technologies can help mitigate adverse impacts such as noise.'

The EU's Communication on a European Ports Policy addresses the issues in a similar fashion.

3.2.3 Environmental assessment regulation

Government regulation of the environmental impact assessment and approvals processes sets the minimum standard of environmental performance required and hence is a key driver for achieving best practice outcomes. Assessment of environmental risks and impacts can be regulated through

- Definition of the requirements that must be covered in the assessment scope
- The methods to be applied
- The qualification requirements of assessors and the processes that must be implemented to check or formally audit that the regulatory requirements are adhered to.

For this approach to be effective in driving environmental performance the completed impact assessment should be reviewed by a qualified person in the relevant government agency or authority against set criteria before it is approved. There must also be consistency and certainty in the application of regulation.

Continuous improvement could also be driven through regulation by stipulating requirements for the review and update of environmental objectives, targets, processes and procedures or preparation and approval of environmental management plans. Such requirements should include regulation of the frequency at which reviews and updates must be undertaken internally, possibly requirements for review and update of practices or infrastructure, and the requirement for independent auditing. Monitoring and internal auditing are particularly important to enable the success or otherwise of measures to be assessed to inform both management of the activity as well as to apply to future projects.

An example of how regulation can be used to guide project approvals processes is the UK's *Marine and Coastal Access Act 2009* and associated Marine Works (Environmental Impact Assessment) Regulations 2007 and Council Directives, which require an environmental impact assessment to be conducted prior to granting a licence for a project. In this case regulation is used to specify:

- The types of projects, activities and limits or thresholds for which an environmental impact assessment is mandatory
- A process for seeking a determination from the regulator on whether an environmental impact assessment is necessary, including the information required to be submitted for determination
- The process for seeking an opinion from the regulator on the required scope of the environmental impact assessment, including environmental studies, methodologies and resources. It is noted that this process may identify the requirement for other studies and approvals in relation to habitat assessment and protected species
- The required information to be provided in the environmental impact assessment (Environmental Statement)
- The requirement for a formal public consultation process (MMO, 2011).

The Port of Southampton in the UK has recently followed this process for the reconstruction of Berths 201 and 202. An Environment Statement is publicly available on the port's website and includes assessment of a range of potential impacts relating to sediment quality, water quality, marine and coastal ecology and ornithology, fish, landscape and visual, noise, among others (Association of British Ports, 2013).

Additional examples of how environmental assessment processes have been applied internationally are considered in this report as part of the site selection and master planning processes (section 4) and as environmental management responses for particular processes or impacts (section 5).

Australian ports are subject to regulated environmental and planning approvals processes for new projects and activities at three levels: federal, state and local government. These regulated processes vary between jurisdictions but generally contain triggers for when a project is subject to regulation, the scope and type of studies or process required, requirements for stakeholder and community consultation (including with traditional land owners), depending on the nature of works proposed. Approval conditions will contain specific requirements for environmental management documentation and auditing. An example of this is the Port of Melbourne Channel Deepening Project, which was subject to an extensive environmental approvals process, with opportunity for public comment, and all approvals documentation made publicly available. Through the implementation phase of the project, environmental management plans were required to be prepared and formally endorsed by the regulator, and were subject to an ongoing and rigorous independent audit program. All management plans, monitoring results, and audit findings were also made publicly available.

3.3 Port governance and management systems

Port governance includes organisation wide planning frameworks or environmental management systems developed to set culture, manage environmental impacts and facilitate continuous improvement as well as activity or issue specific management plans.

Management systems provide a framework to avoid and mitigate impacts and drive continuous improvement. A number of tools are available internationally to assist ports to develop an environmental management system. These include:

- **ISO 14001** – The International Standard ISO 14001 Environmental management systems – requirements with guidance for use (ISO 14001) is recognised internationally as providing a generic standard for environmental management systems. ISO 14001 is designed to assist organisations to minimise their impacts on the environment, achieve compliance with environmental legal and other requirements, and to continually improve their environmental performance. These objectives are facilitated by a 'plan, do, check, review' process requiring organisations to identify and manage their significant environmental aspects. Organisations may choose to become certified to ISO 14001, with a third party auditor conducting a certification audit followed by periodic surveillance audits.
- **European Union Eco-Management and Audit Scheme (EMAS)** – Similar to ISO 14001, EMAS provides a structured framework for driving improved environmental performance and is based around a plan-do, check-act process. EMAS is a voluntary scheme open to both public and private companies in the EU and is governed by the EMAS Regulation 2009.
- **EcoPorts and the Port Environmental Review System (PERS)** – ESPO offers its member ports a number of services aimed at improving environmental management. EcoPorts is one of these (www.ecoports.com) and was developed to encourage sharing of knowledge and experience in environmental management between port professionals. EcoPorts provides ports with two key tools:
  - **Self-Diagnosis Method (SDM)** – The SDM provides a checklist port authorities can use to assess their environmental management program and compare it to the port sector and international standards. When a port completes the SDM it becomes eligible for EcoPort status. This is considered a reward for contributing data on the performance on environmental management and for contributing to the up-to-date maintenance of the ESPO European Benchmark of Performance.
  - **Port Environmental Review System (PERS)** – PERS was developed to assist ports to implement effective environmental management programs. Implementation of PERS can be independently certified by Lloyds Register. Additional recognition under the EcoPorts program is available for ports that achieve PERS certification. 60 ports in the EU are currently registered with EcoPorts. 17 have hold PERS certification and 27 hold ISO 14001 certification, with five ports holding both certifications (EcoPorts 2013).

Some international ports have developed policies, procedures or plans to improve governance of environmental management and manage specific environmental issues or processes. In some cases these documents may have been developed as part of a broader environmental management system, whilst in others these documents have been developed in response to a specific issue or legislative requirement. Some examples of these are provided below:

- **Ports of Los Angeles and Long Beach** – The Ports of Los Angeles and Long Beach, which are located adjacent to each other, developed the San Pedro Bay Clean Air Action Plan designed to achieve significant reductions in air pollution and associated health risks by setting emissions reduction goals and targets, developing strategies to meet these targets, monitoring emissions to assess progress and then reviewing for continuous improvement. This plan was developed to manage a specific environmental issue (air quality).

- **Port of Dover** – The Port of Dover's Sustainable Development Policy states that designs will be developed with consideration of how they will influence operational users to act in an environmental responsible manner. Social and environmental concerns will be considered from project inception stage along with the economic aspects so that the principles of environmental sustainability guide all project decisions. The Port of Dover also considers the environment as part of its procurement processes including procurement for construction.
- **Port of Metro Vancouver** – Under the Canada Marine Act, Port Metro Vancouver is responsible for administration, management and control of land and water in its jurisdiction. In order to administer these responsibilities, Port Metro Vancouver has established an in house Environmental Assessment Procedure to review all project proposals involving physical works in the Port's jurisdiction. The Project Review Application Form requires a description of in water activities, and a description and proposed mitigation measures for project environmental implications. As part of this process the Port may refer projects with particular environmental impacts on to other agencies to review and provide recommendations on conditions of approval. The Environmental Assessment Procedure review then informs conditions that the project proponent must adhere to when conducting the project.

The benefits of implementing environmental management systems in ports include reduced costs and improved efficiency, reduced environmental impact and liabilities, and improved emergency response capability. As an example, the Global Environment & Technology Foundation in partnership with the American Association of Port Authorities and United States Environmental Protection Agency implemented an EMS Assistance Project to assist 11 ports with EMS training, mentoring and technical assistance. Participating ports reported performance improvements such as:

- 58 per cent reduction in waste
- 47 per cent reduction in stormwater constituents
- 20 per cent reduction in insurance costs (Port of Houston Authority)
- Completion of a Natural Resources Assessment and Management Plan, including ecological mapping, to streamline data collection and reduce delays in approval processes (Port of Portland)
- Implementation of a Clean Marina Program (Port of Los Angeles) (Kruse, 2005).

However an EMS is only a tool to drive environmental performance and it does not guarantee outcomes. In order for systems to be effective, the organisation needs to understand the environmental risks, legislation and management practices available and to provide sufficient resources for implementation.

The ESPO and the EcoPorts Foundation conducted a periodic review of environmental benchmark performance of ports in the ESPO in 2009. This review indicated that progress has been made in environmental management and systems, but 71 per cent of ports still experience difficulties implementing environmental management. Challenges included the number of authorities and stakeholders involved, expense, lack of awareness of good practice, status given to environmental issues and information and guidance related to legislation.

Adoption of port wide environmental management systems and, where required, management plans for specific issues, projects or activities, is standard practice in Australian ports, with most

Australian ports publishing details of their approach to environmental management on their websites.

3.4 Port tenants

Environmental management systems, such as ISO 14001, are applied to activities that can be directly controlled or influenced by the organisation. The ability to impose environmental management requirements on tenants is dependent on the lease or contractual arrangements in place.

Examples of how some international ports influence environmental management in tenants include:

- **Port of Seattle** – The Port of Seattle has developed an Environmental Compliance Assessment Program to manage liabilities associated with port tenants. This program involves an environmental site assessment of tenant operations and their consistency with the tenant's lease to identify any operations that might impact on port compliance programs or require an amendment to the lease. Through the assessment process opportunities to reduce potential pollution and waste are identified and recommended for implementation. In 2010 the port was awarded an Environmental Improvement Award for Comprehensive Environmental Management for this program by the American Association of Port Authorities.
- **Port of Dover** – the Port of Dover has an ISO 14001 certified EMS which applies to its tenants, as well as the port's staff and contractors. The Port monitors its tenants and audits compliance with the EMS.

Ports may also incorporate environmental requirements into lease conditions, however, due to the commercial nature of a lease these are not publically available and hence no examples were reviewed as part of this study.

Australian ports also adopt a variety of approaches to influencing environmental performance in tenants, with Australian management approaches including Ports North conducting audits and inspections of tenants, Flinders Ports requiring tenants and contractors to comply with procedures under their ISO 14001 certified EMS, and Fremantle Port Authority publishing EMP guidelines and requiring all tenants to prepare an Operations Environmental Management Plan.

Where lease conditions can be modified or new leases are established, a best practice approach would include incorporating environmental performance requirements into the lease conditions and then the port regularly auditing compliance against these, as this provides a method for mandating a level of performance and then checking and implementing corrective measures if this has not been achieved.

Where lease conditions are unable to be modified, a best practice approach may be to provide guidance to tenants on good environmental management then work with them to facilitate improvements in environmental performance. This may also be achieved through incentive programs (as discussed below in section 3.5). It was also discussed during consultation that port land-use plans, as the subordinate level of planning instruments to master plans, could be further used to influence environmental performance of tenants (see Section 4).

3.5 Incentive programs and awards

A number of ports have adopted incentive programs to drive improvements in environmental performance and to influence other organisations, such as shipping companies and tenants, towards improved practices. Awards and recognition for good environmental performance include:

- **ESPO Annual Award on Societal Integration of Ports** - This award promotes innovation projects in European port authorities that develop co-operative synergies with cities, especially in the city or wider community in which they are located.
- **Environmental Ship Index (ESI)** - The ESI was developed as part of the World Port Climate Initiative aimed at reducing greenhouse gas emissions. The ESI is used to identify ships that perform better in reducing air emissions that required by the current emission standards of the IMO. Ports may choose to reward ships that participate in the ESI, with 24 ports internationally currently listed as providing incentives.
- **Green Award Foundation** - The Green Award Foundation is a neutral, non-profit organisation established on the initiative of the Port of Rotterdam and provides international recognition for extra clean, extra safe seagoing vessels, which are more than welcome in any seaport.
- **International Institute of Sustainable Seaports (I2S2)** - I2S2 was developed in partnership with the American Associated of Port Authorities and is a non-profit centre of excellence designed to promote sustainable practices by port authorities, their tenants and members of the international community.

An industry award can improve the profile of the recipient and thus be a valuable marketing tool to promote environmental credentials. The prospect of obtaining a high profile, well respected award or a valuable incentive may therefore act as a driver for ports to move towards best practice.

The effectiveness of awards in identifying best practice depends on the criteria used to assess applicants, the level of rigour used in the assessment and the independence and qualifications of the persons scoring the applicants. For example:

- An award granted to a recipient who has only improved practices due to requirements imposed by a regulator is rewarding compliance or response to an enforcement action, not initiative, innovation or corporate due diligence
- Awards that are only open to applicants who have subscribed to an industry journal or use a specific product or supplier may exclude applicants who are truly at the forefront of implementing best practice
- Incentive programs may encourage improved performance but their implementation over the longer term depends on the financial viability and practicality of the incentives offered.

3.6 Stakeholder engagement and awareness

Transparent and open stakeholder engagement is important for knowledge sharing and to understand community values. Public reporting is an important component of this; in addition to use of independent review by scientific experts to build creditability and community trust in port practices. The European Union's EcoPorts program encourages knowledge sharing and benchmarking between ports. In Australia, Ports Australia provides an information sharing forum through their Environmental Working Group, which facilitates knowledge sharing within working group between port authorities. In order to maximise the benefit of these forums, open and transparent communication is required to enable successes to be celebrated and failures learned from.

International ports have taken additional actions to encourage community engagement, such as:

- **Port of Los Angeles public reporting and engagement** – Port of Los Angeles has established and maintained a comprehensive environmental webpage, which details environmental programs and actions plans, as well as up-to-date details of how the port is tracking against these actions.

- **Environmental Education Facility at the John Lloyd Beach State Park** - Port Everglades, Florida (US) built an Environmental Education Facility at the John U. Lloyd Beach State Park. This facility features a boardwalk to observe marine wildlife and also provides a meeting space for various environmental groups and for classes and lectures to be held for school groups and interested community members.
- **Keep Port Everglades Shipshape, Port Everglades, Florida** – Port Everglades has implemented the Keep Port Everglades Shipshape program where the community is encouraged to recycle and dispose of waste appropriately. As part of this program, volunteers can paint creative designs on recycled petroleum drums to act as decorative waste and recycling receptacles around the port.
- **Information on planned and future construction projects or master plans** – A number of ports have published details on upcoming construction projects, including links to environmental impact assessment and approval documents for public comment. In most cases, the publication of project information for public comment during the planning stages is also a requirement of regulations. An example of this is the Port of Los Angeles, which is currently exhibiting and inviting public comment on their Draft Program Environmental Impact Report for the update of the Port of Los Angeles Master Plan Update. The exhibition of this document is a requirement of the City of Los Angeles Guidelines for the Implementation of the California *Environmental Quality Act of 1970*.

Ports that are held (or hold themselves) accountable to stakeholders and the public may be more motivated to research and implement new approaches to improve their environmental performance and to be proactive to correct environmental issues as soon as they arise. Also, being open and transparent enables community values and concerns to be taken into account when planning new works and adds an extra level of accountability (in addition to regulatory requirements) that will further encourage compliance to commitments made and continuous improvement. This may provide for higher levels of stakeholder acceptance of the project.

Stakeholder engagement and transparency varies from port to port in Australia. In many cases this is driven by regulation as part of project approvals processes, including for engagement with traditional landowners at both Commonwealth and State level. Most ports choose to feature an environment section of their webpage providing an overview of their approach to environmental management and highlighting specific programs, but publication of performance data is limited. There are some examples of public reporting of monitoring results, such as monitoring data and audit findings for the Port Phillip Bay Channel Deepening Project and operational monitoring data for air quality, noise, sediment quality for Esperance Ports.

3.7 Summary

The study found that best practice was most prevalent where there was a strong regulatory and policy environment for the port sector set by government and good governance of ports. Regulation and good governance provide a framework for identifying and managing environmental risks and driving continuous improvement. Incentive programs and awards and stakeholder engagement can also enable data sharing, enable community concerns to be considered and addressed, and provide motivation and encouragement to ports to improve environmental performance. These approaches are also applicable to the Australian context.

4. Site selection and master planning

4.1 Introduction

Detailed site selection and comprehensive master planning are considered fundamental for the sound management of environmental values at and around port facilities. These activities are typically undertaken as part of the very early stages of the port development cycle as seen in Figure 2. This figure also highlights the importance and central role of 'adaptive management' throughout all phases of the port development cycle.

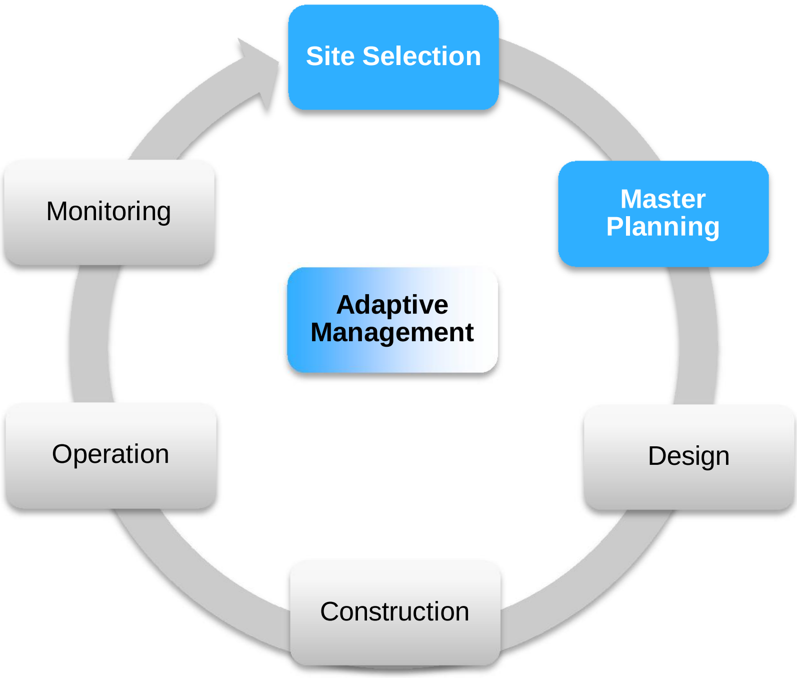


Figure 2 Site selection and master planning in the port development cycle

This section details site selection and master planning elements considered fundamental to good environmental management at seaports. It draws upon lessons from international examples where direct environmental benefits have been evident.

4.2 Considerations in site selection

4.2.1 Historic drivers of site selection

Site selection of port precincts throughout the world has historically been driven by three main elements:

- Existence or proximity to urban social catchments
- Proximity to minerals, resource, or agricultural economic catchments
- Proximity to significant infrastructure networks and unique features such as national, state and regional highways or railways – and areas of naturally deep water (for shipping access).

The key drivers for the site selection of ports are:

Location type	Examples of typical site selection drivers
Social catchments	– Historically coastal cities around the world were developed in locations that were able to accommodate a seaport. – Ability to trade and have access to broader domestic and international markets. – Population growth – generation of high levels of consumer demand for time -sensitive imports and ability to trade and exchange exports
Economic catchments	– Proximity to known and emerging minerals, resource or agricultural catchments. For example, the mineral and petroleum port developments along the West African coast and new-build developments throughout the United Arab Emirates (UAE).
Infrastructure networks and unique features	– Ability to connect to critical logistical networks such as road and railway networks. – Ability to locate near (as far as practicable), deep water access.

4.2.2 Emerging additional drivers of site selection

Whilst these drivers still exist, a number of different drivers are also emerging. In many cities for example, port relocations may be required to address problems associated with urban congestion. Examples such as the Dubai Ports World (DP World) development of 'London Gateway' in the lower reaches of the Thames Estuary, the Maasvlaktre 2 port expansion in Rotterdam, the proposed expansion of the Vancouver ports via the 'Delta Port' development, and the increasing reclamation of additional port lands in south western Singapore provide relevant examples.

In Australia, this trend has also been witnessed – with Brisbane and Sydney providing examples, and to a lesser extent, Fremantle (Kwinana and Cockburn Sound precincts) and Melbourne (Port of Hastings development).

The changing nature of port technology and emerging operational trends has also influenced this relocation movement. Examples include the move towards higher levels of containerisation for atypical containerised products bulk cereals and grains, construction products, break-bulk cargoes, and high value motor vehicles.

4.2.3 Overall site selection factors – moving towards best practice

Additional site selection factors should be considered in addition to traditional drivers as port developments move towards best practice, including key environmental factors, as well as social, economic factors. Most critically, environmentally best practice site selection of ports should be based on well founded and aligned, strategic planning policy that avoids short-term decisions. This is further detailed in Table 3 below.

Table 3 Site selection considerations

Site selection	
Key considerations	**Description**
Environmental	
• protection, maintenance and enhancement of environmental values at and adjacent to proposed port sites, including matters of national environmental significance (including outstanding universal value)	• avoidance of potential adverse environmental impacts, including cumulative environmental impacts - through using spatial and current environmental baseline data and existing regulatory provisions such as specific zoning plans, area classifications or local and regional planning and policy instruments.
• environmental constraints and impact related to coastal processes, hydrology, and wider catchment management considerations	• use of scientifically rigorous information, alignment with strategic policy and sound use of data from relevant monitoring programs to inform selection decisions. This may include use of hydrodynamic modelling at an appropriate scale to assess potential impacts that may result from changes in depths, seabed morphology.
• The ability of the port to sustainably grow and expand	• use of established infrastructure nodes and avoidance of unnecessary greenfield development sites. Includes consideration of legacy issues associated with historic site selection of ports. Significant port expansions should consider environmental impact, and ultimately revisit if development at the site is still appropriate.
• ongoing environmental management	• consideration of efficiencies for ongoing environmental management requirements and responsibilities at proposed sites.
• management of port interface	• avoidance of incompatible land uses and development activities, such as industrial and environmentally sensitive land uses.
• Environmental considerations and opportunities associated with differing port typologies (for example shallow versus deep water, and direct loading versus barging operations.)	• Potential avoidance of construction and operational impacts e.g. reduced dredging footprints via deeper water options.
Social	
• anticipated population growth in hinterland catchment	• underlying consumer cargo demands
• the relationship and function to other ports in the port network given anticipated and qualified growth projections	• overall network planning
• societal development	• fundamental access to global trading network for time sensitive goods and services

Site selection	
Key considerations	Description
Economic	
• cost efficiency	• overall ability to secure equity and project finance
• location of economic hinterlands such as mineral, resource and agricultural catchments	• proximity to key cargo catchments
• contestable cargo opportunities	• increasing competitiveness amongst jurisdictions
• likely trade projections and emerging markets	• capturing current and likely trade forecasts and trading demands
• natural access to critical landside and waterside infrastructure	• access to pre-existing and long established logistic chains and networks beyond the port boundary
• co-location opportunities	• infrastructure efficiencies and cost sharing options

A more comprehensive consideration of social, economic and environmental factors, and the interrelationship between these factors, will help avoid long-term and prolonged legacy issues for the operations of the port and its environment. For example, these issues could include:

- Environmental impacts that could have been avoided at the site selection phase of the port development
- Erosion of industry confidence due to protracted environmental assessment timeframes and potential re-work of development concepts
- Erosion of community confidence and 'social licence' of port development
- Higher operational costs
- Inefficiencies in transport logistics
- Uncertainty for a range of external port stakeholders including reduced network architecture understanding.

Environmental considerations in the site selection phase of port development should be undertaken early and given equal weighting to social and economic factors. In addition to the more traditional industry and engineering skill sets, site selection activities should be undertaken using a range of environmental specialists in a multidisciplinary approach, including those with skills in:

- Environmental land use planning and interface management
- Environmental science and impact management
- Environmental and adaptive management systems
- Coastal engineering and hydrodynamic modelling
- Transport planning and logistics
- Regulation and policy frameworks.

4.3 Considerations in master planning

Comprehensive port master planning (with a horizon of approximately 15-30 years) can facilitate efficient, economically productive and environmentally sustainable port development regardless of port size (current or projected), cargo type or environmental setting.

Port master planning typically includes technical detail of site layout, infrastructure requirements, trade forecasts, port efficiency analysis and strategies, and potential development footprints of port operational and buffer areas. Contemporary port master planning should also include the consideration of beyond the port issues including the interface and relationship with urban and regional communities, including traditional owners, environmental areas and essential transport and logistics networks.

A comprehensively prepared port master plan can help clarify and communicate the port vision; and provide for increased environmental protection and management of environmental values and assets through the early identification of valuable environmental features in the port environs.

Master planning typically follows site selection (Figure 2) but can also heavily influence siting options if conducted early in the overall process (or if conducted on a broader scale prior to port development consideration – for example, as part of a regional planning exercise).

Port master planning should include a number of over-arching considerations such as those detailed in Table 4 below.

Table 4 Over-arching master planning considerations

Master planning	
Key considerations	Reasons
• time horizon	• 15-30 years preferred (in line with recently endorsed National Ports Strategy)
• clear definition of port vision and intended development footprint	• clarity of vision – increasing confidence and understanding for all port stakeholders – internal and external
• opportunity for community engagement, ownership and transparency of port vision	• increased ownership from external parties
• associated, critical port infrastructure such as anchorage areas, shipping channels, wharf and trestle options, dredge and disposal sites that minimise negative impacts on the environment	• due consideration of ongoing operational requirements of the port – not simply, upfront establishment requirements
• changes over time which may influence/impact on design and operations (including sea level rise/climate change impacts)	• due consideration of potential impacts on the port facility over the life of the plan and beyond – infrastructure and environmental preparedness
• baseline values associated with particular area or region	• demonstration of early consideration of environmental values and assets
• whole of port environmental values and cumulative impacts, desired environmental outcomes and measures or activities to achieve these	• clear demonstration of management responses to potential strategic and cumulative development impacts on a whole of port basis
• buffers (important for conservation, protection and societal integration reasons)	• avoid impacts from incompatible, operational land uses on surrounding region
• longer term offsets and mitigation strategies.	• so that offset strategies can be considered on a strategic and region wide basis – not simply via 'project-by-project'

This study reviewed recent and relevant port master planning approaches where environmental values and impacts were comprehensively considered. It focussed on environmental management benefits of master planning and does not include commentary on the broader elements, functions and benefits of port master plans.

4.4 Literature review

Port site selection and master planning literature relevant to this study, and environmental best practice, is limited. However, the following sources were identified and reviewed as part of the literature review:

- The World Association for Waterborne Transport Infrastructure (abbreviated as PIANC) 'Working Group 158' – Port Master Planning Technical Report (international committee work currently underway)
- International Association of Ports & Harbours (IAPH) – Port Planning Guidelines (1999/2001)
- European Seaports Organisation (ESPO) – Best Practice Recommendations/Allied Policies (Codes of Practice etc.)
- UK Department of Transport 'Port Master Plan Guidance - Consultation Document' UK – 'Guidance of the preparation of port master plans' (2009)
- Applying Strategic Environmental Assessment: Good Practice for Development Cooperation (OECD Publishing, 2006)
- The European Strategic Environmental Assessment Directive.

A description of the first four documents is provided below.

4.4.1 PIANC Working Group 158 – Port Master Planning (international committee work underway at the time of print)

The objective of the PIANC Port Master Planning Committee's work is to outline sound practices for port master planning used at various locations throughout the world – to be published as a PIANC Technical Report by the end of 2013.

PIANC Working Group 158 comprises members from UK, France, Italy, Germany, Spain, Netherlands, US and Australia, including representatives from port owners and operators, port planning and engineering consultants, economists and maritime contractors. The committee was established in 2012 and has met six times, in UK, Valencia, Rotterdam, Brussels, Bremen and Marseilles.

Despite the work being work in progress, discussions with committee members has indicated the increasing awareness of the need for ports to take a broader view on port master planning – including the need for early and careful consideration of environmental issues as part of the overall process, including beyond the port boundary consideration of environmental, urban and operational issues.

Further, the undertaking of Strategic Environmental Assessments in parallel with the preparation of port master plans is also raised in the report as a model of best practice – enabling the early consideration of environmental issues. Such assessments can be undertaken at either the state, national or via international agreements (such as EU agreement level).

This report may provide further information to guide best practice port master planning for the Australian port industry and is expected to be available in late 2013.

4.4.2 PIANC Working Group - WG 150

PIANC are currently developing another Technical Report entitled *'Sustainable Ports: A practical guide for port authorities'*. Members of PIANC International Environmental Commission will be in Australia in September 2013 to outline the WG 150 Technical Report, however at this stage, the report remains confidential.

A Workshop has been scheduled for the upcoming Coast and Ports 2013 to be held in Sydney in September 2013, which will address:

- Dredging for sustainable ports
- Beneficial use of dredged material
- Beneficial use for reclamation of alternative materials
- WG143 Report (*'Initial Assessment of Environmental Effects of navigation and Infrastructure Projects'*)
- Regulatory considerations: approvals, licenses and conditions
- Offsets and ecological restoration
- Climate change (impacts, adaption and mitigation).

This upcoming PIANC information may provide further insight into international approaches to various interrelated environmental issues relating to seaports.

4.4.3 International Association of Ports & Harbours (IAPH) – Port Planning Guidelines

The IAPH is often referred to as a leading source of industry information because it is an international organisation representing port interests globally. The IAPH published Guidelines for Port Planning & Design in 1999 (2nd edition released 2001) as a result of many years of work by the IAPH Technical Committees. Despite being over 10 years old, the guidelines are still seen to represent sound principles for port planning.

The guidelines address a range of matters and include a clear statement on the need for increased focus on environmental management: '…*protection of the environment is an essential consideration if a port authority is to be allowed to fulfil continuously its major obligation. This means that, in the decision making process, the environment must be considered alongside economic aspects' (IAPH 1999, p14).*

The guidelines call for all ports to develop Environmental Management Plans and conduct regular Environmental Management Audits of operations. They outline major sources of potential environmental degradation, noting they most commonly occur during construction and operation: '*no port can be made environmentally harmless nor operationally totally safe. However, with adequate planning and design and the strict enforcement of codes and procedures, etc. for all parties involved…..damage and risk can be reduced to an acceptable level'* (IAPH 1999, p21).

This highlights the importance of early, comprehensive port master planning. The large majority of environmental impacts from either port construction or operations can be substantially avoided if comprehensive master planning is carried out in an integrated, collaborative manner.

4.4.4 European Seaports Organisation (ESPO) – Best Practice Recommendations/Allied Policy

The European Sea Ports Organisation (ESPO) was founded in 1993. It represents port authorities, port associations and port administrations of the seaports of the Member States of the European Union (EU) and Norway. Europe's cargo trade sees 90 per cent of goods passing through the more than 1 200 seaports in the 22 maritime Member States of the EU. More than 400 million passengers pass through Europe's ports every year (ESPO, 2012).

ESPO have developed several Codes of Practice for the industry:

- ESPO Green Guide 'Towards excellence in port environmental management and sustainability (2012)'
  - Annex 1: Good Practice examples in line with the 5Es
  - Annex 2: Legislation influencing European ports
- ESPO Code of Practice on Societal Integration of Ports (2010)
- ESPO Code of Practice on the Birds and Habitats Directives (2006)
- ESPO Environmental Code of Practice (2004).

The Codes of Practice offer very good examples of approaches to a range of contemporary port issues. ESPO strongly hold the view that port master planning can assist in addressing environmental management issues.

The ESPO Environmental Code of Practice, whilst written specifically for the European region, offers a practical example of a code of practice. It includes the 'Ten Commandments' (summarised below) for the operation of ports under the Code – which provide a practical working example of the commitment from industry to environmental management.

ESPO - ENVIRONMENTAL POLICY CODE	
The main environmental objectives which the EU port sector should aim to achieve are:	
1.	Contribute to the development of a sustainable logistics chain.
2.	Encourage wide consultation, dialogue and cooperation between port administrations and the relevant stakeholders at local level.
3.	To generate new knowledge and technology and to develop sustainable techniques which combine environmental effectiveness and cost efficiency.
4.	To enhance cooperation between port administrations in the field of environment and facilitate the exchange of experiences and implementation of best practices on environmental issues to avoid unnecessary duplication and enable port administrations to share the costs of environmental solutions.
5.	To increase awareness of environmental concerns and to integrate sustainable development into ports' policies.
6.	To encourage port administrations to conduct appropriate environmental impact assessments for port projects and appropriate strategic environmental impact assessments for port development plans.
7.	To stimulate continual improvement in the port environment and its port environmental management by promoting the use of Environmental Management Information System tools.
8.	To promote monitoring, based on environmental performance indicators.
9.	To promote environmental reporting as a means of communicating good environmental behaviours to stakeholders.
10.	To intensify the communication about environmental improvements achieved by ports.

The benefits of master planning and the early identification of issues and the undertaking of 'Strategic Environmental Assessments' for particular projects are highlighted in the Code, particularly in *'Part 3: Handbook of Recommended Environmental Practices'.*

4.4.5 UK Department of Transport 'Port Master Plan Guidance - Consultation Document'/UK – 'Guidance of the preparation of port master plans' (2009)

This document provides a useful summary of the benefits and processes involved in preparing master plan documents to assist with overall environmental management. The document acknowledges that project assessments provide greater environmental detail but suggests port master plans can play a key role in the early identification of significant environmental issues, which may lead to better decisions being made about the shape and form of port development:

'*The master plan may usefully include not only the port's plans to mitigate adverse environmental impact of new development, but also mitigation of the effects of everyday operations, and new measures specifically designed to improve the environment. It will typically not be possible to identify detailed mitigation measures at master plan stage: this will be done in the light of the project-related Environmental Impact Assessment (EIA) prepared (in most cases) subsequently. This being so, the master plan should describe the proposed environmental control measures in more general terms, and describe (preferably with a rough timeline) the work that is programmed to determine details. The master plan can, however, usefully contain descriptions of what the port already undertakes to mitigate its existing operational impacts*' (UK Government, 2009, p.11).

A particular example is provided regarding the site selection (and consideration of alternatives): '*The master plan process may, depending on timings, present a useful opportunity to test, in liaison with stakeholders, perceptions of what might constitute such alternatives, and whether or not they are in fact feasible.*' (UK Government, 2009, p.12).

The UK documentation supports the early identification of environmental issues and constraints as a critical and well-recognised advantage of undertaking port master planning.

4.5 Case studies

The examples of international best practice port master plans presented are:

- Port of Dover, UK
- Port of Vancouver, Canada
- Port of Khalifa, United Arab Emirates
- Port of Dublin, Ireland.

These ports were selected because:

- They offered access to relevant data as part of this desktop study
- Personal interactions from study team members with senior representatives of the relevant ports
- Recommendations provided by industry journals such as 'Port Strategy' *(recognised as a leading industry journal* – published in UK) and 'Ports and Harbors' *(Official Journal of the International Association of Ports and Harbors)*
- They provided examples of recent master planning work
- Study team members had professional and research experience at the ports.

Additional planning frameworks were also considered during this study including the Port of Singapore, Port of Rotterdam and Port of New Orleans (US). These examples did not present clear data or recent examples regarding port master planning activities relevant to this study.

The sections below detail the selected case studies.

4.5.1 Port of Dover, UK - 2003 Port 30 Year Master Plan and consequential master planning work at the precinct level

The Port of Dover 30 year master plan was the first undertaken in the UK. It has been acclaimed by the UK Department of Transport as a leading example of long-term planning. It was developed in two stages:

- Phase 1 beginning in 2003 with traffic forecasts and assessments of the existing and potential port capacities
- Phase 2 in 2004 involving the preparation of a staged development plan focusing on maximising the potential of existing footprints. It also examined conflicting information regarding alternative land uses and differing commodity advantages and disadvantages.

Since the master plan was developed the port's significant areas have been re-examined as part of ongoing work (e.g. Terminal 2 development works).

In early 2008 the port prepared a consequential, project based Environmental Statement (ES) as part of a Harbour Revision Order application (a component of the overall master planned area). The ES included detailed consideration of project alternatives, which resulted in reduced environmental footprint and impacts compared to alternative development scenarios – that is, the scenario testing as part of the exercise proved valuable in terms of avoiding potentially increased impacts.

The Port of Dover commits to environmental management and protection through its Environmental Policy and sub-ordinate policy framework and an EMS accredited to the ISO 14001 standard – considered very useful for seaport management and governance.

Aspects of the Port of Dover's master-planning that are considered an example of environmental best practice include:

- Ongoing, early and integrated assessment of environmental issues in long term master planning
- Strong governance commitment and follow-up
- Evidence of engagement throughout process
- Promoting early consideration of alternatives sites or development approaches
- Detailed collaboration with a range of stakeholders

4.5.2 Port Metro Vancouver, Canada – Visioning Process

In 2010 Port Metro Vancouver commenced 2050 strategic visioning which included scenario testing. The 2050 visioning exercise differed from traditional approaches to port master planning (which typically simply follow a 'Collect and Analyse - Inform and Decide - Plan - Monitor' methodology), which proved successful with a range of internal and external port stakeholders due to the clarity it provided – socially, environmentally and economically.

The scenario testing incorporated long-term thinking and footprint option analysis. This is a foundation principle of overall environmental management.

The scenario process resulted in substantial amendments to the port's Land Use Plan (the sub-ordinate planning level) where environmental management strategies are enacted. This is considered critical as the Land Use Plan provides the supporting regulatory tools to enable master plan visions and strategy to be implemented and realised 'on-the-ground'.

Aspects of Port Metro Vancouver's environmental management that are considered examples of environmental best practice include:

- Scenario testing, which promotes alternative option and environmental footprint consideration and analysis
- Governance commitment evident
- Included detailed collaboration with a range of stakeholders
- Port tenants and industry involved in process
- Enacts Master Plan vision and strategy via the regulatory tools contained in the Port Land Use Plan – considered fundamental for realising on-the-ground outcomes.

4.5.3 Port of Khalifa, UAE – Master Planning and Strategic Environmental Assessment

Khalifa Port was officially inaugurated in December 2012. It now handles all Abu Dhabi's container traffic. The port is part of a wider industrial development project.

A Strategic Environmental Assessment (SEA) was prepared and submitted to the Environment Agency of the UAE (EAD). The SEA considered the environmental aspects of the project during the master planning and design of the port and the industrial zone.

The SEA showed the project would have a significant impact on the sensitive and important coral reef habitat north of the proposed project area. As a result of these findings the port location and orientation were altered. The port design subsequently included the construction of an environmental permanent breakwater to protect the reef from construction and operational impacts, thereby avoiding potential impacts to known environmental values in the port.

Hydrodynamic modelling included in the SEA led to major changes in the design and location of the industrial area effluent outfall. A stringent continuous monitoring program was set up to facilitate minimal impact of the project on the water quality in the region. These mitigation measures have significantly reduced the environmental impact of the project thereby ensuring safe and sustainable operation of the port.

The inclusion of the SEA as part of the Master Planning phase is a central best practice theme running through this section of the report, however may not be appropriate in every circumstance due to a variety of factors (e.g. size and spatial nature of port, lack of ecologically sensitive or protected features).

Cole and Broderick (2007) suggest the Port of Khalifa SEA was undertaken voluntarily rather than following a regulated process such as the EU Directive 2001/42/EC. Cole and Broderick also suggest the SEA did not show a strong understanding of baseline information and had no real consultation or engagement apart from with the EAD. This suggests a significant shortfall in the process; however the balance of the SEA process led to significant environmental values being considered, identified and protected as part of the master planning work.

The aspect of Khalifa's environmental management that is considered as an example of environmental best practice is the Strategic Environmental Assessment (SEA) included as part of master planning – leading to the sound consideration, identification and avoidance of impacts on coral reef systems in close proximity to a proposed greenfield port development.

4.5.4 Port of Dublin, Ireland – 2012 Port Master Plan

The Port of Dublin's recent master planning process showcases a leading example of comprehensive master planning, including the preparation of a 'Strategic Environmental Assessment'. From the outset of the master plan process the port stated:

'The over-riding reason for producing this Masterplan has been to provide all of the Port's stakeholders with a clear view as to how the Port will be developed over the long-term'.

The provision of strategic clarity regarding the future of the port and its environs can bring substantial benefits, particularly from an environmental management point of view.

The planning process included an SEA. This was not formally required under law because the port master plan did not require approval by an administering authority, but the SEA was prepared to comply with the *EU Directive 2001/42/EC* (the SEA Directive).

The SEA process includes (Port of Dublin, 2012):

- Screening to determine if the master plan was likely to have a significant effect on the environment
- Scoping of the SEA and development of the SEA Scoping Report, including consultation with relevant stakeholders to identify any key issues and concerns
- Development of the SEA Draft Environmental Report to evaluate the significant environmental effects of implementing the master plan
- Consultation to facilitate the final review of the SEA Draft Environmental Report by relevant stakeholders, public, business, political and community groups
- Finalisation of the SEA Environmental Report with subsequent adoption of the Dublin Port master plan
- Development and publication of the SEA Statement, which documents how the SEA and consultation have been taken into account during the master planning process
- Monitoring the plan and preparation of the Monitoring Report.

The fundamental purpose of the SEA was to enable likely significant environmental effects of the preferred master plan options to be identified. Developing the SEA in parallel with the master plan meant environmental considerations and sustainable development decisions were able to be integrated into the decision making process.

The Port made all SEA technical documents publicly available on their website. This included:

- SEA Environmental Report
- SEA Non-Technical Summary
- SEA Post-Adoption Statement.

The inclusion of the SEA in parallel with the development of the master plan has been recognised throughout the port industry as a sound way to enable the early consideration of environmental management issues as this combined approach:

- Promotes early, high level strategic understanding of environmental factors (e.g. increased understanding of location specific environmental issues and values)
- Improves the quality of the plan making process (i.e. a more integrated, holistic process – not simply a design exercise, but one which considers the context and values of the specific setting – including the various stakeholders of the port e.g.: port tenants and transport and logistics operators)
- Helps to prevent costly (via economic and time delays) decisions (i.e. reduces the chance of costly decisions being made regarding development footprints and appropriate use areas)
- Facilitates the identification of alternative and differing opportunities for development (i.e. promotes the consideration of alternative options, such as reduced footprint and intensification options, and no-development scenarios)

- Increases the capacity of the plan to adapt to climate change (i.e. elevates the consideration of climate change in the master planning process – rather than simply being a design consideration at the project-by-project level)
- Strengthens governance and relationships with key stakeholders (i.e. promotes high level, ongoing engagement with critical stakeholders – government, community and interest groups)
- Improves regulatory alignment between neighbouring and allied government agencies (i.e. allows environmental issues to be identified early, thereby allowing associated plans and programs (administered by others) to benefit from the environmental learning).

The Port of Dublin SEA led to relatively few changes to the master plan. This is largely because the master plan was developed in parallel with the SEA. The environmental policies and practices already in existence at the port also show recognition of environmental responsibilities (including regulatory requirements).

Ongoing consultation and dialogue enabled potential concerns to be identified and means of addressing them were incorporated into the master plan proposals. The SEA post adoption statement notes *'the SEA records a number of measures integrated into the Masterplan as mitigation, including (for example) increased use of rail freight, and the relocation of the mooring structures (Dolphins) on which breeding tern colonies are located'.*

The post adoption statement (SEA Post-Adoption Statement, 2012) outlines amendments to the master plan as a result of the SEA, and consultation has included the strengthening of commitments relating to:

- Consulting with the National Transport Authority on any proposed projects
- Provision of supporting infrastructure, including wastewater treatment, water supply, surface and storm water drainage and waste management
- Consideration of the key sensitivities associated with specific developments, including the natural environment, built heritage and visual amenity
- Consideration towards protection against flood risk and protection of water resources
- Taking forward the remaining outcomes of the SEA and the Strategic Natura Impact Statement (sNIS).

The SEA made recommendations for initiatives to be taken alongside the implementation of the master plan, all of which Port of Dublin have committed to. These include (SEA Post-Adoption Statement, 2012):

- An Integrated Environmental Management Plan for the port area (working with relevant statutory and non-statutory stakeholders)
- A Dredging Mitigation Strategy
- A biodiversity, and flora and fauna audit of port lands
- A Port Wide Landscape Plan.

4.5.5 Appropriateness of the SEA approach

Undertaking a SEA may not be appropriate or applicable in all circumstances, however the principle of earlier consideration of environmental issues as part of overall port governance is considered fundamentally important for best environmental practice.

The SEA process can facilitate the consideration of cumulative impacts at the very early stages of project inception – a point that is of particular relevance when addressing potential impacts on MNES (short term and prolonged).

The Port of Dublin example demonstrates best practice integration of environmental considerations into master planning, in particular, the early integration of environmental and stakeholder considerations into the broader decision-making and governance framework. It highlights:

- Significant benefits of SEA conducted in parallel with the development of a port master plan rather than consequentially
- Comprehensive, early and integrated assessment of environmental issues
- Consideration of alternatives sites or development approaches
- Evidence of strong governance commitment including strong collaboration with a range of external agencies and stakeholders, open and transparent information freely available at all times regarding process, outcomes and implementation
- Application of the avoid, mitigate, offset environmental management hierarchy through early, integrated consideration of development scenarios
- An achievable process completed within a 12-month timeframe including the SEA, with results informing final Master Plan decisions.

4.6 Australian context

Governments in each Australian jurisdiction typically approach site selection based on the economic and social drivers of port development as outlined in Section 4.2. Recent work as part of the Australian Government's National Land Freight Strategy (Commonwealth of Australia, 2012) points towards new and expanded seaport sites being selected on the basis of proximity to existing or likely future surface transport networks. This trend is likely to continue as each jurisdiction looks at providing efficient and cost effective infrastructure solutions around the nation. As ports are just one part of the overall logistics chain, their location must be considerate of broader infrastructure elements. However, as discussed, there is a broader range of environmental considerations that should be weighted in the site selection of port development, in the move towards best practice environmental port development.

Many Australian ports have developed master plans in various forms over long periods of time. These documents are not usually published due to the inclusion of commercial-in-confidence material or where issues of cargo contestability are evident. This can create the impression that the master planning has not occurred. It is recommended that port master plan summary documents which protect commercial sensitivities are published to help better inform and include stakeholders. Such summaries could articulate the environmental management approach to be applied across the port-wide region.

The National Ports Strategy released in 2012 by the Council of Australian Governments outlines a renewed focus on port master planning. Whilst each jurisdiction will have their own view on the approach to port master plans, having a common port master planning framework would be very useful for forward planning activities and outlining the standards for what should be included in contemporary port master plans in relation to environmental performance. Alignment of port policy and planning was discussed more broadly during consultation on this report, as a potential means to achieve best practice port development in Australia. While the broader aspects of this have not been able to be explored in this report, it was discussed that alignment of legislation or requirements relating to port master planning could be particularly beneficial.

Ports Australia is currently developing a common framework and understanding for port master planning, which will assist in the understanding of master planning benefits and the key principles and contemporary methodologies for preparing such documents.

The incorporation of SEA as part of port master planning could be appropriate for Australia in some circumstances. The high degree of variability of port settings would necessitate an individual analysis of the benefits of a comprehensive SEA style assessment. Not all port master plans will require assessments at this scale, however, the key principle of early consideration of strategic environmental values and cumulative impacts is central to any assessment. More proactive use of the 'Strategic Assessment' provisions contained in Part 10 of the EPBC Act may be appropriate.

4.7 Summary

Rigorous site selection and comprehensive port master planning with an environmental management focus should form a central part of comprehensive coastal planning. In Australia, these two elements of the overall port development cycle are critical stages for the overall avoidance of environmental impact, as well as protection and ongoing management of MNES.

4.7.1 Site selection

Consideration of a range of social, economic and environmental factors will help avoid long-term and prolonged legacy issues for both the operations of the port and its environment. The site selection process should be informed by industry specialists from a cross-section of technical, economic, environmental, planning and social backgrounds to enable avoidance of significant impacts and early consideration of environmental values. Scenario testing is critical to minimise and understand the full scope of potential environmental impacts associated with different port development scenarios.

4.7.2 Master planning

Port master planning is an important foundation for overall port governance and environmental management considerations. In addition to normal operational efficiency and capacity considerations in a master plan, the port master planning exercise should seek to:

- Incorporate early protection and management considerations of environmental values, and implement the environmental management hierarchy of 'avoid/mitigate/offset (this may include undertaking strategic environmental assessments as part of the master planning process)
- Be informed by sufficient environmental baseline information at the site as well as the wider catchment, to understand the potential environmental impacts of the development as well as consider alternative development scenarios
- Engage stakeholders and promote transparency in port planning, including engagement with traditional owners
- Incorporate the principles of adaptive and responsive management
- Articulate the environmental and land use planning tools (e.g. Land Use Plans, Development Codes, Environmental Management Frameworks, etc.) to be applied to support the realisation of the master plan vision, including time frames
- Consider the underlying architecture of regional, state and national infrastructure networks
- Be underpinned by strong, proactive and coordinated governance

- Align with relevant planning and environmental policies at local, regional, state and national levels.

5. Environmental management responses and standards

This section identifies the management responses and best practice standards that ports outside Australia have made in response to the environmental impacts of port construction and operation. These responses address issues in two ways: through planning, design and construction; and through monitoring and ongoing-management. It is important to note that practices are constantly improving over time and any measures adopted should have an element of adaptive management and continuous improvement.

5.1 Water and sediment quality

Because ports are located on the coast, MNES related to the marine environment are of prime importance in this review. Activities resulting in threats to water quality are not surprisingly the most significant, and are the focus of much environmental management.

Poor water quality can have a number of impacts on the marine environment (Table 5). The impacts can result from:

- **Turbidity – the suspension of sediment in the water column**. Excessive turbidity can cause attenuation of light in the water column thus reducing the photosynthetic activity of marine plants including algae, seagrasses, phytoplankton and the symbiotic algae (zooxanthellae) in corals. The impacts of reduced light can be poorer health of the plants, reduced depths at which they may grow, reduced geographic range, sparser populations and altered community structures or species types. As marine plants form an important part of the structure of many marine communities the impacts of excessive turbidity can extend beyond the direct impacts on the marine plants themselves to other assets such as fauna in the marine ecosystem.

  Suspended sediments in the water column can affect animals that use gills to breathe as these can become clogged by sediments, which reduces their ability to breathe and feed. Visual feeders can find their ability to find food compromised and fish and other organisms that use visual cues to communicate can have behavioural disruption due to turbidity.

  When it settles, the suspended sediment will smother benthic organisms, corals, seagrasses and other environmental assets, reducing their ability to grow, and in the worst case leading to mortality.

- **Contamination** – sediment and water quality contamination may arise from port construction and operational activities as well as historic contamination of the port area from other activities. Water quality contamination can also occur from pollution, spills, cargo handling and stormwater runoff. Contamination can lead to organisms in the ecosystem ingesting the contaminated sediment, leading to impacts such as potential disease, injury or mortality. Likewise, higher predators in the food chain can eat contaminated organisms and be affected themselves. Contamination may also directly impact on sensitive ecosystems such as coral reefs and seagrass meadows.
- **Nutrient input** – excessive nutrients can cause algal blooms, phytoplankton blooms eutrophication and depletion of oxygen levels, which may directly or indirectly impact on sensitive ecosystems such as coral reefs and seagrass beds.

The most significant contributor to a decrease in water quality during construction is dredging. Maintenance dredging can also impact on water quality during operation.

Another major source of poor water quality in ports and surrounding waters is historic contamination levels in sediments and the past and present inputs from catchment sources.

There is also the potential for impacts on water quality from activities such as clearing of vegetation for construction, construction itself, releases of solid and liquid wastes and cargo handling.

Table 5 Threats, the actions that may cause the threat and the potential impacts of water quality

Threat	Activity (Potential Source of Threat) that may result in threat	Potential environmental impacts
Turbidity	Dredging Stormwater runoff Erosion as a result of construction activities Clearing of vegetation Disturbance of sediments through construction Alteration of hydrodynamic regimes through creation of/removal of structures in the marine environment Disposal of waste Return water from reclamations Catchment inflows	Light attenuation reducing photosynthetic activity Fouling of gills of fish and invertebrates Reduced visibility impacting behaviours such as predation, visual communication with conspecifics Increase in water temperature through absorption of solar radiation
Contamination	Dredging Stormwater runoff Erosion Clearing of vegetation Disturbance of sediments through construction Antifouling paints Sewage discharge including spills Garbage Hazardous cargo Return water from reclamations Catchment inflows Oil spill	Toxic impacts on fauna Contamination of food chain Human health impacts
Nutrient input	Dredging Stormwater runoff Erosion Clearing of vegetation Disturbance of sediments through construction Catchment inflows	Eutrophication Algal/ Phytoplankton/ dinoflagellate blooms which are potentially toxic to both animals and humans

Best practice approaches for managing threats to water quality are discussed by activity in the sections below.

5.1.1 Dredging

Dredging is one of the most common marine activities that can generate threats to water quality. The removal of sediment can generate turbidity arising from the mobilisation of sediment into the water column in various ways:

- At the sea-bed where the dredging is taking place through disturbance created by the dredging method
- Through the water column as material is brought to the surface by the dredging operation (if using a grab or backhoe)
- Near the surface of the water (overflow from the grab or backhoe, or overflow from a trailer suction hopper dredge or barge)
- At the location where the dredged material is to be disposed, if disposal at sea is used (and potentially beyond depending on sediment transportation due to currents and other factors).

Where the material to be dredged is contaminated then additional impacts can occur through the mobilisation of sediment through the water column that has the potential to generate impacts on the flora and fauna including food chain impacts.

Dredge spoil disposal and management is governed internationally by the 1996 Protocol to the '*Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matte*r' (the London Protocol), which came into force in 2006 (42 countries are currently contracting states to the protocol including Australia (IMO 2013)). The London Protocol is intended to eventually replace the London Convention (which came into effect in 1975) as an international measure to ensure control of pollution of the seas. The stated aim of the London Protocol is to protect and preserve the marine environment from all sources of pollution and for countries to take effective measures, according to their scientific, technical and economic capabilities, to prevent, reduce and where practicable eliminate pollution caused by dumping or incineration at sea of wastes or other matter. The mandatory requirements for the assessment of wastes or other matter that may be considered for dumping are set out in Annex 2 of the London Protocol including:

- Identification of waste prevention strategies
- Consideration of alternative options other than disposal at sea, including re-use, recycling, treatment, disposal on land etc.
- Characterisation of the material to be dumped
- Development of an action list to enable determination of the levels of contamination that will be considered acceptable for sea disposal
- Identification of suitable disposal sites
- Assessment of potential effects
- Monitoring
- Permit conditions.

Internationally, guidelines have been developed under the London Protocol and Convention, including guidelines for the implementation of the London Protocol at the national level, specific guidelines for assessment of dredged material, specific guidelines for other wastes that may be disposed of to sea, and guidance on action lists and action levels to assist regulators.

One of the important matters to be considered in the assessment of choice of method for dealing with material that is proposed to be dredged is the physical and chemical characteristics of that material. Sediments in the bottom of harbours have the potential to be contaminated from historic activities in the harbour and activities in the catchment. It is also possible that naturally occurring levels of metals and other chemical constituents in harbour sediments may potentially restrict disposal options. Many countries have developed national guidelines in accordance with the London Protocol to prescribe measures for the assessment of sediments and to define the decision making process about management of sediments to be dredged (examples include Chevrier and Topping (1998) for Canada; Cronin *et al* (2006) for Ireland; Helsinki Commission

(2007) for the Baltic States; Palermo *et al* (2008) for the US). These guidelines all have the same basic structure and approach. They all follow the principles of the London Protocol: avoidance of disposal at sea is the primary aim. If this is not possible the guidelines require characterisation of the sediments to assess the environmental risk they may pose so that options for management of the material can then be assessed. There is a general move toward as Cronin *et al* (2006) describe as '*... [a] more integrated assessment of the ecological risks associated with individual dredging and disposal activities.*'

The US Army Corps of engineers have been investigating risk-based approaches to dredging. This was initially focussed around the human health issues with dredging of contaminated material, but is now also focussed on environmental risks. Palermo et al (2008) have provided guidelines which include the need for risk assessment approach. Bride (2001) in a USEPA forum on managing contaminated sediments proposed the following actions for the US Army Corps of Engineers to improve the management of dredged material:

- Develop risk assessment guidance for dredged material
- Characterise and reduce sources of uncertainty in decision making
- Develop comparative risk methods
- Demonstrate the application of risk assessment in dredged material management
- Produce software, databases and models for risk-based decision making.

There has been considerable progress on these actions with the continued development of risk methods for assessing options for dredging and sediment characterisation. For example Bailey *et al* (2012) provide a review of risk-based approaches the development of screening criteria applicable to the beneficial uses of dredged material and Schultz and Borrowman (2011) describe the use of Bayesian models for risk analysis of dredging decisions.

Risk-based approaches for assessing dredging options are being recognised as best practice, particularly where they are applied in the early stages of decision making. For example, the HELCOM guidelines for the Baltic States propose a comparative risk assessment of disposal options to determine whether land disposal is less acceptable than other options including sea disposal if certain chemical criteria of the sediments are not met.

In Australia, the London Protocol is implemented through the *Environment Protection (Sea Dumping) Act 1981*, which includes the loading and disposal at sea of dredged material. The *National Assessment Guidelines for Dredging (NAGD)* sets out the framework for environmental impact assessment and permitting of the disposal of dredged material at sea. It provides more detailed guidance on the following processes to implement the Sea Dumping Act and the requirements of the London Protocol:

- Evaluating alternatives to ocean disposal
- Assessing loading and disposal sites
- Assessing potential impacts on the marine environment and other users
- Determining management and monitoring requirements.

The NAGD identify that comparative risks to the environment and human health of alternatives options are an important element of the assessment. Section 4.3.2 of the NAGD identifies that a risk assessment may be required to identify the potential impacts of loading and disposal of material to be dredged. In Australia there are also a number of state guidelines for assessment of marine dredging projects. These include the Western Australian (WA) *Environment Assessment Guideline for Marine Dredging Proposals* (WA EPA, 2011) and the Victorian Government's *Best Practice Environmental Management: Guidelines for Dredging* (Vic. EPA, 2001). Neither of these guidelines make specific reference to risk assessments of potential impacts of dredging projects, however the WA guideline does recommend monitoring and management plans should '*ideally be risk-based'.*

Impacts of dredging and disposal

There has been a range of investigations in the published literature on the impacts of dredging and disposal of dredged material. Recently a number of papers have reviewed the impacts on particular environmental values such as seagrasses and corals.

The impacts of dredging on seagrasses have been reviewed by a number of authors including Erftemeijer *et al* (2006) and Cubaço *et a*l (2008). The authors of this latter paper concluded that 'Meaningful criteria to limit the extent and turbidity of dredging plumes and their effects will always require site-specific evaluations and should take into account the natural variability of local background turbidity'.

Erftemeijer et al (2013) reviewed the available literature on the sensitivity of coral to turbidity and sedimentation largely as a result of dredging activities. These authors found that coral species exhibit a wide range of sensitivities to turbidity and sedimentation and that coral reefs are exposed to a wide range of natural variation in these parameters. Erftemeijer *et al* (2013) concluded that 'meaningful criteria to limit the extent and turbidity of dredging plumes and their effects on corals will always require site-specific evaluations, taking into account the species assemblage present at the site and the natural variability of local background turbidity and sedimentation.'

A number of impacts of dredged material disposal on the marine environment have been reported with varying results in terms of the scale of impact and the timeframe for recovery. OSPAR (2009) reported that only limited information was available on the overall impacts of dredging on marine communities, habitats and ecosystem processes. They found that generally faunal communities at disposal sites contained less species and had lower biological production than other comparable areas. Fredette and French (2004) concluded that offshore from the New England coast of the US thirty five years of dredged spoil disposal had revealed impacts that were short term and near field. Schaffner (2010) investigated the impacts of two disturbance events resulting from dredged material disposal on the macrobenthos of Chesapeake Bay in the Eastern US. She found it took 18 months or less for the recovery of the macrobenthos in terms of species richness, abundance, biomass and community structure following the cessation of dredging activities. Borja et al (2010) undertook a review of responses to disturbance and found that although there were cases of recovery of marine ecosystems to disturbances at time scales less than five years full recovery from long-term disturbance can take a minimum of 15 to 25 years. Bolam et al (2006), Bolam et al (2011) and Bolam (2012) investigated the impacts of dredged material disposal at 18 different locations in the coastal waters of the United Kingdom and reported that impacts were largely site-specific.

Cooper et al (2011) assessed the impacts of changes in sediment particle size characteristics following dredging and the impact on macrofaunal communities and found that there were impacts and that there were related to the types of taxa present and the type of sediments that were being disturbed. This again reinforces the site specific nature of the relationship between disturbance and impact.

Mechanisms for mitigation of environmental impacts

There are many methods for avoiding or minimising environmental impacts of dredging (PIANC, 2010) and new methods are constantly being developed. Best practice is the application of the most appropriate technology to achieve the desired environmental outcome at any specific site.

PIANC (2006) provide guidance on the assessment of potential environmental impacts associated with dredging and disposal operations through appropriate application of environmental risk assessment methods. PIANC recommend the use of risk assessment methods to assist with the choice of disposal options as well as the identification and management of environmental risks once a disposal method has been chosen. They emphasise the need for a deliberate, transparent, site specific approach to the characterisation of risk and the development of appropriate management measures. PIANC (2006) identified that generic standards, guidelines and criteria may be:

- Blind to site specific conditions or influences
- Fixed in time and not able to incorporate advances in assessment technologies or mitigation options
- Not be applicable to all situations
- Unable to incorporate uncertainty into the assessment process
- Not capable of addressing all the risks associated with an action as the guidelines / standards / criteria have a fixed subset of environmental impacts that need to be addressed.

PIANC (2006) strongly advocate the use of a risk assessment to identify environmental values, identify the threats to those values and for use in the identification and application of dredging methods and mitigations measures that may be required. The scientific literature on the impacts of dredging on sensitive environmental values such as seagrasses and corals conclude that potential impacts need to be considered on a site specific basis. There are a wide range of options for the management of dredged material with new methods becoming available all the time. The risk assessment approach where specific information is collected about environmental values, specific consideration is given to the threats that a dredging program may have to these values and a risk-based choice of mitigation measures (including choice of dredging and disposal technology) is considered best practice for environmental management of dredging projects.

There are many examples where risk methods have been developed as a tool for decision making in dredging projects. Cura et al. (2004) note the implementation of risk assessment methods is widely practised in the US; however these authors conclude that many of the approaches were inherently subjective and more robust approaches were required. There have been advances in the development of risk assessment methods since their review and the applicability of risk assessments to decision making in dredging projects is now more widely accepted (Bridges *et al*., 2010, Wasserman *et al.*, 2013).

Recent examples of the development of risk assessment methods to dredging include:

- Perrodin et al (2012) who applied an ecotoxicological risk assessment to assess the risks of filling old quarries in France with dredged sediments from port dredging. A specific method was developed to assess sediments from three ports.
- Stelzenmüller et al (2010) who developed a risk assessment method for assessing the impacts of aggregate dredging on 11 species of fish and shellfish on the UK continental shelf.
- Choueri et al (2010) presented a method for undertaking ecological risk assessments of sediments from ports and estuaries around the Atlantic Ocean.
- The US Army Corps of Engineers who conduct much of the dredging in the United States have been using risk assessments to inform decision-making in dredging projects since the 1990s (US Army Corps of Engineers / US Environment Protection Agency, 1992; US EPA 1992; Moore et al 1998, Bridges et al 2008). Decision models have routinely been

used to assist options selection for dredging projects in the US (Schultz and Borrowman, 2011) including the use of Bayesian networks to model dredging decisions.

The outcomes of risk methods such as these drive the selection of techniques to avoid or minimise potential environmental impacts. Some examples of these techniques are presented in the following sections. It should be noted that there are many techniques available to address the environmental issues that may result from dredging, ranging from the simple such as choosing a time of year that avoids a sensitive life stage of an animal, to very expensive high technology solutions such as the construction of a purpose-built plant to treat dredged material. The choice of technique is likely to be specific to the dredging program in question and what works for one program may not be the most appropriate solution for another similar dredging program.

The use of risk methods such as those discussed above are entirely appropriate in the Australian context and are also widely accepted by many government agencies in Australia, The approach proposed by the Victorian Environment Protection Authority (EPA) for the assessment of risk of discharges which is line with the approach adopted for water quality and sediment assessment in *Australian and New Zealand guidelines for fresh and marine water quality* (ANZECC 2000). The Victorian EPA's publication 'Guidelines for Risk Assessment of Wastewater Discharges to Waterways' (Vic EPA, 2009) provides a good summary of the approach to risk assessment with examples of its applicability to water quality management which could equally apply to the management of dredging activities.

Dredge methods

Key concerns while dredging is occurring are the potential for turbidity, the spread of contaminated sediments and direct impacts to the seabed and benthic communities. There are a wide range of techniques that provide for the avoidance or minimisation of these impacts, with new techniques being devised as new situations arise. Some of these techniques relate to the operation of the dredge, whilst some are external to the dredge.

Dredge methods include some highly specialised technologies, contracting arrangements, software and management practices which can all be used to assist in the protection of the environment. Methods to address particular situations vary depending on factors such as:

- The type of material to be removed. Fine muds and coarse gravels may require different dredging technologies and may pose a different risk to the environment so can be treated differently. Finer material has a greater propensity to contain contaminants than coarser material so may need to be treated differently
- Hydrodynamic conditions. Differences in the strength of currents and or waves may influence the choice of dredging equipment
- Depth of water in which dredging is to occur. Many dredging technologies such as backhoes have a depth limit
- Tidal range. As for depth a high tidal range means that technologies such as backhoes may be not able to be utilised for much of the tidal cycle because of depth restrictions
- Seasonal conditions such as the cyclone seasons. Dredging is preferred for times when there are not risks from severe storm events
- Presence of infrastructure such as wharves, which may impede dredging
- Navigational constraints. The access to areas to dredge may be constrained by the need for the port to keep operating, frequently a concern for naval ports

- The level of environmental risk that needs to be managed through the choice of dredging technology.

Each technology is best suited to particular conditions and it is not uncommon for a number of dredging approaches to be applied to the one project. The construction work for the Port of Khalifa Port and Industrial Zone required the use of several dredges including a trailing suction hopper dredge with shallow draft for dredging soft sediments, a stationary seaworthy cutter suction dredge for pumping dredged material directly to the reclamation, heavy duty rock cutting sea-going self-propelled dredgers and a series of barge mounted backhoe dredgers and mobile crane mounted grab dredges to bring material directly into the reclamation from either a barge or from the sea floor.

The project area was up to 18 kilometres offshore and one of the main environmental aims was the protection of nearby coral reefs. Monitoring programs provided continuous feedback for the dredging operations so that agreed environmental standards were met. Changes to equipment were required during the project due to higher than expected silt content in the material for the reclamation and different dredging equipment was better suited to the handling of the sediments. It was initially proposed that a spreader pontoon was to be deployed; however this did not give the expected results. Therefore water injection vessels *WID Roomklopper* and *WID BKM 100* were brought to the project to work alongside the *Alpha B*.

This example shows the wide range of dredging technologies that may need to be employed to achieve project goals, including the environmental goals of the project. It also illustrates that there may need to be changes to the range of technologies employed as the project proceeds should the need arise.

Best practice environmental management approaches for dredging must include identifying environmental values that may be at risk; and selecting the correct mitigation measures to manage them. Summaries of available techniques are provided in a range of guidance documents, principally those produced by PIANC, including:

- Environmental Risk Assessment of Dredging and Disposal Operations – 2006
- Biological Assessment Guidance for Dredged Material – 2006
- Dredged Material Management Guide – 1997
- Dredging and Port Construction around Coral Reefs – 2010
- Long-term Management of Confined Disposal Facilities for Dredged Material – 2009
- Management of Aquatic Disposal of Dredged Material – 1998
- Environmental guidelines for aquatic, nearshore and upland confined disposal facilities for contaminated dredged material – 2002
- Dredging Management Practices for the Environment – a structured selection process – 2009.

One consistent message is that each project is unique and will require a specific approach or combination of approaches. These documents describe standard techniques. Other highly specialised techniques suit particular circumstances and new techniques are often developed in response to particular project requirements.

Operational measures outlined in the international guidelines as best or good practices that can assist to reduce impacts on water quality include:

- Reducing the rates at which material is removed from the seafloor, which can assist in reducing environmental impact. Reducing the rate lengthens the time of dredge operations so other impacts may be prolonged.

- Limiting the speed of the cutter head reduces the amount of material that passes into the water column rather than into the dredge. This slows the rate of dredging and also lengthens the time of dredge operations which may mean that other impacts of the dredging operation may be prolonged.
- Changes to dredge operations in response to site conditions including tides, wind and natural turbidity of the waters to minimise the influence of increasing turbidity. Again these measures have the effect of prolonging the dredging but may reduce the overall environmental impact.
- Scheduling construction to avoid critical times of the year when sensitive environmental events are likely to occur (such as coral spawning and turtle nesting). These options can remove the risk for particular fauna or ecological components but may put other environmental values at risk.
- No overflow dredging where the dredge or barge is moving to the disposal area once the water sediment mixture reaches the capacity of the hopper. In comparison, overflow dredging allows for sediment laden waters to be released to the environment which may increase turbidity in the waters around the dredge
- Monitoring used as feedback to alter dredging activities in both the short and long-term.

Techniques that are external to the dredge and outlined in the international guidelines as best or good practice to reduce water quality impacts on the environment include:

- Use of rigid barriers or sheet piles to prevent the movement of sediments away from the location of dredging. The area in the sheet pile can be drained of water creating a coffer dam (which will further mitigate movement of sediments and can also mitigate noise impacts). Sheet piles are expensive to install particularly if large areas are to be enclosed and their installation is generally through piling, which can have its own environmental impacts, such as excessive noise. They are effective only for small scale dredging operations, and are time consuming to build and inflexible. Sheet piles are often used when highly contaminated materials are being dredged.
- Protective silt curtains or screens, which are typically a geo-textile sheet attached to floats that are weighed down to the sea floor and anchored in place. These are used to minimise the transport of sediment from dredging operations to adjacent waters or they can be placed around sensitive environments. Silt curtains are a common feature of small scale dredging and marine construction in ports. They are generally used with mechanical dredgers and may reduce the loss of suspended sediments from the dredge area by up to 75 per cent. Their application is best when current velocities and wave actions are very low. They can be very effective in reducing the aesthetic effects of dredging by trapping the surface dredge plume. Silt curtains can be used around disposal areas as well as the area where sediment is being dredged.
- Bubble curtains are sometimes used in place of silt curtains. These tend to be effective but are difficult to deploy in all but very small dredging operations. Bubble curtains have the advantage that vessels can move in and out of the protected area without having to partially dismantle the protective device as would happen with silt curtains or rigid barriers. They may also help to mitigate noise impacts (see section 5.2).
- The use of a contained sediment transport system to move sediment from the site of dredging. Pipelines themselves can create environmental impacts and can be a hazard to navigation. Failure of a pipeline can result in dredged material being released into undesired locations. Pipelines are generally used where sediment is used for reclamations or land based treatment or disposal.

There are many examples of dredging programs which involve the above techniques and PIANC (2010) describes many examples of the application of these different dredge technologies.

Timing of dredging activity

In addition to technical approaches to mitigation there are instances where the impact on identified environmental values can be mitigated through the timing of dredging. There are sensitive periods for biological and ecological processes including, but not limited to:

- Migration of marine mammals, fish and birds
- Spawning seasons
- Growing seasons for marine flora including seagrasses
- Critical times of the day for feeding or other activities of fauna
- Critical periods for reproduction such as coral spawning
- Critical periods where an ecosystem has reduced resilience from, for example, an extreme weather event.

Timing of dredging activities can be related to tide or season. In the United Kingdom dredging is only undertaken on the ebb tide to reduce impacts on shellfish communities (Murray 1994). In the New York and New Jersey Harbor Deepening project in the US, dredging is not permitted from February to May to protect the eggs and larvae of the Winter Flounder from dredge induced disturbances (Bridges *et al* 2012). In the James River, which comprises part of the watershed of Chesapeake Bay on the east coast of the US dredging is currently banned at the times of spawning of certain fishes (Balazik *et al,* 2012).

These restrictions involve the development of a good understanding of the biology of the fauna to be protected across all life stages and where this is understood it should be incorporated in dredging operations as a component of best practice.

In Australia there are examples where dredging is undertaken at specific times to manage impacts. Most of the large dredging projects in Queensland, for example, have restrictions on the timing of activities to avoid sensitive times of the year such as turtle nesting. The Victorian dredging guidelines provide calendars identifying the times of year when fish eggs, larvae and adults may be vulnerable to the impacts of dredging activities.

Maintenance dredging

Maintenance dredging is frequently required in port areas to maintain the navigability and safety of harbours and shipping channels during the operation of the port. The required timing and frequency of maintenance dredging varies depending on the location of the port and environmental factors such as the rate of build-up of sediments in the channels. The choice of channel location and design that is undertaken during the planning and design phases of a port may be able to have some influence on requirements for maintenance dredging. The costs of maintenance dredging are a consideration in the design of new ports and minimisation of maintenance dredging requirements is always sought. Maintenance dredging however occurs at existing ports where there is almost no opportunity for modification of the design of channels, berth pockets and turning basins to minimise the amount of maintenance dredging required.

Maintenance dredging can have similar environmental consequences to capital dredging except that the material to be dredged generally forms part of an existing dredged area rather than a new undredged area. Dredging volumes are also generally lower than a capital dredging campaign.

In some instances maintenance dredging can be avoided through the use of technology. This may assist in avoiding benthic habitat disturbances and impacts associated with spoil disposal. An example is mobilising sediments to stop them settling into the dredged areas or the remobilisation of sediments into the water column soon after they have settled. This is practiced at the Columbus Street Terminal in the Port of Charleston, South Carolina, US, where a water jet system is employed to maintain a current across the bottom of the berth keeping the sediment in suspension. As a result, the requirement for maintenance dredging and consequently some the environmental impacts associated with maintenance dredging have been reduced. The port reports that this method for reducing maintenance dredging has saved over $7.5 million in dredging costs per annum.

Another approach is deployed in the Bremenports, a major port located near the Wadden Sea World Heritage area on the northwest coast of Germany. Here water injection systems using specially modified vessels prevent sediment from settling in the channels and berth pockets and are also used to remobilise sediments that have settled. The vessels draw water from higher in the water column and then use a tube fitted with jets to inject it into layers near the seabed creating a current that mobilises the sediments.

These techniques may only be considered best practice in certain locations and environments. Before adopting these approaches ports much consider whether there are likely to be other environmental impacts from the continued resuspension of sediments: Resuspension of sediments to avoid maintenance dredging is likely to be appropriate only where there are existing high sediment loads in the water column. Ports located in rivers or estuaries are most likely to find such technology useful.

Dredge spoil disposal

There are several options for the management of dredge spoil. These are:

- Land-based disposal or reuse
- Treatment of the material using a chemical, physical or thermal process.
- Unconfined disposal to sea
- Confined disposal at sea

The London Protocol requires an assessment of alternatives to disposal at sea and waste minimisation as the first action in dredge planning. This can result in removing environmental threats to the marine environment, although terrestrial environmental impacts need to be considered. However, in many cases this may not be an option and therefore disposal at sea is used. The following sections examine international best practices for all four of these options.

Land-based disposal or reuse

Uses of dredged material that are alternatives to marine disposal as identified in the literature include:

- On shore treatment and disposal of sediment
- Land-based disposal (such as land fill)
- Re-use of sediments, such as:
  - Fill for construction purposes
  - Use of dredged sediments in the construction of the port, for example to build a solid wharf
  - Use of dredged material to create new land that is not port related (reclamation)
  - Creation of habitat (that may potentially support offsets).

There are guidelines in place in a number of jurisdictions that regulate the disposal of dredged material on land. In New Brunswick on the east coast of Canada the '*Guideline for The Siting and Operation of a Dredging Material Disposal Site on Land – 2001*' addresses concerns about the potential impacts of the placement of dredged material on aquatic habitats and fresh waters both surface and groundwater.

Land-based CDFs for the disposal of dredged material is commonly practiced in the United States. Much of the dredging in the US is of riverine sediments and in water disposal is impractical as such the development of what are known as 'upland' CDFs is a widespread practice.

Case study - Delaware River Main Channel Deepening Project

The Delaware River Main Channel Deepening Project which was undertaken by USACE for the Philadelphia Regional Port Authority. In this project nearly 9 million cubic metres of silt sand and gravel were disposed of to five upland CDFs. These sites had all been used for disposal of material recovered during maintenance dredging programs at the port. Another 3 million cubic metres was clean and could be disposed of to sea. Contaminated dredged material was pumped into federally-owned CDFs. Within the CDFs dredged material was placed behind dikes designed to contain and isolate the material from the surrounding environment. The dredged material pumped into the CDF contains considerable volumes of water that is discharged back to the river. The water is retained in the CDF until the solids settle out. The material is pumped directly to the CDF from the cutter section dredge which is removing the material from the seafloor. The sediment to water ratio varies from 25 per cent to 75 per cent.

The CDFs are owned by the Federal Government with some having a long history as disposal sites for dredged material. The Fort Mifflin CDF has been used as a dredged material placement site since the late 18th century.

Analysis

The potential to use CDFs depends on the availability of suitably located sites. The Delaware River location had long standing sites located adjacent to the dredging operations. The land for these locations has to be committed to the purpose of a CFD essentially permanently. In Australia many ports would not have access to suitable land within a distance that would make pumping of dredged material acceptable. There is also the issue of the return water which would also likely require treatment before release back into the oceanic or estuarine environments. Many of the CDFs are allowed to dry out an option which would potentially not be available in northern Australia where the large amounts of rain in the wet season potentially preclude drying of a CDF.

As with other options for dredge spoil management there may be situations in Australia where the construction of a CDF may be the most appropriate answer.

Onshore-treatment and disposal is also practiced by the Bremenports in Germany where disposal of contaminated sediments is not permitted in the marine environment due to the level of contamination of the sediments in certain parts of the port exceeding German guidelines for sediment disposal at sea. Dredged material from mooring basins in Bremerhaven is generally uncontaminated such that it can be used for construction projects or dumped in the Outer Weser. However, the muds from the harbour basin, are contaminated with the antifoulant tributyl tin (TBT) so cannot be used. For the past fifteen years contamination levels of the sediments exceed the guideline levels for sea disposal in the marine area, including the Wadden Sea World Heritage Area. Therefore, the material is taken to a 127-hectare site on the right bank of the Weser in Bremen-Seehausen to a biological sewage treatment plant and then disposed of to a land fill at the same location. Bremenports report that the facility is likely to be useful until 2030. This type of approach requires a large area of land that is available for the storage of often-saline dredged sediments and as such the land must not be required for other purposes. The alienation of large areas of land near major ports is not often feasible and is certainly costly. The material may also need to be managed to avoid ongoing environmental issues particularly if there are contaminated sediments in the dredged material. It may be important to contain the material to the site such there are not issues with dust and odour.

Disposal to landfill is another land-based option, but is likely to be the least preferred option as an alternative to marine disposal because of pressure on landfills from other waste streams. Landfill would generally only be used for small amounts of dredged material, and in particular dredged material that may be contaminated.

Many locations where dredging is required do not have the land for storage of dredged material that ports such as Bremenports have available. There is a need therefore for finding other uses for dredged material if dredging is to continue without marine-based disposal. There are many examples of ports re-using dredged material:

- Dredging has for many years been used to source material such as aggregates for activities such as road construction. In fact, 20 per cent of the aggregates used in road making in the United Kingdom is sourced from marine sources recovered by dredging, comprising some 20 million tonnes per annum (British Marine Aggregate Producers Association, 2013). It should be noted that this dredging is specifically aimed at recovering aggregates for use in construction and that these are not a by-product of dredging for other purposes.
- The Port of Baltimore was faced with no longer being able to dispose of material into Chesapeake Bay as a result of changes in the regulations governing the degree of contamination of sediments allowed to be disposed of to sea. It has been providing dredged material for use as building material such as bricks and concrete as well as providing aggregates for road building and capping materials for landfills.
- The STABCON consortium in Sweden has been developing a guideline for the beneficial use of contaminated dredged sediments so that they can be used in port construction.
- The joint effort between the Maritime and Port Authority of Singapore and New Earth Pte Ltd has developed what is termed Crystallisation Technology to recycle maritime and other industrial waste products into value-added construction materials. The process is claimed to treat contamination and stabilise heavy metals such that the dredged material can be used for construction and other industrial purposes.

So the concept of re-using dredged material for purposes other than reclamation and habitat creation is well established. There are many new approaches to the treatment of dredged material to extract useful commodities, particularly for removing contaminants which can be a constraint on final use (see Port of Antwerp example below).

Dredged material is also often re-used internationally for reclamation and habitat creation, sometimes as offsets for environmental damage that may have been identified as occurring in other parts of the same or other projects undertaken by a port. These projects often involve collaboration with not only government agencies but also environment and community groups. There is a wide range of these projects worldwide.

Case study – Houston Ship Channel dredging and habitat creation

The Houston Ship Channel Expansion in the Gulf of Mexico in the US used dredged material for habitat creation. Disposal of dredged material to sea or in Galveston Bay was ruled out as an option as there were no available sites for ocean disposal. The Port of Houston and the US Army Corps of Engineers sought then to develop a proposal simultaneously to find a way of disposing of dredged material as well as providing benefits for the environment and fisheries. Stakeholder involvement through an Interagency Coordination Team was responsible for the planning, engineering and post-project monitoring of environmental issues. Eight government agencies were involved in the task of identifying environmental and economically viable options to utilise the material dredged from the project. The project consulted extensively with a wide range of stakeholders including many who were initially opposed to the project. The project has seen the creation of a wide range of habitats for birdlife, which had been lost since the early 1990s through erosion of natural islands in the area. In addition the project has seen the creation of intertidal marshes and the reconstruction of large areas of oyster bearing substratum.

Analysis

This example was considered best practice because it involved the use of dredged sediments as an alternative use that had environmental benefits. Local environment groups had opposed the placing of dredged material in the open bay and there was a need to find alternative uses of the sediments. The interactions between the port, government agencies and the local community were successful in developing a strategy to use the sediments for environmentally beneficial purposes. The Interagency team that was developed has gained considerable experience which has been used to manage the wide habitats of Galveston Bay so the project has had an influence beyond the particular dredging project. The project commenced in 1997 with funding from a bond issue of $130 million and there has been general acceptance of the benefits of the expenditure.

The use of dredged material for habitat creation is potentially a technique that could be applied in the Australian situation. If there are suitable locations for the disposal of marine sediments that do not impact upon existing environmental values then there are no particular constraints to the application of this type of approach in Australia.

Treatment of dredged material

Re-use of dredged material for construction purposes such as in reclamations, creating habitat or as a building material usually minimises rather than avoids the need for disposal of sediments either to land or sea. In most cases only some of the material is likely to be suitable for use as a construction material. The type of dredged material most likely to be unsuitable for construction is fine muds because they tend to have a higher organic content are more likely to be contaminated than clean sands. Dredged material is likely to need to be dewatered. The dewatering would create a waste stream that may need to be treated before it is discharged to the environment. Return water discharge is generally treated as stormwater and the guidelines for stormwater treatment usually apply.

Many innovative approaches to the management and treatment of dredged material are emerging. In France, Ramaroson et al (2012) assessed the technology of treating heavy metals from dredged sediments to convert metals, mainly Lead, Cadmium, Zinc, and Copper, into insoluble metallic phosphates to engineer the properties of the final residues for beneficial use. In Italy, Colombo et al (2012) looked at thermal treatment of dredged material to decontaminate a vitrify the sediments and their results showed that contamination of treated sediments were well below required levels of contamination. These examples are two of many experimental approaches to the treatment of dredged material to find useful products rather than disposal to sea or to landfill. Enzyme based treatment of dredged material has been explored by She et al (2012) where they treated 2 million cubic metres of dredged material in Guangzhou China. They found their technology reduced the levels of organic contaminants in the sediments as well as improving dewatering. There are many other examples in the literature of the application of new technologies to this field and the options for treatment and reuse of dredged material will expand rapidly over the next few years as these methods become commercially available.

In Australia there are no large scale projects with treatment of dredged material for alternative uses. There are examples where contaminated material is treated, usually as a result of the material being potential acid sulphate soils prior to disposal at a landfill. Landfills will not generally accept acidic soils so that neutralisation is required before disposal. The amounts of dredged material treated in this manner are generally small in size due to treatment costs, the availability of a suitable area to treat the sediments, landfill costs and availability of landfill sites.

Land requirements to store large amounts of dredged material may be significant. For example if the dredging was to remove 20 million cubic metres of sediment then this would occupy ten square kilometres if placed in a layer two metres deep. There may not be areas of land that large available to some ports that can be covered with salty sediment which will also have considerable amounts of water that will need to be treated before being discharged back to the sea. Therefore construction of a treatment facility may be a feasible alternative on economic as well as environmental grounds.

Case study – Port of Antwerp AMORAS Treatment Plant

The Port of Antwerp has determined that disposal to sea of maintenance dredge spoil is environmentally and economically unsuitable. Land disposal is considered the only option, however the volumes of dredged material are relatively large and current land-based disposal options are not sufficient to store the volumes of sediment that are expected to be generated from what is essentially a continuous dredging program. The port has therefore developed the AMORAS project (Antwerp Mechanical Dewatering, Recycling and Application of Silt) to treat sediment on land and then use it in applications offsite.

Material is dredged and then placed in a temporary underwater storage cell with a capacity of 300,000 cubic metres from where the material is pumped to a sieving facility where coarse sediments (>8 mm) are removed. The remaining material is then pumped over a distance of four kilometres to the treatment plant proper. The treatment plant consists of four large consolidation ponds each with a capacity of 120,000 cubic metres where further treatment and separation based on level of contamination takes place. The remaining fine fraction is then mechanically dewatered with the water being treated prior to being discharged back into the harbour. The material generated from the projects is used for clays are proposed to be used as building bricks, fine material is used in concrete and coarser material is used as bulk for road building. The plant can handle up to 2.6 million cubic metres per annum of dredged material and produce 600,000 tonnes of dry material per annum while treating 2.1 million cubic metres of water.

The AMORAS project is an innovative approach to solving the problem of dealing with sediments where disposal at sea is difficult or not environmentally appropriate and there is insufficient requirement on land for large volumes of dredged material. This is an example not only of avoiding disposal at sea, and all the consequential environmental impacts, but also of providing substitute sources of product (such as road building material that would otherwise need to be sourced through other means such as mining in quarries). The project therefore helps reduce the pressure on other parts of the Belgian environment as well as the estuary and the marine environment. The pumping of the material to land also allows the use of a small cutter suction dredge rather than a trailer hopper suction dredge which reduces the impacts of turbidity in the estuarine environment, a further benefit.

The project cost €482 million to construct and €22 million annually to operate. There is no comparison cost of alternatives for the Port of Antwerp as this was the only feasible option that would allow the port to continue to operate.

Analysis

This project was chosen as a case study because it demonstrates an innovative solution to the problem of dredge spoil management with limited options. All of the alternative options such as sea disposal were considered environmentally and socially less attractive than the development of the treatment facility. If the facility produces materials that can be used outside the port, such as road making and building materials, then the benefits of this plant will extend beyond the boundaries of the port. Pressure of alternative sources of these materials will be reduced.

The construction and operation of a treatment plant such as AMORAS may be suitable in certain circumstances in the Australian context. There are particular requirements that would need to be met such as the availability of suitable land close to the site of dredging. The environmental impacts of the construction and operation of the treatment facility would also need to be considered including noise and odour. It is likely that treatment plants such as this would not be appropriate for ports in Australia in urban settings.

The cost of the construction and operation of such a plant would also need to be considered. AMORAS costs €22 million annually to operate and can treat 500 000 cubic metres of sediments, which is approximately €44 per cubic metre and relatively high compared to ocean disposal costs. Ocean disposal costs however do vary and the treatment plant approach may be cost effective should the costs of dredged material disposal through other means prove to be more expensive.

In situations where marine disposal is not appropriate due to potentially significant environmental impacts and where there is limited land available for disposal, an approach similar to AMORAS is clearly feasible. The development of a treatment facility may even be feasible in large capital dredging projects.

Port of Antwerp 2013

Unconfined ocean disposal

While land-based disposal and re-use is used by a number of ports overseas, the most common international practice is unconfined ocean disposal: material is transported to designated areas known by a range of terms including ‘spoil ground’ or ‘dredged material disposal ground’. Material is loaded onto the dredge or a hopper barge, or the slurry can be pumped to the disposal site via a pipeline. Dredge spoil disposal to sea can potentially result in a number of environmental impacts including:

- Smothering of benthic communities both in the designated disposal area or at locations outside the designated disposal area
- High turbidity in the water column which may occur above the designated disposal area and potentially outside the designated disposal area
- Transfer of chemical contaminants, if present in the sediments that are to be dredged, to the designated disposal area and potentially outside the designated disposal area
- Changes in the physical characteristics of the sediments at the designated disposal area and potentially sediments outside the designated disposal area. These changes may result if the material to be dredged is different in characteristics to the sediments at the disposal site. Many species of benthic fauna have specific requirements for sediment characteristics and therefore changes in these characteristics may see changes in benthic communities in and around the disposal site.

The types and extent of impacts depend on the type of technology used, conditions at the site of deposition including the hydrodynamics of the locations, the type and proximity of environmental values and type of material that is being dredged. Although the deposition method is termed unconfined there are measures that can be employed to reduce the likelihood that discharged material spreads to areas outside a designated disposal area. Such techniques include:

- Jetting from a hopper dredger. The technique is essentially the reverse of the dredging process where a trailer suction dredge pumps material from the hopper to the disposal site rather pumping into the hopper.
- Direct mechanical placement using a grab where dredged material is picked up from a hopper and then placed on the sea floor in the disposal area
- Controlling the release of material from a barge so that the material spreads more evenly across the seafloor.

One key factor in managing impacts of unconfined ocean disposal is the choice of location. Selection of disposal sites has evolved since large scale dredging operations commenced. The first disposal sites chosen were based on proximity to the site of dredging with little or no concern for environmental impacts. Over the past forty years environmental impacts of dredged material disposal have been considered, largely as a result of the London Convention and the London Protocol. These impacts are generally managed through permitting systems that require consideration of options for disposal and environmental impacts prior to permission being given for a dredging project to proceed.

Case study: dredge material disposal site selection in the United States

In the US the protection of the ocean environment from adverse impacts of the dumping of dredged material occurs under the Federal *Marine Protection, Research, and Sanctuaries Act 1972* (MPRSA) which is commonly called the Ocean Dumping Act. Dumping of dredged material at sea in US coastal waters cannot occur unless a permit is issued under the MPRSA. The decision to issue a permit is made by the US Army Corps of Engineers. Criteria established by the US EPA are used to evaluate permit applications and the agreement of the US EPA is required for a permit to be issued.

The US EPA is also the agency responsible for the designation of ocean disposal locations for all materials to be dumped at sea including dredged material. Most of the dredged material in the US is disposed of at such sites. These ocean dredged material disposal sites are all required to have a site management and monitoring plans. These plans include details on:

- Timing of disposal operations
- Quantities of material that can be disposed
- Characteristics of the material (both physical and chemical) that are acceptable for disposal
- Identification of any controls over disposal that may need to be in place
- Any actions that may need to be implemented to avoid or minimise potential impacts to the marine environment
- any other management actions that may be required to minimise the environmental impact of disposing of material at the site.

Disposal sites are monitored to check that disposal of dredged material does not endanger either human health or the environment and that there are no unanticipated adverse impacts either from past disposal activities or from the continued use of a site.

The US EPA has an Ocean Survey vessel the Bold that assists in the monitoring of the sites.

Case study: dredge material disposal site selection in the United States

The US EPA and the US Army Corps of Engineers provide guidance (USEPA/USACE, 2004) on the selection of ocean disposal sites including:

- Currents and wave climate
- Water depth and bathymetry
- Potential changes in circulation patterns or erosion patterns related to refraction of waves around the disposal mound
- Bottom sediment physical characteristics including sediment grain-size differences
- Sediment deposition versus erosion
- Salinity and temperature distributions
- Normal levels and fluctuations of background turbidity
- Chemical and biological characterization of the site and environs (e.g., relative abundance of various habitat types in the vicinity, relative adaptability of the benthos to sediment deposition, presence of submerged aquatic vegetation, and presence of unique, rare or endangered, or isolated populations)
- Potential for recolonisation of the site
- Previous disposal operations
- Availability of suitable equipment for disposal at the site
- Ability to monitor the disposal site adequately for management decisions
- Technical capability to implement management options should they appear desirable
- Ability to control placement of the material
- Volumetric capacity of the site
- Other site uses and potential conflicts with other activities (e.g., sport or commercial fisheries, shipping lanes, and military use)
- Established site management or monitoring requirements

Public and regulatory acceptability to use of the site.

Case study: dredge material disposal site selection in the United States

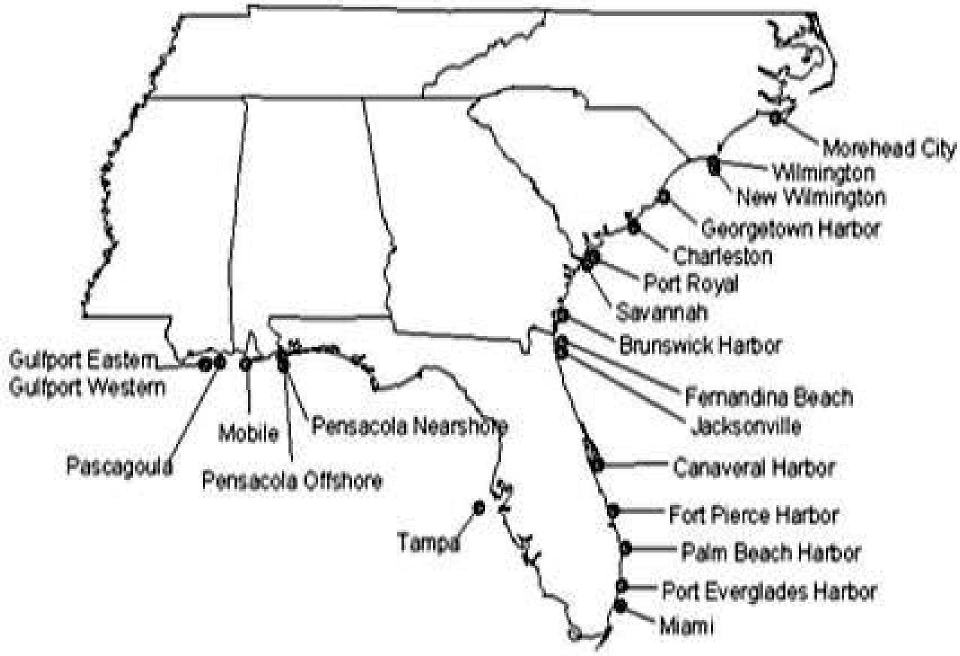


Figure 3 US EPA designated sea disposal sites in the southeast of the United States (from www.epa.gov).

Analysis

The process in the United States provides a framework for the ongoing management and monitoring of dredged material sites by the regulator. The US EPA and the USACE share management and monitoring responsibilities for these disposal sites. Detailed management plans are prepared for each of the dredge sites Environment Impacts Statements which are periodically reviewed for the disposal sites are prepared for each of the sites and these documents are publicly available on the US EPA website. Ongoing consultation with stakeholders is also a feature of the management of these sites.

Such a process is applicable in Australia, though in Australia the management of the disposal sites is undertaken by the port authority rather than the regulator. There are many examples of where ports manage their own dredged material disposal grounds. An example is the Port of Dampier in the Pilbara in Western Australia where disposal of dredged material at sea in Dampier Port is coordinated by the Dampier Spoil Ground Management Committee. This Committee is made up of key stakeholders and spoil ground management is assisted through a management plan and monitoring programs. The Port of Melbourne Corporation also manages its own spoil grounds as does the Port Hedland Port Authority amongst others. However in many cases the sites are not pre-selected with existing management and monitoring plans as in the US, rather they are selected through the environmental approvals process. The benefit of a pre-selected site and associated management plan is that it sets the requirements for dredge spoil disposal before disposal is proposed and therefore can guide decision-making.

In most countries selection of the disposal site is part of the approvals process (apart from the US, as demonstrated in the case study above). For example, in Canada selection of marine disposal sites is part of the dredging approvals process and must consider:

- Proximity to fishery resources and habitat
- Interference with marine use in the area
- Evaluation of mixing and transport characteristics at the site (no specific guidance as to the level of modelling required is given)
- Feasibility of monitoring the disposal site (Environment Canada 1998)
- First Nation concerns where consideration is given to the potential impacts of the dredging and disposal operations on issues related to the native peoples of Canada.

In Germany, if the decision is made to dispose of material to sea once alternatives have been excluded, the German dredging guidelines recommend the following be considered: (BfG, 1999):

- Benthic communities
- Spawning, breeding and feeding grounds
- Migration routes of marine organisms
- Landscape or conservation areas
- Areas of special importance for science or conservation (e.g., bird sanctuaries, seal resting places, eelgrass marshes)
- Areas of special cultural or historical importance
- Recreational areas
- Military areas
- Technical utilisation of the seabed floor, e.g., underwater cables, pipelines.

These criteria are similar to those used in many countries including Australia.

Management of disposal sites varies internationally. In some jurisdictions disposal sites are managed by the port adjacent to where dredging will occur and in others they are managed by government agencies.

Where government agencies, such as the US Federal EPA, manage the disposal sites the long-term management and monitoring of the disposal sites is independent of particular dredging operations (see case study above). There is also a more regional approach to the management of these sites. In comparison, jurisdictions without management plans for their disposal sites tend to have these areas investigated only when specific dredging campaigns are implemented and as such tend to be managed on a more *ad hoc* basis.

In the US, marine disposal sites for dredged material are managed by the EPA. These sites are specifically designated for dredged material disposal under section 102 of the US Federal Marine Protection, Research, and Sanctuaries Act. The US Army Corps of Engineers which undertakes most dredging in the U.S. is required to use these sites wherever feasible. All the ocean disposal sites have their own management plans which deal with the times, the quantity, and the physical and chemical characteristics of dredged material that is dumped at the site; establishing disposal controls, conditions, and requirements to avoid and minimise potential impacts to the marine environment; and monitoring the site environs to verify that unanticipated or significant adverse effects are not occurring from past or continued use of the disposal site and that permit terms are met. These management plans are prepared in accordance with guidelines for the preparation of such plans.

Best practice management of dredged material disposal grounds includes the selection of spoil disposal sites based on solid environmental grounds and the management of these spoil grounds through the development of management plans for the spoil ground that recognise the environmental conditions at the site, the capacity of the site, and ongoing monitoring requirements. Consideration should also be given to the US approach, which involves pre-selecting sites strategically and taking a regional approach to management plans. This could potentially achieve improved environmental outcomes, particularly if cumulative impacts are taken into account.

The literature review uncovered few detailed assessments of unconfined ocean disposal outside Australia. In Australian waters there are many examples of where unconfined ocean disposal is practiced and where monitoring of the impacts in accordance with approval conditions are made public. Examples include the South West Creek project at the Port of Port Hedland, a project involving the disposal of around 7.5 million cubic metres of clean material to sea, where monitoring reports were all placed on the port's website. The Port of Gladstone also provides updates on monitoring results of a range of parameters including turbidity and light. The port has 16 continuous turbidity monitoring sites and six light monitoring sites. Data is available to the public within one day of capture.

There are many examples of unconfined ocean disposal of dredged material in Australian waters. The environmental approvals process has generally considered the alternatives to sea disposal and determined that sea disposal provides for the least environmental impact, or that land-based disposal and re-use is not feasible. There are good examples at the Port of Port Hedland where a range of projects have considered (and used) ocean disposal, as the land-based alternatives would result in covering of mangroves and saltmarsh and could potentially result in acid sulphate soils.

The literature review revealed that the Australian experience with unconfined ocean disposal compares well with international practice.

Confined Ocean Disposal

Confined disposal is the placement of dredged material with some mechanism to prevent the material moving from the location. This can be via placement of the material in a bunded area adjacent to the ocean or capping of material deposited on the seafloor.

Confined ocean disposal is commonly practiced in Europe where historic contamination of sediments often precludes unconfined ocean disposal (Netzband et al, 2002). Approximately 90per cent of the dredged material in the Netherlands and Germany is placed in confined disposal sites (CDFs). Large CDFs are in use such as the 150 million cubic metres capacity Slufter site which the Port of Rotterdam uses for disposal of dredged material. The Slufter receives contaminated dredged material from Dutch rivers, channels and harbour basins. Since the Slufter was built in 1987, the supply of contaminated dredged material has decreased significantly due to reductions in catchment sources of contamination. As a result of this available capacity the site is now receiving material from German ports such as Bremerhaven in an example of international cooperation in the management of dredged spoil.

CDFs are also widely used in the US and Canada. The ports of New York and New Jersey have recently constructed a new CDF because the Newark Bay CDF reached capacity after 15 years in operation. The Newark Bay CDF was closed by capping it with a layer of sand approximately one metre in depth. Natural sedimentation of clays on top of the sand are also used to keep the dredged material in place.

There is guidance from industry on the management of CDFs, including PIANC's 'Long-term management of confined disposal facilities for dredged material' (PIANC, 2009). These guidelines provide information on the technical aspects of design and construction of CDFs as well as the ongoing management of these sites.

In Australia confined ocean disposal is practiced in cases where the sediments to be dredged are unsuitable for ocean disposal. The largest of such projects is the Port of Melbourne's Channel Deepening project where some 23 million cubic metres of sediments were dredged and disposed of to the Port of Melbourne Corporation's Dredged Material Grounds. Material that was not suitable for unconfined disposal was placed and capped with clean sand in a bunded area of around 12 square kilometres which had been and continues to be used for the disposal of material that is dredged during maintenance dredging in the port. The bund and capping were subject to regular inspections and independent auditing to confirm that they had been built in accordance with the design specification and that their integrity did not decline over time.

Catchment approach to reduce contamination of dredged sediments

There are a number of examples where ports are involved in environmental management activities beyond their own port boundaries. Many of these actions such as community involvement programs for clean-up of beaches, planting of vegetation, and support for local environment groups are done as part of port's good neighbour programs or as environmental offsets. There are however examples where ports are involved in wider projects to assist in improving water and sediment quality in the port harbour. Such actions are often difficult for ports as they are outside their area of jurisdiction and such actions are often beyond the scope of the port's charter.

Case Study – Ports of New York and New Jersey CARP Project
The CARP project was established in order to address issues with contamination of sediments in the New York/New Jersey harbour and involves the port as well as Federal and State government agencies and non-government organisations and stakeholders. This project was established in 1994 in response to contamination issues with dredged material from the harbour. In 1997 the ports contributed $30 million to the commencement of the CARP project and the financial contributions since then have been high. CARP is an attempt to understand and therefore potentially be able to control pollution from upstream in the Hudson River before it enters the port areas and becomes an issue if contaminated sediment is subsequently required to be dredged. The project is one result of the Joint Plan for dredging of the Port of New York and New Jersey, which both states signed in 1997. This project tracks the levels of contaminants in the harbour and through information gathered, attempt to reduce the flow of contaminants into the harbour. Specific actions have been developed to assist in the reduction of contaminants that may flow into the harbour and the results from the program have also been used to characterise sediments that may be dredged. The project was initiated as the Ports of New York and New Jersey saw the costs of dredging increase tenfold during what was termed the 'dredging crisis' when traditional open ocean options were no longer possible due to contaminated sediments and increased dredging costs were threatening the viability of the port itself. Identifying catchment sources of contamination with the aim of reducing catchment levels became an imperative. Eighty-five per cent of the material dredged since 1992 has been considered unsuitable for ocean disposal and has been required to be treated and managed through alternative means. These alternatives have included barging the material to Texas then transporting it by rail to Utah to be used as landfill cover a process that cost the ports A$155 per cubic metre (Derman and Schlieper 1999). The

Case Study – Ports of New York and New Jersey CARP Project

contamination problems in this harbour are serious and long-term. One of the main sources of contamination is the Upper Hudson River PCBs Superfund Site. Through contaminant modelling CARP concluded that if PCB loadings continue at current levels, sediments in large areas of the port have the potential to be unsuitable for ocean disposal for the next thirty years.

Analysis

The involvement of ports in wider catchment issues seems to be driven by the level of constraint that water and sediment quality issues have on the port's activities. Where, for example, options for the disposal of dredge spoil are constrained by levels of contamination that are exacerbated by additional material coming from catchment sources then there seems to be an increased involvement of ports in helping to manage catchment sources of pollution. For the Ports of New York and New Jersey, the costs of dredging due to contamination triggered their involvement in CARP.

Ports in Australia are generally not faced with the situation where there are ongoing serious contamination issues emanating from upstream sources. However, CARP could provide a model for joint activities between port authorities and other stakeholders to address broader catchment issues (such as catchment water quality).

Monitoring and feedback

Many dredge projects have environmental management plans that include monitoring programs which identify ways to minimise risk if particular monitoring parameters are exceeded. These approaches are particularly important for large scale dredging projects in sensitive marine and coastal environments. Doorn-Groen (2007) provides an account of the approaches that should be taken for dredging for reclamations, but these apply equally to other dredging projects. This research states that in addition to applying control measures it is also important that the effectiveness of these measures can be demonstrated. Of equal importance is the ability for monitoring programs to directly feed back into the dredging program in a timely manner such that effective and rapid response mechanisms can be implemented.

This concept is further examined by Erftemeijer et al (2012) who stress the importance of effective monitoring and feedback mechanisms to minimise impacts on corals during large scale dredging operations. These authors highlight the importance of having a statistically robust design such that appropriate statistical power is achieved (statistical power is the ability of the analysis to detect the level of change it is required to detect). If the monitoring program is not properly designed then it may not be possible to validate the observations. For example; a monitoring program may have been put in place to detect a 10 per cent change in coral cover, but if there is insufficient statistical power it may be able to detect no more than a 50 per cent change. So it important that the statistical design matches the requirements of the monitoring program, which requires sufficient understanding of sensitive environmental receptors prior to dredging.

Downes et al (2004) provide a good explanation of the design requirements of monitoring programs that should be applied to all monitoring including dredging projects. Doorn-Groen (2007) uses the example of the protection of corals in Singapore to highlight the development of a proper monitoring program for dredging operations, stating that monitoring programs should include:

- An identified question that:
  - specifies what the monitoring program is required to determine or inform, and

– establishes what parameters should be measured, at what frequency and to what level.

- A definition of the environmental effect that is to be measured. That is, what is the level of environmental change that is required to be detected? This information will inform the statistical requirements of the monitoring program. For example, if the program needs to be able to detect a five per cent change in coral cover then there must be enough sampling locations in the monitoring program to be able to detect change at that level.
- The information gathered during the monitoring program must be useful in informing management. The monitoring program needs to be able to inform the management of the current activity or future activities of the same nature. There has to be a purpose to the monitoring.

The design of a monitoring program, not just for dredging but for all aspects of port management, must be based on the hypothesis for environmental impact and tailored to answer specific questions. There were few examples encountered in the literature review of this approach.

The literature review also did not uncover much information about baseline environmental conditions. These are generally described in environmental impact assessments where baseline data collection is generally a regulatory requirement. The US EPA undertakes monitoring of sea disposal areas in Long Island Sound through the Disposal Area Monitoring System (see Fredette and French, 2004) but this is a long term monitoring program for already established disposal areas. Baseline environmental monitoring is identified as a gap in the international literature and publicly available information on port websites.

In Australia monitoring of dredging activities is generally a condition of approval. There are many examples of publicly available monitoring programs including those at the dredging for the Western Basin Project at the Port of Gladstone which commenced in 2009.

Monitoring for the Port of Melbourne's Channel Deepening project was undertaken by an independent office of the state government, the Office of the Environmental Monitor (OEM). The reports from the OEM are accessible to the public via the OEM's website. The monitoring was a risk-based program and covered a wide range of environmental variables including water quality, turbidity, bacterial contamination, seagrass, deep reefs and Little Penguins During consultation, the importance of transparent and publicly accountable monitoring programs was raised as a key issue and where it is able to be achieved, a component of best practice. It was also discussed the importance of data that is interpreted to ensure its significance (or insignificance) can be clearly understood, as well as the need for use of plain English and communication of the whole story of why ports undertake activities like dredging.

Best practice environmental monitoring involves the identification of questions to be answered, proper selection of parameters to be modelled, the use of power analysis to identify whether the statistical design is adequate and the *a priori* selection of a statistical model. There is ample scientific literature available on the design and interpretation of monitoring programs so that there should be no reason for an inappropriate program to be designed or implemented.

Summary

Developing a benchmark for environmental performance of dredging activities that would be applicable across all projects is not appropriate. Dredging projects have the potential for a wide range of impacts on the marine environment. In addition, sensitive environmental receptors such as seagrass and corals have site-specific responses to the kinds of disturbances that dredging can create. Avoidance and mitigation of impacts to these receptors is clearly the preferred option and is consistent with the London Protocol and guidelines such as those produced for individual nations as well as industry guidelines such as those developed by organisations such as PIANC and CEDA.

There are a wide range of options to avoid or minimise the impacts and there are new techniques being developed all the time. The correct matching of avoidance or mitigation technique to manage an identified environmental issue is best practice. A risk-based approach for assessing the potential impacts of dredging operations is seen as the most effective process to correctly match mitigation measures with potential impacts and as such is considered best practice. These are techniques that are becoming well-developed internationally and are also being used in the Australian context (i.e. Port of Melbourne Corporation's Channel Deepening Project, Port of Hastings Development Project and maintenance dredging for Port Hedland Port Authority). Development of an appropriate risk method to determine the environmental values that need to be protected and the mitigation and management measures that may be needed to protect the identified environmental values, if undertaken correctly, provides the most effective, scientifically valid and transparent approach to the environmental management of dredging projects.

Further key findings on international best practice relating to dredging are outlined below, but need to be considered within a risk-based approach:

- As required under the London Protocol, land-based dredge spoil disposal or re-use should be considered before disposing at sea. International examples demonstrate that there are many ways in which this can be achieved, but there are a range of factors (such as land availability, cost, sediment type and terrestrial environmental impacts) that may make this option unviable for some ports.
- Marine based disposal of dredge spoil is common internationally. The selection of the disposal site is the key factor in minimising environmental impacts. An approach similar to that taken in the US, which involves strategically pre-selecting disposal sites and developing management plans for these sites, could be further considered as a mechanism to avoid and mitigate environmental impacts.
- In situations where broader catchment activities are contributing to environmental issues in the harbour, there may be opportunities for port authorities to work with other stakeholders to achieve environmental improvement.
- The timing of dredging activities is critical in avoiding and mitigating environmental impacts. There are also a range of operational technologies and techniques (such as no overflow dredging or protective silt curtains) that may be appropriate to apply if there are likely to be impacts on sensitive environmental receptors.
- Environmental monitoring involving the identification of questions to be answered, proper selection of parameters to be modelled, the use of power analysis to identify whether the statistical design is adequate and the a priori selection of a statistical model, is imperative to enable adaptive management to be implemented.

5.1.2 Stormwater run-off

Stormwater runoff has the potential to:

- Introduce sediments to the marine environment resulting in increased turbidity
- Release contaminants from terrestrial surfaces into the water column
- Add nutrients to the water column, resulting in algal blooms, or eutrophication where water bodies receive excess nutrients which results in excessive plant growth which then results in the depletion of oxygen levels in the water.

A large proportion of an operating port is covered with impervious surfaces such as concrete and asphalt such that the volumes of stormwater making their way to the marine environment can be higher than from nearby natural areas. As these hard surfaced areas are generally constructed for the purpose of conveying machinery and cargo there is also a higher likelihood of contamination of these areas. In bulk ports there is also the potential for stormwater runoff from stockpiles and the accumulation of settled dust from storage and loading that can generate impacts on water quality. During construction additional threats from stormwater quality can arise through the erosion of disturbed areas of land.

Internationally, the management of stormwater in ports is generally covered by government regulations. For European ports water pollution control is covered by the 'European Union Directive Framework for Community Action in the Field of Water Policy' (EEC 2000). The Directive covers the management of surface fresh water, estuaries and coastal waters (including marine waters up to one nautical mile from shore). All European ports are required to comply with the Directive which sets the framework for their storm water management. The Directive requires full compliance by 2015. Ports must meet locality specific standards related to:

- Ecology, including fish, benthic invertebrates and aquatic flora
- Geomorphology of rivers, estuaries and coasts
- Physical-chemical parameters such as temperature, oxygen and nutrient levels
- Water chemistry. These standards specify maximum concentrations for specific water pollutants and all designated chemicals must be below guideline levels.

Actions ports take to avoid or minimise stormwater discharges to the marine environment are generally those recommended by the various best management practices for stormwater management; these are a component of most jurisdiction's water management requirements. Actions include:

- The use of porous pavements to maximise absorption of stormwater and minimise runoff volumes - the Port of Portland in Oregon on the west coast of the United States used porous pavements in its auto storage yard in conjunction with vegetated swales which virtually eliminated stormwater runoff
- On site wetlands for treating stormwater - the Port of Skagit in Washington State on the west coast of the US has employed an extensive system of wetlands to treat stormwater before it is discharged into the natural environment
- Landscape irrigation systems using stormwater - the Port of San Diego in southern California has developed landscape irrigation systems based on recycled stormwater to reduce its environmental impact
- Water recycling initiatives - the Port of Los Angeles has worked with its tenants to develop wide range of incentives and programs to help them reduce contamination of stormwater runoff. These include litter and solid waste management as well as water usage and recycling
- On-site treatment facilities - the Port of Le Havre in the Netherlands has a large on-site treatment system to collect and process stormwater from its coal storage yards with more than 90 per cent of the pollutants recovered. This plant expects to recover 5 500 tonnes of coal annually through this process that otherwise would have passed into the environment.

ESPO's Green Guide (ESPO, 2012) also highlights good environmental practice with regard to stormwater management. Water quality entering port waters is one of the issues addressed and there are some examples provided in Annexe 1 of the guide. These examples include:

- Port of Dover - the Port of Dover has a stormwater interception system that captures any landside spills and includes a contingency plan for clean-up. Monitoring of harbour waters is conducted weekly during the seasons when it is used recreationally.
- Groningen Seaports, the Port of Le Havre and the Port of Saint-Nazariare - have all constructed water treatment plants to treat stormwater runoff prior to its discharge. In addition, at the Port of Saint Nazariare, the terminal operators are provided with incentives to reduce the input of contaminants into the treatment system. Consideration is being given to extending this to accommodate additional areas located near the port.

These actions can generally be considered good practice for managing stormwater in the port area and enable compliance with government regulation for protecting water quality.

Other ports have initiatives that extend outside the port area with the intention of improving water quality in the harbour. In Italy, the Port of Genoa was a partner in Enhanced and Sustainable Treatment for Urban Stormwater (ESTRUS), a project with the goal of demonstrating the suitability and cost-effectiveness of catchment based treatment solutions for storm water runoff into harbour areas. This is a case of cooperation with other government agencies toward a catchment solution to stormwater management issues (however this project has now finished). This project provided quantitative information on the water quality issues in the catchment and the hydrodynamic conditions influencing these issues so that targeted water quality initiatives could be implemented (ESTRUS, 2009; Gnecco et al, 2010).

In the US management of stormwater is primarily through the National Pollutant Discharge Elimination System (NPDES) Permit system under the Federal Clean Water Act; and the Stormwater Pollution Prevention Plans (SWPPPs) prepared under these permits. The US Navy in their seaports has mandated stormwater treatment and management through their own Best Practice Management of Stormwater Guidelines. These guidelines are based on the NPDES above and take users through a structured process of planning, assessing risks, identifying options to avoid and treat, and implement the actions.

In the US there were a number of examples of ports working outside the port boundary, with their tenants and/or with the wider community to address stormwater issues. The Port of Los Angeles identified that stormwater management is one of the key challenges to overcome to maintain water and sediment quality in San Pedro Bay. The site has been an active port for several centuries. It is surrounded by one of the largest urban areas in the world, resulting in considerable historic contamination. The port has implemented a number of initiatives (see case study below).

Case study – Port of Los Angeles and Port of Long Beach - Water Resources Action Plan

The Port of Los Angeles has developed a joint Water Resources Action Plan (WRAP) with the adjacent Port of Long Beach with the objective of improving both water and sediment quality by obtaining the full beneficial reuse of water on site. In achieving this; one of the aims of their combined program is to '*identify and utilize innovative approaches, including those that exceed regulatory requirements where feasible*'.

The WRAP, which was developed with wide consultation with stakeholders and the community, sets out the strategies and goals for the ports to:

- Work with wider government agencies to develop strategies and implement identified

Case study – Port of Los Angeles and Port of Long Beach - Water Resources Action Plan

actions to clean up historic contamination in harbour sediments

- Continue to engage with stakeholders including the community, NGOs government agencies and port tenants who are able to attend monthly Plan Advisory Committee meetings
- Establish the Tenant Outreach Program-which provides education and advice about stormwater management as well as evaluations of tenant sites in order to help port tenants understanding and compliance with overall stormwater management goals of the port
- Establish a clean marine program where the port promotes best practice management practices and provides resources for marinas
- Monitor the environment including a wide range of contaminants in sediments and water as well as fish tissue such that there is ongoing feedback on the state of the water and sediments of the harbour which can be used to modify the plan if necessary
- In addition to the WRAP the port has a number of other initiatives. In order to address the issue of catchment-sourced contamination, the Port is a member of Los Angeles County's Dominguez Watershed Task force whose goal is to address the issues of catchment inputs to port waters.

The actions of the Port of Los Angeles are considered to be above the standard measures to manage stormwater. In addition to local engineering management measures, the port has sought to interact with both its own internal stakeholders as well as the community and government and non-government organisations. The communication is open and frequent (monthly). The port also engages with all stakeholders on a continual basis (not just at the development stage of the WRAP) and works with internal and external stakeholders to address problems of past, present and future water and sediment quality issues. The WRAP is reviewed annually and periodically updated upon the receipt of new information thus an example of continuous improvement. The aim of the WRAP to exceed regulatory guideline levels also takes this project above the standard business as usual approach.

Analysis

The actions of the Port of Los Angeles and the Port of Long Beach are considered to be above the standard measures to manage stormwater. Key elements of best practice in this example include:

- Engagement with the broader community to develop and implement the plan
- Provision of education and other resources to tenants and marinas to help them improvement their management
- Transparency, by making information on meetings available on the port's website.
- Open and frequent engagement with all stakeholders on a continual basis
- Monitoring and continuous improvement, including annually reviewing the WRAP and periodically updating it upon the receipt of new information
- The aim of the WRAP to exceed regulatory guidelines also takes this project above the standard business as usual approach.

There are no particular constraints to the adoption of this type of approach in Australian ports.

Other ports in the US and Canada exhibit elements of the Port of Los Angeles approach as follows:

- The Ports of the Columbia River in Oregon have implemented systems that have virtually eliminated stormwater runoff to the river (IISS, 2010). in partnership with government and the community as part of the Lower Columbia Estuary Partnership
- The Port of San Diego is working with its 700 tenants through the port's 'Jurisdictional Urban Runoff Management Program' to reduce stormwater
- Port Metro Vancouver in Canada is integrating its stormwater management planning with other local planning processes including Community Plans, Neighbourhood Concept Plans, recreation and parks plans, and strategic transportation plans.

Many Australian ports have stormwater management systems in place as part of the Environment Management Plans. The Port of Townsville's Planning Codes and Guidelines (PoTL, 2013) includes a stormwater management guideline to ensure that the port and its tenants implement measures to protect the adjacent waterways and catchments from adverse impacts of stormwater, including flooding. The Port of Brisbane has adopted many water sensitive urban design features into the port to reduce the potential impacts of stormwater runoff into adjacent waterways. The effectiveness of these measures is assessed through an ongoing monitoring program. In general stormwater management systems are designed for ports to comply with local guidelines for water quality and discharges into waterways. Australian ports performance in stormwater management is similar to that seen in international ports.

Summary

Stormwater runoff from ports and port operations has the potential to be a major source of water and sediment contamination. Many ports have implemented wastewater capture and treatment systems to attempt to reduce the amount of material escaping to the environment. A variety of approaches have been applied depending on the particular circumstances and requirements of the port. In addition to in-port activities, some ports are also involved in catchment wide actions to reduce stormwater pollution.

5.1.3 Air and water quality – dust

Dust from bulk commodity stockpiles at ports can contribute to poor air and water quality. Large stockpiles of iron ore, coal, bauxite, copper concentrate, sulphur, limestone magnesium, rare earths and other minerals are a significant feature where these products are loaded. There is potential for dust to blow off these stockpiles or to be created during unloading from the trucks or trains which have brought the material to the port or when being loaded onto ships. The dust can settle on the water and contaminate both the water column and the underlying sediments. As the volumes of dry material handled by bulk ports is sometimes large (for example the Port of Port Hedland routinely exports one million tonnes of iron ore in a tide) the potential for even a small proportion of this material spilling into the water can mean impacts on environmental values. A comprehensive review of the potential impacts of coal dust in the marine environment was conducted for the cumulative impact assessment for Abbot Point (WBM, 2012). This report considered the potential impacts to include:

- Increase in fine particulate matter in the water column increasing total suspended solid concentrations and potentially influencing light attenuation
- Changes to sediment physical characteristics as a result of coal dust settlement on the seabed
- Introduction of chemical contaminants into the water column.

There are two main approaches to the dust management of bulk materials - the enclosure of dust sources from handling operations and stockpiles, and options for the treatment of stationary material such as in a stockpile.

Covering is impractical for many large stockpiles of coal and iron ore. Keeping the stockpile moist is the best measure for dust suppression. Control strategies usually involve applying water, or a mixture of water and chemical dust suppressants for transport, and water sprays in addition to the methods described above.

Case study – Great Lakes Ports Stockpile Runoff Management System

The Great Lakes Maritime Research Institute and the American Great Lakes Port Association, a body representing 12 US and Canadian ports around the Great Lakes, has developed a Manual of Best Management Practices for Port Operations and Model Environmental Management System (Corson, 2008). The manual addresses the management of bulk cargos amongst a wide range of environmental management issues and provides guidance on measures that should be applied to minimise the treatment of dust emanating from bulk ports.

Corson (2008) describes the components of best practice dust management for handling dry bulk materials in the Great Lakes Ports as:

- using enclosed conveyors or chutes, and telescoping arm loaders to reduce spillage and dust; also, minimize the distance between the working face and trucks or trains being loaded to reduce the area that has to be swept and cleaned
- suspending unloading and handling operations during unfavourable weather conditions (such as precipitation and wind) that could, otherwise, increase run-off or blowing dust
- spraying a light mist for dust control during handling operations; however, caution is required to prevent run-off from occurring.

These ports are complying with both air and water quality guidelines for their respective federal state or province and local governments. As the twelve ports of the Great Lakes cover two countries and several states and provinces, the guideline levels that they are required to achieve vary.

The techniques that are described in Corson (2008) provide a cost effective response to the management of dust from stockpiling operations. These recommendations are predicated around the need to meet guidelines levels for water quality. There are a wide range of bulk cargos that are exported through the bulk ports of the Great Lakes system and the management systems that are proposed provide a flexible approach to meeting stated environmental aims. Each situation is assessed on its merits and the most effective and appropriate mechanism to manage stockpile dust is chosen.

Analysis

The methods described above are those that are generally applied to dust management of ore stockpiles to minimise dust. Information on dust management from other ports outside the Great Lakes and Australia was not readily available

Australian ports have well developed methods for dealing with dust of stockpiles and provide public documentation to support their efforts.

The Port of Ashdod Company in Israel limits the dust discharged during the loading of bulk cargos. Each year, millions of tons of fertilizers of the type of potash and phosphate are exported through the Port of Ashdod. In the past, the bulk ships were loaded by means of a pipe loader that caused increased emissions of phosphate and potash dust to both the air and marine environments. In response to this issue all the old loaders were replaced by dust suppressor loaders. This action removed more than 95 per cent of the particulate matter released during ship loading. In addition, all the bulk and general cargo areas in the Jubilee Port of Ashdod were fitted with a drainage system with settling pits, so that cargo spilt on the piers would be trapped by the settling pits and not released into the sea.

Australian ports have well developed methods for dealing with dust of stockpiles and provide public documentation to support their efforts. For example, North Queensland Bulk Ports manage several of the largest coal terminals in Australia. Dust is a high profile issue at these facilities. Dust management is a key element in the environmental performance of the port. Methods that are used are described in the Port of Hay Point Environment Management Plan and include:

- Reducing residence time for coal product
- Ensuring adequate moisture content of coal at the rail receival area
- Applying water to coal stockpiles to suppress dust generation
- Reducing stockpile height in the summer months when more severe weather is experienced
- Maintaining the minimum elevation of the stacking boom while stacking
- Regular clean-up of any coal spillages
- Using weather data to predict adverse weather conditions to allow pro-active dust mitigation measures
- Use of real time dust monitoring data.

Monitoring is a condition of the state government licence and the data is made publicly available through North Queensland Bulk Ports' website.

Port Hedland Port Authority also sees dust as a major environmental issue. As the largest bulk export port in the world with iron ore as the principal material loaded at the port, management of very large stockpiles is a major task. The port uses dust monitors around the port which track the performance of dust control measures. The information from these monitors is publicly available in real time. Primarily controlled through an automatic system of water application Port Hedland Port Authority has implemented enhanced dust management procedures since 2012 and seen an 85 per cent reduction in exceedences of air quality targets set by the WA Department of Environment and Conservation.

For smaller stockpiles alternative measures are also being employed in Australian ports. Esperance Port in Western Australia has mineral product stockpiled in pressurised sheds. Material is transported in a fully enclosed conveyor from the rail area to the ship loading facility. The Port of Esperance makes the point that this facility has limitations in the amount of material that it can handle. Pressurised sheds would not be suited to large volumes of material such as exported through the iron ore ports of the Pilbara and the large coal ports on the east coast of Australia.

Summary

There were few examples of dust management of stockpiles available for the literature review. Best practice is related to the outcomes of the actions to reduce dust and stormwater runoff from stockpiles. The use of water spraying systems (with associated measures to capture runoff from the stockpiles) is the generally accepted practice for stockpile dust management along with a range of other measures that can be utilised (such as enclosed conveyors and suspending loading during unfavourable weather conditions).

5.1.4 Shipping operations

Risks from shipping operations include collisions, groundings, excessive moored ship motions, accidents, gas leaks, fires and explosions, major releases of cargo which may result from failures of port systems, and damage to the static marine infrastructure. These events have the potential for releases of contaminants, largely fuels and cargos, into the marine environment with often serious consequences. Although rare, these events are high impact and high profile, and have the potential to effect large areas with persistent effects over many years.

The ongoing growth of shipping traffic in both size of ships and the number of vessels has the potential to result in a higher risk of both collisions in coastal waters and of ships running aground, events which may see the release of subsequent large amounts of cargo and fuel as well as other pollutants.

Shipping is an industry that is heavily regulated, particularly in the areas of navigation, cargo handling, ship management and the handling of waste. The International Regulations for Preventing Collisions at Sea 1972 (COLREGs) and other regulations of the IMO have been adopted in many countries and form the basis of collision avoidance. Compliance with these rules is considered standard practice. If a collision was to occur through either non-compliance with navigations rules or as a result of factors such as bad weather or equipment failure ports should have adequate response processes and equipment.

All ports have emergency response plans. Many of the consequences of an emergency are not likely to be related to protection of environmental assets such as MNES. One area of particular concern is that of an incident that causes the spillage of undesirable material into the environment. The most obvious of these is an oil spill that results from either loading or unloading vessels or thorough a shipping accident.

A range of international guidelines from the IMO governs the release of all pollutants from ships across all scales and these are generally supported by national legislation in those countries that have ratified these conventions. The conventions deal with ship related marine pollution and include:

- International Convention on Civil Liability for Bunker Oil Pollution Damage 2001
- International Convention for the Prevention of Pollution from Ships (MARPOL) 1988
- International Convention on Oil Pollution Preparedness, Response and Cooperation 1990.

These conventions provide measures that seek to control the risk of pollution being released from ship operations. By defining pollutants, MARPOL specifies prohibitions, restrictions and conditions for discharges at sea. MARPOL is continually being amended to provide the most current and relevant protection to environmental values.

Oil and other chemical spills

Oil spill response needs to be organised through the development of contingency plans for oil spills. An environmental risk assessment that includes not only the risk of the oil spill but also the risks of response options is recommended by the IMO. Many of the response options such as the application of chemicals to disperse oil have their own environmental impacts and these need to be considered in the decision making process (ITOPF, 2011). The risk assessment needs to address any sensitive environments that may be impacted by any spills and assess likely trajectories of material that may be released as a result of a spill. The response plan, including any equipment that may be required, is then developed to meet the specific risks of the particular location. The equipment that may be used for a spill that threatens a mangrove forest would be different to that used to combat a spill that threatens a rocky shore. In order to develop a management plan information is required on:

- Physical characteristics of the port
- Types of vessels using the port
- Types of oil based products in use in the port – the type of oil has a large bearing on the way that it behaves if spilt and therefore has important implications for the response options
- Location and type of environmentally sensitive receptors
- Detailed information and models of the currents; tides, winds and other influences on the movement of spilt oil.

ITOPF (2011) states that '*An effective response to a spill of oil is dependent to a great extent on the preparedness of the organisation and individuals involved. This can be greatly enhanced by developing and maintaining a plan to address all likely contingencies. The process of producing a contingency plan provides the opportunity to identify roles and responsibilities and to define response strategies and operational procedures without the intense pressures that inevitably arise at the time of a spill'.*

The Texas Oil Spill Prevention and Response Program, implemented by the Texas General Land Office, is a program that involves the cooperation of all the marine ports in Texas as well as large industries including oil refineries and the fishing industry. Funded by a one and one third cent levy on each barrel of crude oil that is loaded or unloaded in Texas ports, the program has an extensive education program for both the public as well as vessel and port operators in addition to a focus on prevention.

One of the key components of the Texas approach is the toolkits, which are comprised of environmental sensitivity maps, local knowledge guides, Area Contingency Plans for the entire Texas coast. In addition to the Texas coast the adjacent states of Alabama, Louisiana, and Mississippi are also covered. The Atlas that is provided with the toolkit has sensitivity maps showing the location of environmental values along the coast.

Spill response in Germany is the joint responsibility of the German Federal Government (through the Federal Waterways and Shipping Board of the Ministry of Transport) and the Federal Coastal States of Bremen, Hamburg, Niedersachsen, Mecklenburg-Vorpommern and Schleswig-Holstein. The Central Command for Maritime Emergencies (CCME) is responsible for coordinating responses.

The German government has plans to deal with a spill of 15,000 tonnes, though this is predicated upon the condition that mechanical recovery is possible. A range of vessels and oil spill response equipment is identified and processes are in place for this to be available should the need arise. Each major port of Germany has its own private oil spill response company that it can call upon. Assistance might also be sought from other organisations such as the Navy and salvage companies.

The German government provides two remote sensing aircraft and further resources are identified for use if required. Germany has in place bilateral agreements with government around the Baltic and North seas as oil spills do not recognise national boundaries and international cooperation may be necessary to deal with an incident. Individual ports and harbours in Germany are obliged to maintain adequate contingency plans and response resources.

The German national plan for oil spill response includes a detailed sensitivity map supported by computer based spill tracking models which are available for the North Sea, German Bight, Wadden Sea and Baltic. A computer based ship accident management system and processing data from a variety of sources is also used to support an oil spill response.

In Germany, the CCME is also responsible for dealing with these spills as well as oil spills. The capability of this agency is largely limited to the recovery of packaged goods. The CCME does however have at its disposal four vessels that have sensitive gas analysing systems on board. These vessels can be applied to the role of detecting, recovering and storing hazardous substances in addition to the transporting and accommodation of 30 people each to assist in the clean-up of spills. These vessels can sample both air and water and undertake in situ atmospheric monitoring. An example of such a vessel is the Arkona which has two sweeping arms systems which can cope with 320 cubic metres/h each, an on board oil separation plant, gas detections systems and a capacity to hold 1 000 cubic metres of liquid.

Material other than oil may be spilt into the environment. Germany has been involved in the response to a number of incidents involving the spillage of hazardous materials including styrene, methyl ethyl ketone, isopropyl alcohol and arsenic pentoxide (European Maritime Safety Agency website).

The German oil spill response system is able to respond to oil spills and spills of toxic chemicals. The German government has a series of well-equipped vessels available to assist in the response to a chemical spill at sea and supports any such response with aircraft and a well-developed series of response plans. There is integration between the individual port’s oil spill response plans and those of the government.

Canada’s marine oil spill preparedness and response is designed around collaboration between industry (including ports) and government. Canada has a ‘polluter pays’ principle: under the Canadian Marine Liability Act the polluter is strictly liable for oil pollution from ships, including all reasonable costs related to recovery and clean-up. Polluters are also responsible for the costs of oil spill preparedness. All vessels calling at a Canadian port must contract with a government-approved spill response organisation. Under the Marine Liability Act a ship’s owner is responsible for any ship-sourced pollution.

The Canadian Coast Guard monitors the arrangements in place and can also act to support oil spill response when it is seen to be in the public’s interest. The prevention and control of ship-source pollution is governed by the Canada Shipping Act, 2001 (CSA) which gives Transport Canada the responsibility for shipping matters and the Arctic Waters Pollution Prevention Act.

Under the CSA all tankers of more than 150 GT and all other vessels of more than 400 GT must carry an approved shipboard oil pollution emergency plan to operate in Canadian waters. Under the CSA, Transport Canada has responsibility for shipping matters. The Canadian Coast Guard (CCG), a special operating agency of Fisheries and Oceans Canada, is the lead agency responsible for ship-source and mystery spills. The CCG Marine Spills Contingency Plan defines the scope and framework within which the CCG will operate to enable an appropriate response to marine pollution incidents.

Within port limits, the responsibility falls under the appropriate port authority and ports have developed spill contingency plans. For example at Port Metro Vancouver all tankers entering the port are subject to inspection and must comply with particular navigational requirements. These requirements include restrictions on the timing of ship movements, tug requirements, a requirement for two pilots to be on board and other specific navigational requirements related to specific harbour conditions. In military port areas, the primary responsibility is held by the Department of National Defence, who will respond to all spills from their own vessels and facilities.

In Japan the lead government agency with responsibility for oil spill is the Japan Coast Guard however responsibility for clean-up of ship sourced spills lies with the owner of the vessel. Japan has in place contingency plans for spills of up to 10 000 tonnes, however these plans only apply to the areas that are considered most at risk namely Tokyo Bay, Ise Bay and Seto Inland Sea. There are joint government and industry committees at 95 of Japan’s ports. The ports themselves are responsible for controlling pollution including oil spills within their port limits but usually have little or no oil spill response capability.

The Japan Coast Guard maintains the equipment to fight an oil spill including specialised vessels, booms, skimmers, and supplies of dispersants and sorbents. A joint industry and government funded organisation, the Maritime Disaster Prevention Centre has 40 equipment bases located around Japan as well as arrangements with 143 private contractors in 83 ports. If a spill, occurs the Japan Coast Guard will respond through the dispatch of vessels and aircraft while calling upon the owner of the vessel involved to take responsibility for the clean-up. Tankers entering Japanese waters must maintain stocks of equipment and supplies to counter an oil spill. There are contracts between the tankers and the Maritime Disaster Prevention Centre who maintain and supply the equipment if required.

In Qatar the Oil Spill and Emergency Response Department of Qatar Petroleum is the authority responsible for receiving reports of oil spills. In the event of a spill in the Port of Doha the port would be responsible for the oil spill response. Elsewhere in Qatar, Qatar Petroleum would be responsible.

Qatar has a national contingency plan for oil spill response, which has recommendations for how resources to combat the oil spill may be applied. For example; dispersants are not allowed to be used in shallow waters, nor near coral reefs or seagrass beds nor in the vicinity of water intakes for desalination plants or other industrial intakes. Qatar has large amounts of equipment to fight oil spills and can call upon resources in other ROPME countries for additional support.

In Australia ports have their own emergency response plans including responses to oil spills. For example Sydney Ports Corporation is responsible for emergency response to marine-based incidents and for the clean-up of any environmental spills including oil spills in Sydney Harbour, Botany Bay and for 90 kilometres of the New South Wales coastline for three nautical miles out to sea. The port has two emergency response tugs with additional repose vessels that can be used for oil spills. Many of the incidents that the port deals with are not due to port of shipping operations but are a result of other activities such as recreational boating or runoff from land based incidents.

The coordinated management of oil spills in terms of environmental management (in addition to an emergency management focus) was raised during consultation, as an area for potential improvement at Australian ports. Best practice was discussed as a multi-tiered governance response to oil spills and a strong framework for assessment of risk, where first strike capability and response time match and are proportional to the local environment and sensitive environmental receptors.

Case study: Port of Rotterdam oil spill response
The Port of Rotterdam is one of the busiest tanker ports in the world with the port handling over 8 000 tanker visits per year. Most spills in the port are less than 250 litres with the port reporting that, in 2007, 50 cubic metres of oil was spilt in the port. The Netherlands government has a national contingency plan for oil spill which was adopted in 2006. In the Netherlands oil spill response is the responsibility of the Ministry for Infrastructure and Environment, however port authorities are responsible for spills within their port limits. The Port of Rotterdam has contracted the private company HEBO Maritiemservice BV to undertake oil spill response and emergency repose for the port. The port also operates patrol vessels to assist in an emergency. Eight of these vessels are available at any time with a response time to an incident of 30 minutes (in 95 per cent of all incidents). Four of these vessels are oil spill response vessels. The vessels contain up to 15 cubic metres of foam and are equipped with up to 100 metres of oil absorbing boom. In addition the vessels also may

Case study: Port of Rotterdam oil spill response

have fire fighting equipment on board. Containers with 300 metres of oil absorbing boom inside are strategically positioned in throughout the port area. In total there is 4 500 metres of boom available to contain oil spills in the port. The booms are deployed by the royal boatmen association Eendracht, who have a total crew of 350. The Netherlands does not have its own stock of dispersant so would rely on that from the United Kingdom if dispersant was needed to cope with an oil spill. The types of spills likely in the Port of Rotterdam would not generally require dispersant to be applied.

The Port By-laws state that all spills have to be reported to the Harbour Master immediately. Failure to comply with these by-laws is punishable by Dutch law.

Figure 4: One of the oil spill response vessels in the Port of Rotterdam

Analysis

The Port of Rotterdam has a response plan catered to the types of spills that occur within the port. The equipment is specific to the port and can be well distributed if required. The response time is reasonably rapid – 30 minutes for 95 per cent of cases. The approach by which the port identifies the specific response needs,(i.e. identifying the types of incidents and environments to be protected), is one that should be adopted by all ports including Australian ports.

Summary

A feature of almost all the oil spill response systems internationally is the collaboration between industry, including ports, and government. Governments frequently provide the equipment and the resources to manage an oil spill and these are often funded by industry. Governments provide the framework within which oil spill responses are made including the identification of sensitive environments, the matching of the responses to environmental values to be protected and additional resources such as trajectory modelling so that the right equipment can be deployed in the correct location. Ports generally have their own response plans, which can include measures to reduce the likelihood of a spill.

Best practice oil spill management for ports means having a site specific response plan including measures to reduce spills in the first place as well as having in place the interface with the agencies responsible for oil spill management at a national scale such that the fastest most effective response can be implemented.

5.1.5 Cargo handling

Incidents resulting from release of material as a result of cargo handling are not likely be a major risk to MNES. The focus of the dangerous goods regulations has mostly been developed from the safety point of view, meaning the primary purpose of regulations and legislation has been to prevent hazardous material from being released which may cause harm to humans, property, or the environment. Cargo handling operations can result in accidental discharges and emissions. Bulk liquids cargoes have the potential for leaks, emissions and spillages with the extent of impact on the environment depending on the type of material discharged and the volume of the discharge. There are both hazardous and non-hazardous bulk liquids that are carried by ship; both have the potential for adverse impact on the marine environment. Non-hazardous bulk liquids may include vegetable oils; fresh water and the similar materials. Hazardous cargos include:

- Oils
- Gases including liquefied petroleum gas
- Noxious liquid substances or chemicals including wastes
- Dangerous goods including hazardous and harmful materials covered by the International Maritime Dangerous Goods Code (IMDG Code).

The IMDG Code is international standard practice for the transport of hazardous goods by sea. The code covers the packing, stowage, handling and shipping of incompatible substances and the loading and discharging of hazardous cargoes. The code provides for different classes of hazardous substance including, but not limited to, those which are flammable, explosive, toxic, corrosive and radioactive. The code also addresses training for those handling these cargos and actions if an incident involving these cargos should occur. Nations that have ratified the code are required to develop their own national procedures in line with the IMDG Code and these, in concert with the management of runoff from port facilities and the control of shipping to avoid collisions, are the actions that best placed to reduce the risk from hazardous cargos entering the marine environment. Within the code dangerous goods are classified into different classes according to their properties and characteristics. There are nine classes of materials which cover explosives, gases, flammable liquids, oxidising substances and organic peroxides, toxic and infectious substances, radioactive material, corrosive substances and miscellaneous dangerous substances and articles. Materials in each of these classes have differing requirements for packing, storage, transportation, response in case of spillage and first aid.

THE IMDG Code gives direction on:

- Packaging
- Labelling
- Documentation
- Packing
- Quantities
- Storage methods
- Segregation
- Design of containers and tanks.

Ports can control activities in their jurisdiction but are generally subservient to national regulation. The Port of Southampton in the UK is typical in requiring that entry to the port by any ship is contingent upon all goods being in accordance with the UK's Dangerous Substances in Harbour Areas Regulations 1987. These regulations govern the carriage, handling and storage of dangerous substances in harbours and harbour areas in the United Kingdom.

The Port of Los Angeles in common with other Californian ports regulates the handling of hazardous cargoes in accordance with the California Environmental Quality Act and the US

National Environmental Policy Act. Detailed management systems for the handling, storage and shipment of hazardous goods are implemented by the port.

In Canada, Transport Canada is the organisation responsible for the regulation of activities related to the transportation of hazardous goods. Transport Canada operates under regulations made under the Canada Shipping Act and under the Canada Transportation of Dangerous Goods Act. Canadian ports prepare their own management systems for handling of hazardous goods under this system. Particular ports may have site-specific requirements depending upon the cargo types that are handled and the location of the port. For example Port Metro Vancouver, which has a wide range of goods passing across its docks from bulk liquids and solids to containers, has specific requirements including a minimum of 24 hours advance notification for all hazardous cargos entering Port Metro Vancouver and limitations on the time that material can be in the port, the quantities that may be transported and the type of loading and unloading that can be implemented. On-dock storage of hazardous goods is not permitted at Port Metro Vancouver; goods must be immediately loaded onto a vessel or removed by road or rail as soon as they arrive in the port.

In Europe there are specific guidelines prepared by the United Nations Economic Commission for Europe that govern the carriage of dangerous substances and articles. The guidelines contain provisions concerning their carriage in packages and in bulk on board inland navigation vessels or tank vessels, as well as provisions concerning the construction and operation of such vessels. They also address requirements and procedures for inspections, the issue of certificates of approval, and the involvement of trained personnel in auditing and inspection. These regulations are again consistent with the IMO conventions and policies.

The Port of Hamburg in northern Germany, one of the largest ports in the world, manages the shipping of dangerous goods through the implementation of international rules of the IMO, such as the SOLAS convention and its amendments as well as German national regulations on management of dangerous goods. In addition the port has regulations entitled ‘The Regulation on the Transport of Dangerous Goods applicable in the Port of Hamburg’ which contain specific regulations applicable to ships carrying dangerous goods. These additional regulations describe contractual arrangements around the management of these goods in port including responsibilities of the various parties involved in the movement of dangerous goods through the port, linkages with the port’s anti-terrorism systems and methods for activities such as fumigation should it be necessary.

Australia has ratified the IMDG and Australian ports have detailed management plans for the handling of hazardous and dangerous cargos that are built around both occupational health and safety and environmental issues.

Summary

Best practice cargo handling at the port level requires compliance with the IMDG code and is implemented through country level regulations and laws. Over 160 countries have signed up to the IMDG code and have produced local legislation to enforce the IMO policies. As ships travelling internationally must move from one jurisdiction to another it is essential that there is harmony between the various regulations of each country. The ports in each country are bound by their own government’s legislation but there are particular variants in each port that relate to site specific requirements but all must be consistent with the IMO guidelines.

5.1.6 Anti-fouling paints

Antifouling paints are applied to ships and marine structures to discourage the settlement and growth of marine organisms. They are a known source of environmental contamination for water and sediments. The International Convention on the Control of Harmful Anti-fouling Systems on

Ships (2001) prevents the use of organotin compounds such as tributyltin (TBT) being used on ships. It proposes a mechanism to prevent any further harmful substances in antifouling paints in the future. A considerable amount of TBT is present in the environment particularly in the sediments of ports and harbours as a result of historic usage (Sakultantimetha et al. 2009; Schecter 2012). It does degrade over time to less toxic products but the process can be slow (Dowson et al 1996). TBT poses a risk when sediments are disturbed and contaminated material is released into the water column.

Copper has been widely used as a biocide in antifouling paints and there is a reasonable understanding of the bioavailability and toxicity of copper based antifouling paints in the environment (Thomas and Brooks, 2010). Newer components of antifouling systems are less well understood both in terms of their persistence in the environment and their potential for bioaccumulation (Thomas and Brooks, 2010).

The focus on anti-fouling has largely been directed at smaller vessels and marinas. In California in 2011 and 2012 legislation was introduced to ban the use of copper based antifoulants in marinas and on small vessels. Various Californian government departments including the Department of Pesticide Regulation and the California State Lands Commission are conducting research with the aim of further regulating antifoulants.

Antifouling paints are also used on marine surfaces including wharves. Little focus has previously been given to the impacts of these painted static structures. Many of the compounds are currently under review in many jurisdictions around the world (see NZ EPA 2013 for a summary). In general wharves are painted with coatings that are designed primarily as protection and as corrosion barriers and these materials, such as epoxy resins, are generally considered non-toxic.

Summary

The primary management system for antifouling paints is the control of their application, which is generally not managed by the port except in the case of their application to wharves. Best practice management of anti-fouling paints is an activity that is managed at the national level through the implementation of the IMO conventions and policies on the subject. Australia is a signatory to the IMO convention and implements the policies.

5.1.7 Waste from ships

The International Convention for the Prevention of Pollution from Ships (MARPOL) Annexe 5 (1988) governs waste discharged overboard from ships. In January 2013, a revised MARPOL Annex 5 (Garbage) introduced stricter controls on the disposal of garbage from ships at sea. The new Annex stipulates that the discharge of all garbage into the sea is prohibited, except for food wastes, cargo residues and water used for washing deck and external surfaces containing cleaning agents or additives which are not harmful to the marine environment and that are discharged en-route. The disposal of plastics anywhere into the sea is totally prohibited. Governments that ratify the convention are obliged to provide waste reception facilities at ports for the proper disposal of garbage.

Environmentally-sound management of wastes at sea and in port, and the collection and disposal of wastes should be standard practice. The take up of the opportunity to dispose of waste in port-based collection systems has however not always been at the desired level (ESPO 2012).

This was raised during consultation as an issue at Australian ports, where provision and availability of segregated recycling and waste management systems at ports is sometimes limited. This has the effect, where ships are coming with segregated waste, for it only to be recombined where only one bin is provided at the port. It was also discussed that the fee structure associated with waste management at port sites often affects the environmental outcome. When waste disposal is provided as an additional fee for port users there is low uptake, compared with when it is included in the fee. In Australia there is a mixture of fee structures in place.

Case Study – Port of Antwerp Waste Management System

The Port of Antwerp created an incentive scheme to encourage the correct disposal of waste in their port collection system rather than dumping it at sea. Up to 40 per cent of ships calling at Antwerp present waste for port-based collection (Port of Antwerp, 2012). The port also developed a waste management plan in the framework of directive 2000/59/EC.

This action by the Port of Antwerp may have been in response to action taken by the Maritime Commission of the European Union in 2008 where Belgium and Estonia claimed 'insufficiency of provisions on fees to be paid by ships in order to cover the costs of port reception facilities. The directive provides for such fees to be applicable to all ships whether or not they use the facilities, as a way to give operators incentives to such use'.

Actions required by ships which are visiting the port of Antwerp include:

- Notification of waste at least 24 hours prior to arrival and not later than departure from previous port
- Information about type of vessel and type of waste on board
- Inspection of vessel by Port State Control
- Fees for waste collection are then calculated according to a formula which is based on the average costs of the use of a port waste reception facility and is charged whether the facility is used or not. There is a refund paid to vessels that use the Port of Antwerp's waste collection facilities.

Analysis

The action by the port has had the desired effect which has increased the proportion of waste collected at the port, particularly oil water, which can be managed onshore rather than disposed of at sea.

Summary

Best practice waste management at ports involves the development of a waste management plan specific to that port, provision of waste facilities including recycling to meet the projected waste profile for ships visiting that port and the use of incentives to assist in encouraging waste management in accordance with the waste management plan.

5.1.8 Abrasive blasting

Abrasive blasting is commonly used to clean metal structures during both construction and maintenance of wharves and other marine structures such as navigation beacons. Abrasive blasting is also used widely in shipyards and ship maintenance facilities that are frequently associated with ports. Generally a blast material (commonly garnet) is blasted onto a painted or corroded metal surface to remove the paint. The waste product then includes both the blast material (which is generally inert) and the paint or other contamination from the surface. The risk is that, in an uncontrolled circumstance, the waste can make its way, either directly via dust, or indirectly via stormwater run-off, into the water column generating impacts on flora and fauna in the marine environment.

The guidelines for abrasive blasting in the marine environment are generally limited to occupational health and safety issues in shipyards. The United States Department of Labour's Abrasive Blasting Guideline identified the contaminants that may occur from blasting activities and prescribes control measures such as blasting cabinets or blasting rooms, which can, if properly implemented, eliminate exposure to the outside environment. While primarily a health and safety measure, the application of these devices will also prevent the passage of spent blasting material to the wider environment. In Europe a number of countries including the United Kingdom and Germany have banned the use of silica based blasting material on health grounds, as it causes the lung disease silicosis. Outside Australia the literature search did not reveal any additional controls for abrasive blasting for environmental reasons.

Australia has guidelines for abrasive blasting that focus on environmental issues. For example; the South Australian EPA has prepared an Environmental Assessment Guide for Abrasive Blasting (SA EPA, 2011) which has a specifically identified purpose to address the issues of abrasive blasting from an environmental viewpoint. Similarly in Queensland there is a Code of Environmental Compliance for Abrasive Blasting (Queensland Department of Environment and Heritage Protection (2013) and Over-water Abrasive Blasting Guidelines (Environmental Risk Assessment) (2005). These codes set standards for the activity and apply to activities undertaken by ports and are required to be incorporated into Environmental Management Plans for activities where abrasive blasting may be a component. North Queensland Bulk Ports, an operator of several major ports in Queensland, requires that over-water abrasive blasting for any projects in the port will be in accordance with the Queensland guidelines. This includes that the abrasive blasting media used is tested prior to works commencing and meets regulatory requirements and that appropriate capture and disposal techniques are implemented. The testing of the abrasive medium to check that no potentially contaminated material is used was not found to be a feature of international examples.

Summary

Guidelines for management of abrasive blasting in international ports are focussed on occupational health and safety issues rather than environment. The only examples identified in this study of ports considering environmental issues associated with abrasive blasting were in Australia.

5.2 Coastal processes and hydrology

Dredging, reclamation and the construction of port infrastructure may result in changes to coastal hydrological and geomorphological processes that can impact on particular ecosystems and species, including by altering habitat. Hydrological and geomorphological processes vary significantly from site-to-site. Potential impacts of port construction and operation on coastal processes and hydrology should be identified at the site selection and planning stage through tools such as hydrodynamic modelling. Establishing the means of avoiding and mitigating impacts on hydrodynamic conditions and coastal geomorphology (such as through modifications to the design of the port, dredging and reclamation activities) should also be considered at that point, as well as during the design phase.

On the west coast of Canada, Port Metro Vancouver's annual maintenance dredging program is designed to maintain the shape of the riverbed as part of the Fraser River Estuary Management Program. This program brings together the agencies responsible for land and water management of the Fraser Estuary. The program involves the dredging of 3.5 million cubic metres of sediment per year.

For European ports, the European Union Water Framework Directive (Directive 2000/60/EC establishing a framework for Community action in the field of water policy) includes hydrodynamic processes and coastal geomorphology. For example, in 2010 the Port of Antwerp required an expansion of the channel capacity through the Scheldt estuary to the port. Environmental NGOs and the Dutch government (through whose territory the Scheldt flows on its way to the sea) claimed that monitoring showed that the previous deepening works resulted in environmental degradation in the Western Scheldt. As a result any further deepening had to maintain the dynamic and complex flood and ebb channel network in the Scheldt, which is known as the multi-channel system. Much of the dredged material was therefore relocated in the estuary to restore old hydrodynamic regimes and restore areas of habitat (Beirinckx *et al*, 2012).

Outside Australia the application of hydrodynamic modelling to the determination of potential environmental impacts of port development projects is largely framed through the requirements of the approval process for the particular port. These requirements are defined by the approvals body in each jurisdiction.

In Australia the application of detailed hydrodynamic modelling to understand the potential impacts of project interventions on the hydrodynamic regime and other environmental values is widely practiced. The use of independent peer review of hydrodynamic modelling adds to the robustness of the process. Many port development projects in Australia have used hydrodynamic modelling in the design and approvals parts of projects mainly related to dredging. The requirements for the use of models for informing environmental impact assessments are generally determined by the approval bodies. The Great Barrier Reef Marine Park Authority has guidelines for the application of three-dimensional hydrodynamic modelling for dredging projects in the Great Barrier Reef Marine Park (GBRMPA, 2012). The GBRMPA guidelines are a good example of a policy that sets the expectations for requirements to allow for proper assessment of dredging projects.

Summary

Best practice requires that coastal processes are considered in the planning stages of construction and other port activities through hydrodynamic modelling. The standard of hydrodynamic modelling required should be proportionate to the identified risks of the project and must be at an appropriate scale. A benchmark for the application of hydrodynamic modelling would necessarily involve independent peer review of any hydrodynamic modelling programs.

5.3 Noise and vibration

A range of port activities from construction and operations create noise and vibration in both the terrestrial and marine environments. Concern about the impacts of underwater noise has been growing since the 1970s with an increasing focus in research on the subject (OSPAR, 2009; Erbe, 2013, Knight and Swaddle, 2011). Terrestrial noise is much better understood and is identified as the number one environmental issue for ports in Europe based on surveys of ports undertaken by ESPO (ESPO, 2102). Noise impacts on both terrestrial and marine fauna, in decreasing order of severity, include:

- Physiological damage including organ damage which may result in the death of fauna
- Permanent Threshold Shift (PTS): a permanent shift in hearing sensitivity
- Temporary Threshold Shift (TTS): a temporary effect on hearing
- Behavioural changes which may be short or long-term avoidance of an area; cessation of feeding or other activities and changes to migration routes. This includes masking where the anthropogenic noise masks noises such as communication signals from animal to animal.

Port activities that may contribute to noise issues include:

- Piling for both construction and maintenance
- Shipping and other vessel traffic
- Noise from dredging operations
- Onshore port activities.

Investigations of impacts of noise on terrestrial fauna, including the impacts of noise on those fauna that inhabit mudflats have followed a similar pattern to that for marine noise (Erbe 2013, Knight and Swaddle, 2011, Ortega, 2012). Initial investigations were concerned about high intensity noise that could cause physical impacts. More recently investigations have focussed on behavioural disturbances that may have more subtle ecological impacts.

In the context of marine mammal conservation, behavioural responses are defined by Southall *et al.* (2007) as responses that may result in demonstrable effects on individual growth, survival, or reproduction. Examples given for the onset of significant behavioural response include:

- Individual and/or group avoidance of a sound source
- Aggressive behaviour
- Startled response (that may expose an individual to danger)
- Brief or minor separation of mother-and-calf
- Extended cessation of vocal behaviour
- Brief cessation of reproductive behaviour.

The authors concluded that there is insufficient data on the levels and types of underwater noise that may elicit adverse behavioural responses in marine megafauna to recommend underwater noise management guidelines addressing these types of response. Specifically, they note that when data on behavioural response/sound pressure levels is pooled across laboratory and field contexts, different initial animal activities, habituation/sensitisation periods, and considered in the context of biologically relevant natural signals, there is no correlation between response and noise exposure that can be generally applied. They conclude that any future behavioural response noise relationship will likely need to be developed for specific defined noise source, species and behaviour.

Underwater noise needs to be assessed on a site specific basis with regard to particular local conditions, the type of activity being proposed and the likely species that may be exposed to the underwater noise. In many cases there is insufficient data on the potential impacts of noise on particular species but this uncertainty must be incorporated into the assessment process.

5.3.1 Terrestrial noise management

Noise impacts on the terrestrial environment are generally treated internationally as a health and safety or nuisance issue. The ‘Good Practice Guide on Port Noise Mapping and Management’ produced by the NoMEPorts Project (Noise Management in European Ports) was developed to help ports meet the Environmental Noise Directive (2002/49/EC) and its subsidiary local regulations. This report is based largely on health impacts of noise on humans. Similarly the approach of the US noise regulations is around human health and nuisance values.

At the Port of Oslo in Norway a range of activities have been implemented to reduce noise levels in the port and surrounding areas. If noise reduction were desired to limit impacts upon animal populations rather than humans then these activities may be also effective. These measures include:

- Development of a programme simulating noise effects
- Replacement of forklifts and reach-stackers with gantry cranes with rubber tyres
- Substitution of diesel engines with electric power
- Reduction of noise from warning bells
- Insulation of machinery
- Installation of rubber bricks on trailer trucks preventing sharp noise
- The terminal ground has been asphalted in order to level the surface
- Establishment of a noise deflection wall.

Australian ports manage noise in accordance with local regulations. The Port of Townsville though its Planning Codes and Guidelines requires development by both the port and its tenants to comply with Queensland government noise guidelines. Such an approach is similar throughout Australia. The Port of Newcastle has developed noise management plans for port areas where terrestrial noise may be an issue which address particular issues.

Summary

Best practice noise management involves matching the required reduction in noise with the sensitive environmental receptors that may be affected by the noise. Terrestrial noise management is generally treated internationally as a health and safety or nuisance issue. However, there are a variety of techniques used that could also be applied to address noise impacts on terrestrial species.

5.3.2 Marine noise management

Underwater noise sources have the potential to impact on surrounding fauna at some distance from the site generating the noise. Until the last decade, the focus on underwater noise has been largely about high intensity noises including marine piling, sonar and seismic surveys. Of these noise sources ports are generally only concerned with marine piling. There has been a widening of interest in lower level marine noises over the past ten years or so. The impacts of noise on behavioural responses of animals including interruption with communications, disruption to feeding and the masking of vocalisations are amongst many impacts of low level noise that can occur (Southall *et al.* (2007). Although general assumptions about noise impacts can be made based on existing knowledge, there are gaps in many areas, particularly the sensitivity of individual species to noise. Therefore any assessment of the potential impact of marine noise will have to incorporate this uncertainly into the risk assessment process.

Boyd *et al* (2008) proposed a risk framework for assessing the impacts and management of underwater noise on marine mammals as part of environmental impact assessment. The risk framework includes:

- Hazard identification
- The type of construction equipment to be used in the project including the noise signatures and the timing of the works
- Characterising exposure to the hazard
  - Occurrence of fauna in the area that may be impacted by the project
- Characterising dose-response relationships
  - Understanding the hearing sensitivities (frequency and hearing thresholds of the fauna
  - underwater noise modelling

- Risk characterisation
- Risk management.

Quantification of the information required for each of these steps is important.

There has been a range of regulatory responses to the issue of marine noise. The EU's Marine Strategy Framework Directive (2008/46/EC) states that objectives for underwater noise should be set such that *Introduction of energy, including underwater noise, is at levels that do not adversely affect the environment.* As such each member state is required to develop guidelines for each of the marine areas in their jurisdiction. There is still considerable work being undertaken in Europe and elsewhere to establish the quantitative impacts of underwater noise and what control measures need to be in place. Organisations such as OSPAR are moving to investigate how they can manage underwater noise.

Underwater noise management guidelines for the protection of some marine fauna (e.g. cetaceans and pinipeds) are currently in a developmental phase internationally and are subject to on-going studies, investigations and discussion in the international scientific community. However, there are guidelines that have been developed for the oil and gas industry specific to the operation of seismic air-gun arrays (for example EPBC policies in Australia).

The auditory and behavioural effects of anthropogenic marine noise on cetaceans have been extensively reviewed and summarised by Southall *et al.* (2007).

Outlined below are measures being used internationally to address marine noise from the main sources that may be relevant to ports: marine piling, shipping and dredging.

Marine piling

One of the areas of marine construction where there has been scrutiny over recent years with respect to noise impacts is marine piling. Pile installation by hammering is a practice that has been employed for centuries to construct wharves and other structures in marine environments. The hammering of piles into the substratum has the potential to produce noise levels that could cause injuries and maybe death to fauna close to the activity and elicit changes in behaviours at some distance from the activity. Evidence for both types of impact is available in the literature (Bailey et al., 2010). Injury causing impacts are generally localised to within a hundred metres or so to the noise source, whereas behavioural impacts can be detected up to 50 km away (Bailey et al., 2010).

Underwater noise from piling operations is frequently considered in the environmental impact assessments of ports internationally. Piling can occur both in the construction of a new port as well as in existing ports where expansion may be taking place where piles need to be replaced. Additional focus has come onto this activity through the increased construction in the marine environment internationally of wind farms and other structures in shallow waters where piling is an option for construction.

There has been a range of regulatory responses to the issue of piling noise, including the EU's Marine Strategy Framework Directive (2008/46/EC) as summarised above.

The Joint Nature Conservation Committee, a public body that advises the UK Government and devolved administrations, on UK and international conservation, has developed protocols for minimising the risk to marine mammals as a result of injury from piling derived noise (Joint Nature Conservation Council, 2010). This protocol is aimed at minimising injury and death to marine mammals and does not seek to minimise the wider impacts such as behavioural disturbances. The protocol requires the use of marine mammal observers as well as monitoring of underwater noise and the restrictions of activities at times such as at night and during other periods of poor visibility. Other requirements include the soft start of the pile driver such that noise builds up in the marine environment and there is potential for marine mammals in the area to move away.

In the US the impacts of piling on fish and mammals may be captured by legislation including the Endangered Species Act; Clean Water Act; and the National Environmental Policy Act. A number of federal agencies such as US National Oceanic and Atmospheric Administration (NOAA) Fisheries and U.S. Fish and Wildlife Service must issue a Biological Opinion about the potential impact of the noise on listed marine fauna before a piling project can proceed. Several major projects have been delayed because of concerns related to the effects of noise from pile driving on fish. These have resulted in the implementation of technical measures such as the use of bubble curtains and cofferdams to mitigate any potential impacts.

The California Department of Transportation has developed Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish (California Dept. Transport, 2009) this provides detail on the potential impacts of piling as well as mitigation measures.

As for other management measures for noise, undertaking piling operations at times when sensitive species may not be present is the most effective way of avoiding potential impacts. Many sensitive species such as whales and fish are migratory and as such there are opportunities for construction windows when they are not present in the immediate environment. In Canada, piling operations at Port Metro Vancouver were required to be undertaken when migrating juvenile salmon were not present in the harbour thus avoiding impacts altogether. The migration calendar for salmon is well known and many contract works in waterways along the salmon migration routes are prohibited during certain times of the year. During the construction of a new car terminal at the Port of Grimsby in the north east of England, foundation piling was prohibited for three and a half months from May to July so as to avoid disturbing migratory birds feeding on the adjacent mud flats.

Other attempts at avoidance involve the use of observers to detect the presence of sensitive fauna in the vicinity of piling operations. There is little evidence available to allow an assessment of the effectiveness of this method. The effectiveness of observers during poor weather and at night is likely to be less than during ideal conditions. In most cases the use of observers should be used in combination with other measures to enable avoidance and mitigation of impacts.

If avoidance is not an option then there are methods that can be used to minimise the energy transmitted from piling operations. There are a range of technical options identified in the literature and being used by ports internationally such as:

- Vibratory pile driving where a vibratory hammer is used in place of an impact hammer. Usually used for smaller piles this method is expected to produce lower peak pressures than impact piling, however because this method operates continuously the total noise may be comparable to impact piling operations (Spence et al., 2007).
- Soft start, where piling starts at a low level and progressively builds in intensity through a piling session. There are concerns that the use of this method results in sensitive fauna still being present when piling noise increases in intensity and thus may still be exposed to high noise levels.
- Pile caps where a cushion of material is used to cushion the impact of the piling hammer. Laughlin (2006) investigated the underwater sound levels during construction of the Cape Disappointment Boat Launch Facility in Washington State US. The pile caps tested were constructed from wood (plywood), Conbest, Micarta, and Nylon. Piles were driven with an air hammer. Micarta achieved the best sound level reductions, with the exception of wood, while retaining hammer efficiencies and minimizing safety hazards. Pile caps have

a limited life span so considerable waste is generated through their use. More investigation appears required to establish their effectiveness.

- Cofferdams, which are temporary structures used to separate the area around the piling operations from the general marine environment. Sometimes cofferdams are dewatered providing an effective noise barrier. Stokes et al (2010) modelled the reduction in noise for a large dewatered cofferdam for a windfarm installation and found a reduction of 20 dB could be achieved. Cofferdams slow down the rate of piling and require structures to be built and dismantled; they are more effective than other methods however are more expensive.
- Bubble curtains have been found to be effective to minimise the noise from piling. Produced by forcing compressed air through holes drilled in a ring or pipe). MacGillivray and Racca (2006) reported on the effectiveness of this method and concluded that the bubble curtain proved effective in mitigating both sound pressure and particle velocity generated by the pile driving. Reductions in the peak pressure noise from piling operations have been reported to range from 5 to 20 dB (CSA Ocean Sciences Inc., 2013).

In Australia underwater noise has been given considerable attention, particularly for development projects. For example the Outer Harbour at Port Hedland (Salgardo Kent et al., 2009), the Port Expansion Project at the Port of Townsville (GHD 2012) and the Underwater Noise Assessment for the Abbot Point Cumulative Impact Assessment (McCauley et al. 2013). These and other similar investigations have taken the approach that each project is different and different species may have different responses. Therefore detailed investigations are needed for each project to assess potential impacts of underwater noise.

Shipping noise

Propeller-driven ships have become the most dominant human-induced low frequency noise in the marine environment (Erbe 2013). Evidence is accumulating that ship sourced noise is having an impact on marine fauna and in particular whales. For example, reports suggest that North Atlantic Right Whales have lost two thirds of their communication space in the Stellwagen Bank Marine Sanctuary off the north east coast of the US as a result of noise from ships (van der Hoop et al 2012). Data from the Bay of Fundy in Canada, which covered the period following the events of September 11 2001 when there was greatly reduced ship traffic, found that there was decrease in right whale stress hormones during this time (Rolland et al, 2011). The European Union, through the Marine Strategy Framework Directive, has identified marine noise as an area where environmental improvement can be made.

In 2007, the US attempted to have the IMO address the issue of shipping noise as a contributor to the rising noise levels in the marine environment. In 2012 the Marine Environmental Protection Committee of the IMO reaffirmed the previous agreement that non-binding technical guidelines designed to reduce the incidental introduction of underwater noise from commercial shipping, be developed as a means to reduce the potential adverse impacts of this noise on marine life. The IMO has moved to address noise on board ships as an occupational health and safety issue (IMO 2013) but has yet to move beyond voluntary approaches for external noise generated by shipping.

Ship design is the leading mechanism for improvements in this area largely through improvements in propeller design. Cavitation (the formation and then implosion of water vapour pockets which are caused by pressure changes across the propeller blade) has been identified as the main source of noise from moving vessels (Renison Marine Consulting, 2009).

The literature review revealed no specific actions being taken by ports to reduce marine noise generated by shipping, though noise reduction may be a by-product of speed restrictions (such as those that are in force at the Port of Los Angeles and Port of Yokohama in Japan) which are implemented for other reasons, such as reduction of emissions, health and safety, and avoiding ship strike with marine megafauna.

Dredging noise

Both PIANC and CEDA have recently prepared documentation to address the issue of dredging induced marine noise. Over the past decade there has been a range of investigations to characterise the marine noise that dredging operations can produce (Dickerson et al., 2001; Reine et al 1998; Reine et al., 2012a, 2012b; Thomsen et al, 2009). Noise can be produced from dredging operations as a result of:

- Excavation and sediment removal - the noise of the cutter on a Cutter Suction Dredge, a drag head on a Trailer Suction Hopper Dredge or the noise of collection using a grab dredge. This also includes the sound of the pumps, the noise of which may be transmitted through the vessel's hull and into the water as well as the noise that may be generated through any pipelines that may be used;
- General shipping noise whilst moving
- Depositing of the dredged material.

Dredging noises are not considered to cause physiological damage or injury, but there is potential for behavioural impacts. Thomsen et al (2009) and CEDA (2012) in their position paper highlighted the absence of any experimental work on the impacts of dredging noise on marine fauna. They also acknowledge a lack of information on the consequences of environmental noise emanating from dredging operations.

Robinson *et al* (2011) investigated the underwater noise that is produced by marine aggregate dredging in the United Kingdom. Aggregate dredging is conducted to recover material for use in road and other construction and is generally undertaken with a fleet of Trailer Hopper Suction Dredges. The authors concluded that sound levels produced during the aggregate dredging operations at frequencies below 500 Hz were generally in line with noise levels generated by a cargo ship travelling at modest speed and that sound levels at frequencies above 1 kHz show elevated levels of broadband noise in excess of that produced by shipping. The aggregation extraction process was the main source of this noise which was dependent upon the type of material being dredged. Gravel extraction produced higher noise levels than sand extraction.

The Port of London Authority, assessed the potential impacts of noise on shorebirds which inhabit the mudflats adjacent to maintenance dredging activities in the winter months (PLA, 2004). Maintenance dredging at the Port of London occurs using water methods four times per year. Bureau Veritas-Acoustic Technology (2003) considered that the noise disturbance from dredging operations would be only a minor contribution to the general noise levels in the area of the port and that it was likely that the presence of dredge would be of more importance as a source of disturbance for the waterfowl. They concluded, however, that as the dredge was slow moving it was likely that the level of disturbance from dredging would be low.

The only mitigation measures so far proposed are avoidance of dredging at times when sensitive life stages of particular species may be present (Reine et al 1998). These dredging windows are usually implemented to cover a range of potential impacts from the dredging operation such as increased turbidity (Bowen and Payne, 2012). The approach therefore is to avoid impacts and as such is likely to be an effective solution to a noise problem. As yet there is insufficient information to support the use of noise as a sole criterion for timing restrictions on dredging. This is an area of potential environmental where more data is required.

The CEDA position paper on noise from dredging discusses the risk-based approach of Boyd (2008) for assessing the potential risk of the dredging and then identifying the most appropriate mechanism to mitigate identified impacts.

Summary

The approach of Boyd *et al* (2008) represents best practice as it identifies a process for examining noise impacts and tailoring the response appropriate to the risk. Marine piling is the major source of noise impacts from ports, with dredging also having an impact. Ports internationally have in general responded to marine noise issues through the application of specific techniques in response to specific situations. In particular, the timing of the activity and monitoring of the presence of species can assist in avoiding impacts, as can technical solutions (such as use of bubble curtains, coffer dams, piling caps and vibrational piling) Australian ports are also adopting these practices where applicable.

The study did not reveal any specific actions being taken by ports to reduce marine noise from shipping, although notes that this may be a by-product of actions such as speed restrictions which are implemented for other reasons, such as emission reduction, health and safety and to avoid collisions with megafauna.

5.4 Lighting

The impacts of stray light on fauna may confuse natural patterns of behaviour, influence migration, deterring fauna from established foraging areas, and affect breeding cycles by altering the natural patterns of light in space, time and across wavelengths. Artificial lighting over marine areas has the potential to interfere with the behaviour of marine organisms. Turtles in particular are vulnerable to anthropogenic light in the marine environment (Kamrowski *et al* 2012). Extension of light periods into the night has the potential to reduce the success of turtles nesting through disorienting the turtles on their way to the nesting beach or while they are on the nesting beach. Light over or in the water can deter turtles from nesting altogether and once hatching has occurred lighting can not only disorient the hatchlings but also allow them to be more visible to predators. These is also potential for marine light pollution to impact upon other fauna such as whales but these impacts are less well known and documented than for turtles.

The impact of artificial light on birds is well known. The Royal Society for the Protection of Birds, a British NGO, reports that a number of British birds now sing in the night, behaviour that was previously restricted to daylight hours only, as a consequence of the extent of light pollution in the British Isles. Light pollution is recognised as a major threat to seabirds in particular (Weise et al 2002). Many nocturnal seabirds including gulls, shearwaters and petrels have been observed to have ecological disruptions as a result of increasing amounts of light (Montevecci, 2006; Raine *et al* 2007). Light pollution can influence, navigation, feeding behaviour, reproduction and habitat choice. Light attraction is a major problem with shearwaters, petrels and albatross where the birds are attracted to light sources which disrupts migration and makes these birds more vulnerable to predators which they are trying to avoid by being active at night. Increases in mortality of these birds have been attributed to artificial lights (Le Corre *et al* 2002). These impacts have also been reported for other types of birds such as wading birds.

The impact of lights produced by ports was addressed in Bailey *et al*, (2004) where the light impacts on wildlife was recognised in addition to impacts on humans. Lighting for construction activities may have a short lived effect compared to operational lighting at a port which in almost all cases is a permanent feature. Operating ports need lights for safety and security but the spread of light beyond the boundary of the port is not required. Baffling of light for nuisance reduction is a common practice in urban environments for reducing nuisance lighting and could easily be applied by ports without a reduction in the effectiveness of the lighting for designated uses. The periods at which lights are operating may also be investigated as an option for reducing the potential impacts, although most ports operate 24 hours a day and as such this option is likely not to be feasible.

There are examples internationally where light management practices are being implemented to reduce impacts on turtles. One example is where the International Union for the Conservation of Nature (IUCN) has assisted the Port of Dhamra on the east coast of India to manage environmental issues for the growth and management of the port. One of the issues to be managed is the presence of Olive Ridley Turtles. Specific measures such as baffling of lights and directional lighting to prevent lighting from spilling over to off shore waters have been developed. IDA (International Dark Sky Association) parameters are also required to be implemented to assist in the reduction of light impacts on the turtles.

Port Canaveral in Florida in the US has a light management plan that has been developed to reduce the impact of port lighting on the natural environment and in particular to address issues with turtle nesting. Actions as part of the lighting strategy include:

- Shielding all new lights so that they are not visible from beaches
- Providing multiple levels of control on new lighting so that lights can be turned down when used for security rather than operational purposes
- Applying timers and motion detectors to lights so when not needed for security they can be turned off
- Port Canaveral requires all tenants to submit individual light management plans for any new construction that must be consistent with port's own light management plans.

The examples mentioned above were included because they involve actions that go beyond the normal management of lighting at ports. The involvement of external stakeholders (the IUCN in Port Dhamra's case and US Fish and Wildlife in Port Canaveral's case) and the extension of the requirements to tenants shows a commitment to the reduction of the impact on turtles. The economic impacts on the ports were not significant. These methods do not only provide a mechanism to reduce light impacts on turtles but also help save energy and money. More efficient lighting and lighting that is turned off when not necessary means lower energy use. These types of approaches are frequently used in many different industries internationally.

Summary

Light impacts from ports internationally are generally considered in terms of their impacts on human activity. However, there is potential for impacts on the natural environment as well as aesthetic effects. There are measures which are widely implemented to reduce the impacts of light from a social perspective which could also be applied to address environmental impacts.

5.5 Aesthetic

Aesthetic values are recognised as an important value of many natural areas, including along coastlines and waterways. For example World Heritage properties that meet natural criterion vii are those that 'Contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance'. The presence of marine infrastructure for a port or indeed the presence of ships in transit or at anchor may degrade from these aesthetic values. This disturbance to natural values can occur both onshore as well as offshore. There are limited opportunities to design out the aesthetic impacts of port infrastructure. Particular port structures are designed to operate to interact safely and efficiently for their intended purpose, which is the loading and unloading of ships. This means that structures such as container cranes or bulk loaders cannot be substantially reduced in size. There are some opportunities for minimising the visual impact of the port. An example is the Vuosaari Harbour Project for the Port of Helsinki. Constructed in the conservation area of Mustavuori grove and Östersundom bird wetlands, aesthetic considerations were included in the design of this facility to reduce the aesthetic impact on the nature reserve, even though the Environmental Impact Assessment for the port identified that there were ‘few factors by which the visual appearance of the port centre can be affected... however these can be effective’. Vegetated noise barriers were constructed around the port, light spill was limited through design and storage sheds were limited to single storey only.

Ships sitting at anchor can also be an aesthetic issue for ports that have some bulk operations (Tengku-Adnan, T. 2009). Container vessels and cruise ships usually have set schedules that do not require them to wait for a berth at the destination port.

A review of the international practice with regard to vessel arrival systems for anchorage management revealed that the only ship anchorage management system related to a port is that which operates at the Port of Newcastle in New South Wales, Australia and relates to ships waiting to load coal. Other queue management systems such as for the River Schelde in Belgium for the Port of Antwerp, the Turkish Straits and Bosporus in Europe, and the Suez Canal in the Middle East have been designed and are operated for different purposes, e.g. tidal assistance (River Schelde), traffic separation (Turkish Straits) and transit convoy planning (Suez Canal). The need for or otherwise of ship queuing systems will be dependent on the particular circumstances of a port. The availability of existing anchorage space, the types of cargo handled by the port and economic factors will largely drive the need for a ship queuing system.

However, it is worth noting the development of ship charter contracts by some global oil companies (e.g. BP) and some global bulk agricultural traders (e.g. Cargill) to try to incentivise ship owners to slow-steam or optimise ship speeds. These contracts aim to match scheduled arrival dates at berths with availability of cargo as opposed to ships racing to a load location, as is also the case with some ships arriving to load coal. The advantage of ship slow-steaming is not only economic (fuel cost savings) but is also environmental (reduced greenhouse gas emissions and reduced anchoring). These contractual developments between cargo-owners (exporters/importers) and shipping companies should help support the operation of vessel arrival systems aimed at managing anchorage supply/demand and ship queues as well as providing environmental benefits (reduced anchorage area foot-prints and ship greenhouse gas emissions).

The aesthetic impact of the port itself is something that is dealt with at the site selection planning and design phases. Once the port has been constructed there is limited opportunity to influence aesthetic impact. Navigational structures may also have an impact through the presence of in water and on land structures that are visible both by day and by night. The importance of these to the safe operation of the port means that there is very limited scope to mitigate any aesthetic impact they may have.

Summary

There are limited measures that can be taken to reduce the impacts of ports on the aesthetics of an area. The structures in ports are designed on functional grounds and there are limited opportunities to reduce heights, although there may be opportunities to minimise some impact through landscaping. The primary opportunity to reduce aesthetic impacts of the port itself is at the site selection stage of port development.

Ship anchorages are at times cited as areas where there is impact on aesthetic values and as such where changes may be made. Ship anchorage management is uncommon internationally and in most cases is undertaken for safety or commercial reasons. In addition many anchorages are not under the control of the ports themselves so ports have no opportunity to influence outcomes. Ship queuing systems, such as those used at the Port of Antwerp and the Port of

Newcastle, may provide an opportunity to reduce aesthetic impacts of ship anchoring, but may not be an option for all ports.

5.6 Direct ecosystem impacts

Direct impacts, including impacts on individual species, communities and ecosystems, can arise from both port construction and operational activities. The most obvious actions are the clearing and removal of the natural environment and its replacement with industrial infrastructure during the construction of a port. Such actions include vegetation clearing in the terrestrial environment. In the marine environment, the creation of reclamations, building of overwater infrastructure such as wharves and jetties and the dredging can see the permanent removal or smothering of natural environments.

Direct impacts on species can also occur from shipping and dredging operations.

5.6.1 Port development and habitat removal

The best methods for avoiding impacts are the minimisation of the extent of any disturbance. No disturbance at all is clearly the best position for the environment, but may not be practical for the port. Minimisation therefore is an essential consideration in port design. If impacts are to occur offsets are often an option.

Offsets can be linked to specific projects or be part of a port's overall environmental management program. Offsets are emerging as an increasingly employed mechanism for achieving net environmental benefits, with offset policies being advanced in a wide range of countries (i.e., United States, Australia, Brazil, Colombia, and South Africa). This is the third component of the 'avoid, minimise, offset' hierarchy established under the United Nations Convention of Biological Diversity.

The objective of the offsets process is to achieve no net loss of species community structure, habitat integrity, ecosystem functioning, and the associated social values due to unpreventable impacts associated with project development (construction and operation). The process of developing biodiversity offsets needs to follow the efforts in planning phase of the project to avoid, reduce, and manage the potential impacts.

Case Study – Port of Helsinki Vuosaari Harbour Project
The Port of Helsinki required expansion, but like many urban ports was constrained by surrounding infrastructure. To resolve this, the port left passenger traffic in the centre of the city and moved the cargo traffic to a new purpose-built facility to the east of the metropolitan area of Helsinki. The harbour has a total land area of 150 hectares, including 90 hectares of reclaimed land. Significant economic advantages were to be obtained from moving the harbour to the new location. Between the location of the new port and the Helsinki metropolitan area was the Natura site of Mustavuori grove and Östersundom bird wetlands. This site is part of the Natura 2000 network of conservation sites. In order to avoid the wetlands, road and rail access to the port is achieved through a system of tunnels and bridges. The tunnels were specifically designed to prevent impacts on the groundwater or surface water systems of the wetland and construction was undertaken outside the bird-nesting season between April and July. There are also controls on the operational noise that can result from the tunnels and construction traffic was managed to avoid disturbing the wetlands. Other features of the project included the construction of noise barriers from old car tyres, which the project proponent claims has resulted in significant savings.

Analysis

This case study was selected as an example of best practice as the port's design and construction program enabled avoidance of impacts on the wetlands. This is an approach that could be considered and adopted in port developments within Australia.

Additional examples

The Port Everglades is located in heart of Greater Fort Lauderdale in Broward County, Florida. It is a cruise and container port and is one of the most active ports in the US. The port is located in an important natural ecosystem with a mangrove community. An area within the port also provides winter habitat to manatees, which are protected under the US Marine Mammal Protection Act 1972 and the US Endangered Species Act 1973. The port is currently undergoing large scale improvements to handle more international cargo more efficiently and improve tourism services including the deepening and widening of the navigational channels.

The project requires the removal of 8.7 acres of existing mangrove conservation easement which is to be offset with a 16.7 acre upland enhancement within the port of approximately 70,000 new mangroves, plants and seeds as well as environmental improvements in nearby West Lake Park. The development of a plan for the new mangrove habitat is in consultation with the Florida Department of Environmental Protection. The project is currently in the design and permitting phase and scheduled for completion in 2017.

In Florida Seagrass Mitigation and Management Area funded by the Manatee County Port Authority, a medium sized bulk port in the Gulf of Mexico, aims to improve the local ecosystem by protecting manatees, transplanting and protecting seagrasses, and enhancing local environmental points. The protection of manatees and seagrasses in and around Port Manatee is partially achieved by prohibiting operation of internal combustion engines within a 480-acre area of surrounding waters. The port has also restored more than five acres of seagrass and added more than 20 new acres to the mitigation area.

In Washington State, in an effort to protect the Port of Bellingham in Puget Sound from erosion and to provide improved surroundings for marine wildlife, the port removed 5,600 tons of concrete and rock from the shoreline of a waterfront park and replaced it with a sloping cobble and sand beach. In addition to improving marine wildlife habitation, the new beach is a recreational asset for the local community. In addition to this the port is helping salmon recovery a high profile environmental issue in the area through:

- The construction of intertidal mudflats
- Improving nearshore connectivity
- Removing creosote pilings and unnecessary over-water structures
- Restoring of urban shorelines.

The Port of Bremen (Germany) is undertaken substantial compensatory activities to offset for the creation of the Container Terminal 4 expansion. On Luneplate, a former island in the Weser to the south of the port of Bremerhaven, a range of environmental projects aimed creating habitat for flora and fauna are being implemented. This project has set new European standards. The project involves the rehabilitation of farmland into natural habitat. The offset site is in the order of 1000 ha and also is used as compensation for other port projects.

Indirect offsetting is also being practices at some ports. The Port of Long Beach in Southern California provides some $2.6 million in grant funding through Community Mitigation Grant Programs, which are designed to offset the environmental impact of the Port in the communities nearest the Port and its trade corridors. Grant funding currently available comes from Port projects such as the Middle Harbor Redevelopment and the Gerald Desmond Bridge Replacement project.

Summary

Best practice management of port development is the avoidance of impacts on habitats through minimisation of the extent of any disturbance. No disturbance at all is the best position for the environment, but may not be practical for the port. Impacts should then be mitigated where possible through design, engineering and management or operational controls. If impacts are to occur then offsets are often an option. Offsets should achieve no net loss of species community structure, habitat integrity, ecosystem functioning, and the associated social values due to unpreventable impacts associated with project development (construction and operation).

5.6.2 Shipping operations and dredging impacts on fauna

Shipping

Shipping is an international business. In order for regulation to be effective controls need to be consistent and coordinated across international boundaries. The IMO is responsible for the safety and security of shipping and the prevention of marine pollution by ships. The IMO is largely a technical organisation which undertakes work in the following areas:

- Dangerous goods, solid cargoes and containers
- Fire protection
- Flag state implementation
- Safety of navigation
- Radio communications and search and rescue
- Ship design and equipment
- Stability and load lines and on fishing vessels safety
- Standards of training and watchkeeping.

The IMO has developed International Conventions on these issues which are adopted individually by member states which then bring these conventions into their own legal frameworks. Through its history the IMO has developed over 50 conventions and protocols. Individual ports are bound by their government's adoption of IMO conventions and protocols into their local regulations.

Large marine fauna including whales, dolphins and porpoises, large sharks, dugong and large fish such as sunfish can be injured or killed through collisions with vessels. This can have impacts on marine ecosystems. The incidence of collision with cetaceans is difficult to determine but it is believed that up to one third of whales found dead have signs of vessel strike (Laist et al., 2001). In the case of endangered, endemic or geographically-isolated cetacean populations (such as the North Atlantic Right Whale) ship strikes may pose a significant conservation threat. Increasing speed of vessels is thought to be a contributing factor to the increase in collisions (Laist et al, 2001). There are limited means of avoidance as ships cannot change course or stop within any reasonable distance. The most effective avoidance mechanisms identified in the international literature are vessel speed and operational locations. Vessel speeds are generally regulated with respect to safety, local conditions and navigational rules. A certain minimum speed may be required to enable the vessel to be safely steered so slowing to very slow speeds may not be possible.

In 2008 the IMO provided guidance for minimising the risk of ship strikes with cetaceans. IMO Circular MEPC.1/Circ.674 advocates actions for gathering and disseminating information, education, and consideration of new technology. The IMO circular also recommended operational measures such as routing and reporting to assist in the avoidance of cetacean strike. These were non-binding measures and the effects of their application remain unclear.

There are a number of situations internationally where governments have taken action. Alterations to shipping routes and speed restrictions have been introduced in response to the incidence of ship collisions with whales. Offshore from the North East Atlantic Seaboard of the US the Atlantic Right Whale is an endangered species at risk from collision with large vessels operating in the area. Between 1999 and 2003 there was an average of 2.6 deaths per year attributed to ships strikes. There are a series of locations along the coast where vessels in excess of 19.8 metres are restricted to 10 knots or less between 1st of April to July 31st each year. The effectiveness of these mandatory restrictions is expected to be evaluated in late 2013.

Research is being undertaken to determine whether restrictions of shipping routes may also help reduce collisions between ships and Atlantic Right Whales. A preliminary assessment in 2012 (Silber and Bettridge, 2012) reported that the timeframe for analysis had been insufficient to obtain statistically rigorous results but there was a suggestion that the speed limits for shipping were potentially effective in reducing the potential risk to the whales.

In 2007 ship strikes are thought to have caused the deaths of four Blue Whales in and around the Santa Barbara Channel offshore from the southern California coast. In response the IMO announced in late 2012 that it had adopted proposals to reduce ship strikes with ships on the approach to San Francisco Bay, the Santa Barbara Channel and the ports of Los Angeles and Long Beach including the changing of shipping routes.

All cetaceans in Australian waters are protected under the EPBC Act and all vessels operating in Australian waters are obliged to avoid harming these animals. An example of this being applied in practice is the EMP Port of Melbourne Channel Deepening Project, which contained specific requirements for monitoring for cetaceans and required actions for vessels in the event of a cetacean sighting. The EMP, including the cetacean monitoring requirements, was subject to internal as well as external independent audit.

Dredging and direct impacts on fauna

One of the identified potential interactions between dredges and marine fauna is the potential for fauna (turtles in particular) to be entrained into the dredge with fatal results. Worldwide turtles have been reported as being injured and killed by dredging operations and most species of turtles appear to be affected.

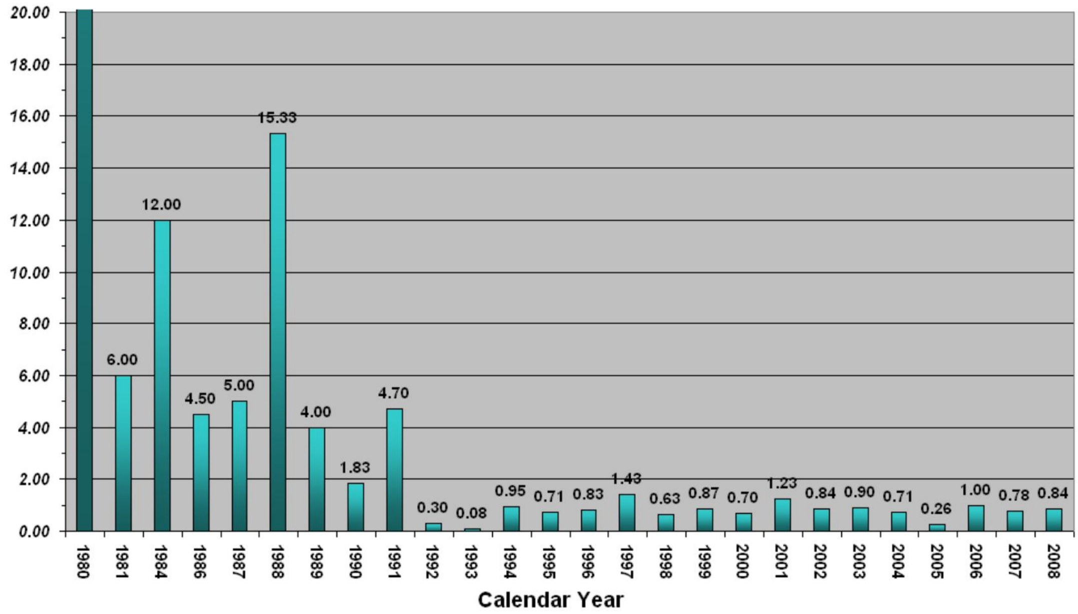
A number of mitigation measures have been proposed including:

- Appropriate siting of dredge operations - this is often difficult for existing ports but is an essential consideration for any new ports in contemporary ports planning. Siting of new ports should consider all environmental values and if risks to these values can be mitigated through choice of location of the port then this should be considered if at all possible.
- Timing of dredging operations. Periods of turtle nesting are potentially times when incidents with dredges are more likely and therefore if possible dredging should be schedule to avoid these times.
- Dredge type; section dredges are more likely to cause impacts on marine megafauna than mechanical dredgers.
- Modifications to dredges. There are modifications such as turtle deflectors and chains that can be used to limit the potential for intake into the dredge.

- Operational methods such as not operating the suction pumps when the drag head of the dredge is not on the bottom.

Dickerson (2010) reported that the implementation of these methods saw a marked reduction in the number of turtle takes per dredging project in the US (Figure 5).

Figure 5 Number of turtle takes per dredging projects in the US for the period 1990-2010. Protection methods were introduced in 1992 (from Dickerson, 2010)



Summary

Discussion of many of the potential sources of direct ecosystem impacts has been included in other sections of this report. For example many of the shipping issues are covered in the section on impacts on water quality. The issues of direct and indirect impacts through land clearing and reclamation are primarily port planning issues, however construction environmental management plans can be used to minimise impacts on species during clearing.

The actions that are adopted by ports in response to the issue of direct impacts on fauna through shipping and dredging operations are generally implemented through environmental management plans for these operations. In general, the responses are common techniques used by ports such as speed limits and shipping route restrictions to avoid ship-strikes and technical measures for dredging operations.

5.7 Air quality

Air quality generally has limited impacts upon MNES, so it has not been considered in detail in this report or analysed to identify best practice. Dust emissions have been considered in section 5.1 on water quality.

However, air quality is a major environmental issue for many ports globally (ESPO, 2010) and there are a wide range of actions being implemented to reduce both greenhouse emissions and other air quality impacts. Such actions include:

- Cold ironing: Ships when in port stop their engines and derive their power supply from direct connection to the local electricity grid. This reduces emissions and noise emanating from the ships themselves while in port.

- Fuel sources: Some ports in Europe are beginning to offer LNG as a fuel source and there is already conversion of existing vessels and the building of new vessels to run on LNG. LNG is much cleaner than existing fuel oils that are conventionally used in shipping. Even without conversion to LNG the change from traditional heavy fuels to lighter low sulphur fuels is a trend worldwide.
- Fleet preference schemes: The Port of Los Angeles' (Port) Voluntary Environmental Ship Index Program rewards vessel operators for reducing Diesel Particulate Matter and nitrogen oxide (NOx) emissions from their ocean-going ships. This program rewards operators for going beyond compliance by bringing their newest and cleanest vessels to the Port and demonstrating technologies onboard their vessels. It also encourages use of cleaner technology and practices in advance of regulations.
- Vessel speed reduction: The Californian ports also have adopted, as far back as 2001, a program that requires a reduction in vessel speed for the last 40 nautical miles of the ship's journey to the port such that NOx emissions are reduced.
- Electric vehicle fleets: The landside operations of many ports are using electric vehicles to again reduce noise and emissions.
- Alternative power sources: Use of alternative power sources, such as wind power is being implemented in both European and Japanese ports.

5.8 Invasive species

The intentional or accidental transport and subsequent introduction of invasive marine pest species (IMPS) to new regions is one of the primary threats to marine biological diversity (Carlton 1996, Hewitt et al. 2004; Minchin 2006). As addressed in Rilov and Crooks (2009), the introduction of IMPS into new environments can have significant impacts on:

- Human health
- The viability of populations of rare and endangered species
- The viability of living resource-based industries, such as fishing and aquaculture
- Economic, ecological, social and cultural uses of the marine environment
- The integrity of ecosystems.

Following invasion by a marine pest, impacts are typically cumulative, irreversible and at times synergistic with other impacts (Neil et al. 2008). Hewitt et al. (2009) reflect that the scale and global spread of introductions throughout the world's oceans means that no region can be considered untouched by this issue.

Hewitt and Campbell (2010) reviewed the relative contribution of different vectors to the introduction and translocation of invasive marine species and confirmed that biofouling (marine organisms that live on the hull or other below water structures of a ship) and ballast water associated with shipping are the main sources of marine bioinvasions.

Biofouling and ballast water management

The shipping industry has seen continued growth in frequency of vessel movement and geographical areas visited as international trade expands. Between 1970 and 2010 there has been an increase of over 300 per cent in the bulk tonnage shipped (IMO, 2012).

Shipping causes the transfer of approximately three to five billion tonnes of ballast water internationally each year (GloBallast 2002). A similar volume may be transferred each year through domestic in shipping. Several thousand marine species are thought to be transported globally in ships' ballast water every day (Smith et al. 1996) with many also transported via biofouling (Hayes et al. 2005).

The likelihood of introduction of a marine pest has increased due to the increased frequency of international shipping, improved vessels that allow a faster transit time (therefore a higher likelihood of species surviving the journey) and changing vessel behaviour (increased stationary or slow moving vessels that have increased contact with the sea floor such as dredgers, barges and drilling platforms (GISP, 2004).

The IMO has been working with its member states to address the potential impacts of invasive species over the last 40 years and currently has a program for management and prevention of bioinvasions called 'GloBallast'. Two major actions are:

- IMO's Global Ballast Water Management Program (Globallast) - Set up in conjunction with the IMO convention detailed below. The website provides information for industry, government and individuals regarding treatment technologies, legislation and regulations, research publications, and educational materials. The Program additionally has been implemented to assist six pilot countries in the main developing regions of the world improve their capacity to implement ballast water management measures.
- IMO's International Convention for the Control and Management of Ship's Ballast Water and Sediments (BWM) - Set up in response to Agenda 21 of United Nations Conference on Environment and Development in 1992 that requested the development of rules on ballast water discharge to prevent the spread of alien species under the United Nations Convention on the Law of the Sea (UNCLOS). Includes Technical Guidelines to support the implementation of the BWM. These guidelines have been adopted by 30 States since February 2004.

The IMO through the GloBallast program and MARPOL, and in partnership with the Global Environment Facility and the United Nations Development Program, has developed specific requirements and guidelines to reduce risks associated with marine bioinvasions. These requirements principally focus on ballast management for ships, as described by the International Convention for the Control and Management of Ships Ballast Water and Sediments.

The Convention (adopted in 2004) and IMO requirements work from a principal of minimising impacts through the implementation of vessel based comprehensive and consistent ballast management strategies. Strategies that have received global acceptance through the GloBallast program as opportunities to reduce the risk of ballast facilitated bioinvasions include:

- Minimising uptake of organisms into ballast tanks
- Routine maintenance of ballast tanks to remove sediments
- Avoiding unnecessary ballast discharge, particularly when in port; using discharge to onshore facilities where required for risk management
- Exchanging coastally sourced ballast mid-ocean or in deep water and where required
- Treating ballast to remove or render inert any harmful organisms.

Ballast management needs to be partnered with biofouling management and on ground implementation of relevant management actions supported by legal frameworks and institutional arrangements to achieve holistic management of the risk of bioinvasions. A resolution adopted by the IMO in July 2011 provides guidelines for the control and management of ship's biofouling to minimise the transfer of invasive aquatic species. That resolution notes that as this issue has worldwide concern, a globally consistent approach is needed to the approach of biofouling management.

The biofouling guideline works from the same principal as the Convention, minimising impacts through the implementation of ship based comprehensive and consistent biofouling management strategies. The Guidelines are intended to provide useful recommendations on general measures to minimize the risks associated with biofouling for all types of ships and are directed to States, shipmasters, operators and owners, shipbuilders, ship cleaning and maintenance operators, port authorities, ship repair, dry-docking and recycling facilities, ship designers, classification societies, anti-fouling paint manufacturers and suppliers and any other interested parties. A State should determine the extent that the Guidelines are applied in that particular State.

These measured identified by the IMO for control of biofouling are:

- Using anti-fouling systems appropriate to a ship hull and activity
- Applying appropriate operational management practices to reduce the development of biofouling (e.g. maintaining seawater intake system cleaning)
- Maintaining a biofouling management plan and record book to identify procedures prescriptive to each ship regarding biofouling management and to maintain records of procedures and measures being applied for each ship's biofouling management
- Ensuring ship maintenance (e.g. of the anti-fouling system or other vessel components where biofouling accumulates) is completed on an appropriate life cycle to minimise growth of biofouling
- Where in-water inspection of ships is required, consider whether targeted maintenance of areas where biofouling accumulates is appropriate. Risks associated with environmental harm from inwater cleaning are acknowledged by the biofouling guidelines and a number of measures to reduce risk of harm are identified including completion of risk assessments, avoidance of cleaning where harm is likely
- Appropriate design and construction of ships to minimise befouling accumulation
- Dissemination of information of relevance to biofouling management in each port state to confirm regional, national or local legal requirements for biofouling management.

Training and education of ships masters and crews regarding the risks associated with biofouling transference of marine pests and procedures of minimising risk. The IMO guidelines on biofouling management also acknowledge that significant research needs to occur to improve management opportunities and minimise future risks of marine pest introductions as a consequence of biofouling.

Application of management measures globally

Eradicating marine pests is an extremely difficult and costly task (Hayes et al. 2005). Proactive prevention of introductions or early detection mechanisms to enable early management intervention are considered by the IMO and other governing bodies to be the most appropriate application of IMPS management effort.

Shipping and the issues associated with bioinvasions are a global issue which requires management responses at a national or multi-national level. While the IMO is working with its member States to develop a standardised international legal instrument a number of jurisdictions are also unilaterally developing legislation and policy for IMPS management. Typically such measures are targeted at not only shipping vector risk management but also seeking to address risks from other IMPS vectors, such as mariculture.

The IMO reports that national and sub-national programs of marine pest management have been established for a number of locations including Australia, Brazil, Canada, Chile, Israel, New Zealand, the USA (including various states in the USA) and various individual ports around the world (e.g. Buenos Aires, Vancouver). A review completed by GloBallast (2002) prior to adoption of the Convention identified the following location prescriptive requirements for IMPS management:

- Port of Odessa (Ukraine) requires ballast water exchange and logging by a ship immediately upon entering the Black Sea
- Panama prohibits discharge of ballast water in the canal
- China restricts ballast water discharge under both quarantine and ship source pollution legislation.

The review indicates that the extent to which legislation either does or could regulate risk of IMPS introduction to ports globally was uncertain, a situation that has not improved with more port states developing unilateral requirements since 2002. For instance, the Regional Steering Committee on Ballast Water Management for the ROPME Sea Area put into effect a requirement for all ships to exchange and/or treat ballast water taken up outside the ROPME Sea Area in 2009 (MEPC 59/INF.3). Beyond this requirement, individual ports and countries in the ROPME Sea Area have been progressing unilateral actions (such as port baseline surveys) to protect their environs from IMPS risks. The unilateral development of IMPS management by different port states is typically a function of most countries approach to environmental management from an integrated basis. For instance, national and sub-national programs may not solely be focussed on the activities that ports (and their relevant authorities) implement for IMPS management, but consider all potential risk areas that require management attention. For instance, management of bioinvasion risk from recreational boating or mariculture is typically also addressed.

It is clear from the numerous reviews completed to date (r Carlton, 1996, Hayes et al. 2005; Hewitt et al. 2010 and references contained within) that the locations at greatest risk of IMPS inoculation are port environments. These nodes have the highest exposure to internationally sourced ballast and biofouling. They therefore provide a point of first entry and also provide an opportunity for active management to prevent introduction. The role individual port authorities or port management agencies have in managing marine pests is intrinsically linked to the legislative requirements and in-country jurisdictional requirements under which that authority or agency operates.

Depending on governance arrangements eradication response to marine pest incursions may be cost shared among affected parties or could be the responsibility of the port management authority. Marine pests can result in quarantine restrictions placed on ships sourced from that port and ongoing environmental management costs for maintaining infrastructure affected by marine pests. Prevention of introduction is, therefore, a focus to reduce the economic risk of impacting port operations as well as managing environmental risk.

Port authorities require ships to adhere to quarantine requirements and avoid releasing pollutants (including marine pests) to the environment they are operating in. As such, they typically manage risk of pest introduction through pre-entry border control mechanisms. This can be a requirement of the port authority or of the countries border control biosecurity agency.

Actions that may be undertaken to validate ships adherence to these requirements include environmental monitoring and compliance auditing. For marine pests, actions can take the form of dedicated baseline assessments, as have been completed for countries including New Zealand, Australia, Mombasa and other countries surveyed during Phase 1 of the GloBallast Project. It can also take the form of targeted marine pest surveillance or passive monitoring. Marine pest surveillance uses targeted sampling techniques to screen at risk habitats for species of concern. Passive surveillance uses devices like mussel traps or crab traps to continuously monitor for ‘new arrivals’. These activities may be prescribed by the port management authority, the county biosecurity management authority or a mixed jurisdictional requirement. These tasks can, however, be completed by port authorities as part of their routine environmental site management. However they are sourced, data from baseline assessments and surveillance provide valuable information for detecting marine pests if introduced and supports ability to action appropriate eradication response and management if any pests are detected.

Management in Australia

Australia has been taking action to improve legislation in relation to management of invasive species. To date the management of biosecurity within Australia has been achieved under the *Quarantine Act 1908*. In recognition of the need to continually advance our management measures and legislative tools the Australian Government has developed new legislation, the Biosecurity Bill 2012, which will supersede the *Quarantine Act 1908*. The legislative reforms are proposed to provide greater support to prevention and early intervention actions consistent with biosecurity policy. Proposed amendments are intended to facilitate better management of invasive species across land and water interfaces and between jurisdictions previously addressed by different pieces of legislation.

The new biosecurity legislation will create a single ballast water management regime for vessels in Australian seas, both international and domestic. It also provides for the majority of the measures identified by the (not yet ratified) 'International Convention for the Control and Management of Ships' Ballast Water and Sediments 2004' to be implemented within Australia.

Biofouling controls are not prescribed by the proposed new biosecurity legislation. Currently, legislation does not provide for a nationally consistent approach to management of biofouling biosecurity risk. However, the Australian Government has been investigating biofouling management options for vessels arriving in Australian waters for application at a national level. The International Maritime Organization (IMO) Marine Environment Protection Committee recently released voluntary guidelines to minimise the transfer of invasive aquatic species by ships' biofouling. The proposed Australian biofouling management options are consistent with the IMO guidelines.

The Australian Government exploration of biofouling management strategies has been completed in consultation with interested parties through a number of processes, including, but not limited to, consultation on a Regulation Impact Statement. A regulatory approach applied via Commonwealth legislation is an option for management of biosecurity risks associated with biofouling. If this is adopted there would be a number of requirements placed on vessel owners and operators to assist in determining risk associated with any marine growth carried by the vessel. Treatment or hull inspection could be required for vessels whose biofouling was considered to pose a threat to biosecurity. It is intended that measures provided under the new legislation will be flexible to enable adoption of biofouling management into the future as required.

The new legislation is designed to provide clear provisions for efficient management of biosecurity risks and to streamline previous legislative complexities that have evolved through the last century.

Summary

The best process for minimising the threat of IMPS at the port level is through education and awareness and information sharing among port users regarding IMPS risks and actions needed to prevent the introduction and spread of marine species. Pre-entry quarantine actions are also another barrier to invasive species incursions. Finally environmental monitoring to demonstrate performance of management measures and enable a rapid response to any detected incursions provides an additional level of protection.

6. Summary

Overview

This report has largely drawn on examples of management responses in Europe and North America. Their regulatory regimes and the planning, development and operation of their ports are mature and the ports tend to engage more with their communities than may be the case in other regions. This means there is more information publicly available for review and evaluation. Limited information was uncovered about responses to environmental issues in areas outside these two continents.

This study found that best practice was primarily driven by three key factors:

- Strong regulation and policy environment and governance arrangements
- Consideration and avoidance of environmental impacts through rigorous site selection and master planning processes (incorporating strong stakeholder and community engagement processes)
- Adoption of a site specific and risk-based approach to selecting management options to avoid and mitigate environmental impacts.

Regulation, policy and governance

Most actions by international ports were in response to local environmental laws and regulations or were in response to particular environmental issues and approvals associated with port development activities. This was also common to Australian ports. Many international ports also have certified ISO 14001 Environmental Management Systems or similar governance processes which provide a robust environmental management framework. It is important therefore that regulation and approval conditions extend to include implementation mechanisms, such as management plans, monitoring programs with triggers for action and independent auditing to drive accountability and continuous improvement. Monitoring and auditing also enables the success or otherwise of actions to be captured and recognised and lessons shared to inform future projects.

Transparent stakeholder and community engagement, including with traditional land owners, can encourage data sharing, enable community concerns to be considered and addressed, and provide motivation and encouragement to ports to improve environmental performance. International organisations such as EcoPorts provide a forum for networking and sharing of information. In Australia, Ports Australia facilitates an Environmental Working Group, although this is restricted to industry representation from Australian ports. Most ports considered as part of this study had some information available on their website as to their approach to environmental management and upcoming or current projects; however only very few ports published details as to their ongoing environmental performance or monitoring results. In many cases, both internationally and in Australia, stakeholder engagement appears to be driven by regulation as part of approvals processes.

Site selection and master planning

Comprehensive and transparent site selection and master planning processes incorporating proactive stakeholder and community engagement principles are critical to enabling avoidance of long-term and prolonged legacy issues for port operations and the environment. Site selection, master planning and design are the stages in a port's development where there is the most opportunity to avoid and mitigate environmental impacts, especially impacts on coastal processes and hydrology, aesthetics and habitat. These processes need to consider a range of aspects including the regulatory setting, environmental values of the location, cumulative impacts, and operational requirements. This study highlighted a best practice example from the Port of Dublin, where a Strategic Environmental Assessment was conducted as part of the master planning process (instead of consequentially), enabling integration of environmental and stakeholder considerations into the broader decision making and governance framework. Many ports in Australia have developed master plans however these are often not publicly available due to commercial in confidence or other potentially sensitive material, and are not necessarily comprehensive in terms of their consideration of environmental issues. Depending on the port and nature of the master planning activity, inclusion of a strategic environmental assessment as part of port master planning could be applied in an Australian context.

Management of activities and environmental impacts

The study examined practices of international ports in managing particular environmental issues and activities. The range of issues assessed was based around the potential for impacts on matters of national environmental significance and considered practices to manage water and sediment quality, coastal processes and hydrology, noise and vibration, lighting, aesthetic impacts, direct ecosystem impacts, air quality and invasive species. The literature found that the most prominent environmental issues that international ports are focussing on are water quality (especially from dredging impacts), noise, and air emissions. Air quality from port operations is generally treated as a human health issue and has limited impacts upon matters of national environmental significance and so has not been considered in detail in this report.

Deterioration of water quality is one of the most serious potential impacts ports can have, because of its effect on a wide range of environmental values. Poor water quality can cause a range of environmental impacts including reduction in light, smothering, fouling of gills, reductions in visibility and, if sediments contain contaminants, toxic impacts on fauna. The literature review found that the level of impact on environmental values such as seagrasses and corals arising from turbidity and sedimentation was site-specific and dependent upon the species assemblage present and natural variability of local background turbidity.

Large scale dredging, a common port activity, is the largest potential cause of poor water quality. The study found that many issues associated with dredging can be considered during the site selection, master planning and design phase. It also found that a risk-based approach to management of a dredging program is the most effective process to match mitigation measures to potential impacts. This is consistent with the approach taken on recent Australian dredging projects such as the Port of Melbourne’s Channel Deepening Project and maintenance dredging for Port Hedland Port Authority but there is an opportunity for it to be more widely practiced at Australian ports. There are a wide range of measures to control the impacts of dredging both at the site where material is being removed as well as at the disposal site. Other measures such as timing of dredging operations to avoid sensitive times of the year, for example when fish are migrating or when turtles are nesting, and real-time monitoring programs with trigger levels for action, can be used to further minimise impacts. This study has identified several best practice examples for dredging and management of dredged spoil; each of these was tailored to meet a particular circumstance, but could be considered, amongst other options, for application in an Australian context.

Water and sediment quality can also be affected by stormwater runoff, dust from stockpiles, spills of chemicals or cargo and the use of antifouling paints on ships. The latter three are heavily regulated through conventions of the International Maritime Organisation that are ratified by most countries. Australia has ratified conventions to control navigational and cargo handling issues as well as the management of waste at sea by ships. Oil spills are managed on a region wide basis but each port has its own responsibility for maintain and implementing oil response equipment within port limits. Stormwater is managed to meet local requirements for the management of discharges into waterways and there are methods such as the use of treatment ponds, on site treatment and recycling which have been employed by ports both internationally and in Australia to achieve required environmental outcomes. Stockpile dust is generally managed through spraying the material with water, sometimes with a dust suppressant added. Whilst Australia's approaches are consistent with those internationally, there are many different technologies available and there are opportunities to continue learning from other ports.

Port activities have potential to generate noise and vibration in both the terrestrial and marine environments. Terrestrial noise is generally well understood and was identified by this study as the primary environmental issue focussed on by European ports (particularly as a human health and nuisance issue). There is less knowledge around underwater noise. Until recently, most of the focus has been on the physical impacts of high intensity noise such marine piling, sonar and seismic surveys, with less information on the impacts of lower level noise from activities such as shipping. Noise impacts on fauna can include physiological damage, impacts on hearing sensitivity and behavioural changes. There are a range of techniques used internationally to mitigate underwater noise particularly from high intensity sources such as use of bubble curtains, coffer dams, piling caps and vibrational piling. Other techniques include timing of activities to avoid impacts on fauna that may not be present at all times and modifying the rate of the noise generating activity.

The literature review did not reveal any specific actions being taken by ports to reduce marine noise from shipping, although notes that this may be a by-product of actions such as speed restrictions which are implemented for other reasons, such as emission reduction, health and safety and to avoid collisions with megafauna. Similarly to international ports, Australian ports consider terrestrial and underwater noise as part of port development and operation and are implementing measures to minimise impacts.

Outcomes of this study

Overall this study has found that environmental performance of ports internationally is largely driven by regulation, policy and governance. The ability to avoid environmental impacts is greatest at the site selection, master planning and design stages of a port, and hence it is critical that these processes consider environmental and social values along with operational requirements. For port construction and operation activities there are many different technologies and environmental management solutions used internationally, each with its benefits and constraints, and so while there is evidence that environmental management practices and approaches employed by Australian ports are comparable to those internationally, there are opportunities for Australian ports to learn from international ports. Further consideration may also need to be given to the difference and potential gap between meeting best practice, and achieving best environmental outcomes.

This report has highlighted examples where the available literature indicates international ports have avoided, mitigated and offset environmental impacts as far as practical for their situation and hence could be considered to have achieved best practice. Each of these examples of technology or process could be considered for application in an Australian context. Most of the examples cited in this study were well tested responses to the issues faced, with standard approaches often preferred by ports because they involve proven technologies with low risk of failure. For this reason, it is important that ports monitor their performance and share knowledge around progression in technology and successes, as well as failures, to enable continuous improvement in environmental management.

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Appendices

Appendix A - Summary of Consultation

Consultation Process

A number of key stakeholders were consulted in preparation of this report, including relevant Australian Government and state government departments, industry representatives including Ports Australia and several port authorities, as well as marine scientific experts (see full list below).

Consultation included a stakeholder workshop to discuss the report in detail, identify any additional examples of international best practice that should be included, benchmark current Australian management approaches against the international examples, and discuss the applicability of findings in the report to an Australian context. Workshop attendees were also invited to provide additional information following the workshop. Five submissions were received and comments are included in the summary below.

List of stakeholders consulted

- Australian Government
  - Department of Sustainability, Environment, Water, Population and Communities
  - Great Barrier Reef Marine Park Authority
  - Department of Infrastructure and Transport
  - Department of Agriculture, Fisheries and Forestry
  - Infrastructure Australia
  - Australian Maritime Safety Authority
  - Department of Resources, Energy and Tourism
- Queensland Department of State Development, Infrastructure and Planning
- Academic and industry experts from the Gladstone Independent Review / University of Wollongong, James Cook University, Pollution Research P/L, Independent Science Panel – Gladstone Healthy Harbour Partnership
- Ports Australia
- Queensland Ports Association
- North Queensland Bulk Ports
- Port of Townsville
- Port of Brisbane
- Port of Newcastle

Key themes

The purpose of this report was to identify examples of international environmental best practice port development, and benchmark current Australian management approaches against these with consideration to the relevant opportunities and constraints for implementation in Australia.

Examples of Australian management approaches were identified during stakeholder consultation for the purpose of further understanding the context of these international practices. Following this process, Australian practices have been included within the report, however a detailed review of best practice in Australia was outside the scope of this particular piece of work.

A number of themes were raised during the stakeholder consultation process. These include:

General:

- There is a strong interest from key stakeholders to further understand and work towards environmental best practice port development.
- The potential benefit of integrating management and planning for port development in Australia, particularly in relation to port master planning.
- This report is current now, but will need to be reviewed in the future and progressively updated to keep up with changing technology and practices.
- Difference between maximising environmental outcomes and best practice port development.
- Monitoring and independent auditing is an important component of undertaking best practice adaptive management at ports (in addition to publishing successes), and should be part of the management cycle.
- Management of holding and anchorages.
- Management of terrestrial noise and shipping.
- Further work is required in future to consider ports in a world heritage area context.
- Port practices are site specific to an extent but still enable capturing of lessons and identification of best practice.

Regulation, policy and governance:

- Community empowerment, transparency and public reporting as important components of best practice ports governance, planning and environmental management.
- The need to engage with port tenants to achieve improved environmental performance and outcomes at ports.
- Need for certainty and consistency in regulation.

Site selection and master-planning:

- There are potential legacy issues associated with past site selection of ports. Significant port expansions should consider broader environmental consideration in terms of avoiding irreversible impact, and ultimately revisit if development at the site is still appropriate.
- Strategic environmental assessments need to be adaptive and respond to the changing nature of what is acceptable in terms of environmental best practice, by way of adaptive management and established review periods. For example, include conditions that require continuous improvement.
- Consideration could be given to the use of strategic environmental assessments to form a model for a more integrated planning and whole-of-government approval process for port development.
- Ports master planning needs to clearly articulate short, medium and long-term development vision and intentions. However, long-term planning needs to be coupled with adaptive management and opportunities for review.

Dredging:

- Discussion was held on the importance of innovation for developing technology for beneficial re-use of large volumes of clean dredge material. Regulations need to focus on outcomes, not the practice, so that innovation is not stifled.
- Need for a risk-based approach to environmental management rather than a 'one size fits all' approach.
- Need for transparency of assessment decisions for dredging in regulatory processes.
- What is best practice in terms of offshore disposal?
- There is no Australia-wide organisation that has responsibility or funding for management of monitoring data, or for monitoring requirements of sea dumping and disposal sites. Need for long term monitoring to be conducted and made publically available.
- Compliance measures are needed with monitoring activity.

Invasive species:

- Port monitoring on invasive species is highly beneficial if it is done nationally at all ports, as this data can then be used to inform domestic biosecurity and ballast water risk assessments.

Waste management:

- Provision of waste reception facilities alone at ports is not best practice- ports need a segregated recycling and waste management system.

Emergency response:

- Best practice is a multi-tiered governance response to oil spills. Australia in general is lacking a framework for assessment of risk, and understanding of risk including how long port authorities need to manage emergency situations before further support can arrive.
- First strike capability and response time needs to match and be proportional to the local environment and sensitive environmental receptors.
- There is a difference between major incident spills, and minor but chronic spills; and subsequently a difference in the appropriate management response.
- Further work should be done in this area on best environmental outcomes beyond MNES.

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