Chapter 17
Ports and Climate Change: Building Skills in Climate Change Adaptation, Australia

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Abstract The debate on climate change in relation to the ports and shipping sector has largely focused on their impacts rather than the question of adaptation and vulnerability. Limits to current levels of adaptation to existing climatic variation are demonstrated by the impacts and costs to society associated with extreme events such as floods, ice storms, droughts and hurricanes. Assessing vulnerability, and therefore the resilience of social-ecological systems, such as ports, needs to take account of three dimensions: (i) real or potential impacts on the system, (ii) the systems' ability to cope and adapt to these impacts and (iii) the extent to which coping capacity may be constrained by environmental or societal conditions. In this context, this paper reflects on the results of a training needs analysis conducted within the ports and shipping industry in Australia, in order to explore what might be most relevant issues for the sector and its implications for future adaptation strategies. The paper reflects on the issues raised and argues that the key to building adaptive capacity is implementation of training packages focused on vulnerability assessments.

Keywords Ports · Shipping · Climate change · Vulnerability · Needs analysis · Training · Management

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Introduction

Climate change, its impacts and solutions are at the forefront of a collective global consciousness. Instituting adaptation frameworks that can assist professionals to respond to climate change, yet be tailored to specific sectoral needs, is crucial. Professionals working at the "coalface" of the climate change challenge need to build new skills and create innovative solutions in social and political contexts. However, there are a number of challenges to creating management frameworks that address climate change while meeting the needs of different sectors.

Using the ports and shipping sector as a case study, this paper reports on the experience of implementing a training needs analysis of the ports industry in Australia in relation to climate change.

This needs analysis was part of a project designed to develop climate change adaptation curricula for ports professionals, and part of the process we adopted was to try and determine what core training needs were. However, this process also revealed interesting trends in relation to the adaptive capacity and perception of the industry, which form the basis of this paper. The project is funded by the Department of Climate Change and Energy, Australia, and was conducted while the authors were working at the National Centre for Marine Conservation and Resource Sustainability, Australian Maritime College, UTAS, Tasmania, Australia. The results are now incorporated within a draft online certificate in climate change adaptation training.

While obvious to some, it is nonetheless worth noting that the ports and shipping sector is very diverse. While our summary of the industry is done by using the term "ports and shipping", we acknowledge that this is a fairly rudimentary term that does not capture the nuances of the industry. We do, however, use it for convenience, especially as we ensured that we undertook to gain an understanding within our review of the experiences and needs of the sector across the board.

Methodology

The training needs analysis was undertaken to: (i) develop an understanding of what the industry training needs were and (ii) what content and style of delivery to adopt for the ports sector. Table 1 shows the methodology we adopted to undertake this process. We conducted a desktop survey of ports across the world, but in particular focused on the ports of Tasmania, Queensland and Victoria, Australia as our case studies.

Why Ports?

Current climate change science has arrived at four important conclusions: (i) that warming of the climate system is "unequivocal", (ii) the study of palaeo-climatic data supports the view that this warming is unusual and comparatively accelerated

Table 1 Methodological framework for conducting a needs analysis

Typology of needs	Definition	Methods used
Expressed needs	Those stated by industry representatives themselves	Desktop survey Workshops
Indicative needs	Those indicated by community/ sector characteristics	Data sources such as the ABS
Normative needs	Those drawn from applying benchmarks	Performance indicators for industry
Comparative needs	Those suggested by comparison to others such as other sectors, i.e. local government, fisheries	Expert workshops Individual interviews Focus groups

and shows that where warming did occur, so did sea level rise, (iii) that the increase in temperatures that have been documented since the mid-20th century are "very likely" to have been human induced, and (iv) that continued emissions outputs will cause further warming (Steffen 2009; IPCC 2007).

Climate change is anticipated to have a major impact on ports. An international study by the OECD of 136 cities with over 1 million people (in 2005) into the vulnerability of ports across the world highlights the importance of this issue (Nicholls et al. 2007). Key findings from this report indicate that already large populations are exposed to coastal flooding in port cities, and that across all cities approximately 40 million people (0.6% of the global population, or roughly 1 in 10 of the total port city population in the cities (within the project study) are exposed to a 1 in 100-year coastal flood event. The study also found that the top ten cities (in 2005) that have the most exposed populations include: Mumbai, Guangzhou, Shanghai, Miami, Ho Chi Minh City, Kolkata, Greater New York, Osaka-Kobe, Alexandria and New Orleans (Nicholls et al. 2007). The sheer number of ports, combined with Australia's geographical size, means that any climate change impact on ports in Australia will have flow-on effects for maritime transport, food security and environmental protection.

Extreme weather events will include chaotic, heavy precipitation, high wind loads, increased wave action and storm surges. These events will lead to a variety of impacts for ports including: increased coastal runoff and siltation (requiring ports to generate increased GHG emissions from more frequent dredging); increasing bioavailability of entrained heavy metals and other pollutants; increased high wind and temperature stoppages under OH&S laws, with consequential delays to berthing and cargo-handling operations; and coastal flooding requiring increased coastal hardening. Extreme wind speeds are likely to require engineering upgrades to piers, berths, wharf moorings, container gantries and other cargo-handling equipment.

Most ports are already operating at their limits as far as channel utilization capacity goes, and margins for error have been reduced to a bare minimum. Adverse weather conditions will require shipping to go outside the boundaries of Permanent International Association of Navigation Congresses (PIANC)

guidelines for channels. Present resources may not be adequate to facilitate safe movements, resulting in down time. Pilots and tug operators will probably call for the safety margin in channels and swinging basins to be significantly improved by (i) reducing length and beam restrictions or widening channels; (ii) restricting transits of vessels with high wind loads.

Extreme weather and changing climatic conditions may also force the creation of new ports and marinas as commercial fish stocks migrate further southward and trading patterns change in keeping with greater focus on greenhouse gas emissions. Development of new ports are likely to occur in response to proximity of bulk export resources as well as the conflicts with urban development restricting existing port expansion requirements.

Rising ocean and air temperatures coupled with increasing ocean acidity are likely to increase corrosion, biodeterioration and biofouling and also create new opportunities for biological invasions associated with shipping. New environmental conditions coupled with ships spending increased time in port waters due to more frequent storms will result in greater potential for the establishment of species in ports.

It is highly likely that these weather changes will drive changes to the regulatory framework, including: tightened planning regulations for coastal developments and spoil dumping, and changes to the weather components of OH&S legislation. Other changes will probably include upgraded requirements for harbour tug capacity, changes to draft and air-draft restrictions, and possible moves towards cold-ironing. Regulatory restrictions on port emissions will probably lead to significantly slower transit speeds in port waters and the need for greater fuel efficiency in cargo-handling systems and operations. The use of alternative fuels, such as LNG, in ships to reduce greenhouse gas emissions will, in turn, require new infrastructure for bunkering operations.

Moreover, the ports industry will not only be subject to climate impacts but is also seen as an important point source for ongoing emissions. CO_2 is the major greenhouse gas emitted by ships. SO_x emissions have a potential cooling effect and/or create local climate disturbance. The sulphur content of marine fuels will decrease due to measures being adopted by IMO. NO_x, HC, CO, PM, CH_4, N_2O, HFCs, fugitive VOCs, POPs and others have a minor role in global warming and will need to be accounted for. SO_x, NO_x, HC, CO, PM, fugitive VOCs, POPs and others have significant local air quality impacts. Although most air quality emissions only play a minor role in global warming, the increased community awareness of emissions due to the prominence of the global warming issue, and the potential for climate change to affect the dispersion of air quality emissions, will emphasize the need to accurately quantify air quality emissions. There is also the potential for greenhouse gas mitigation measures to affect levels of air quality emissions. Emissions sources at ports include ocean going vessels, harbour vessels, cargo handling equipment, locomotives and vehicles (EPA 2009).

Climate change also introduces another level of complexity to the operating environment in which port authorities and government plan Australia's port infrastructure capacity. With approximately 30,000 commercial vessel calls a year (Ports

Australia 2009), ports are a critical element of Australia's trade infrastructure. Although there is great diversity in the delivery of current capacity in our ports, ranging from small, regional ports such as Flinders Island to major ports such as Melbourne and Sydney, all contribute to Australia's position as a global trader, with nearly 800 million mass tonnes of throughput in 2007–08 alone (Ports Australia 2009). Over 99% of Australia's exports and imports, by mass, are carried by sea, and expectations are that Australia's trade will continue to grow: international container trade alone is predicted to nearly treble by 2020 to almost 12 million TEU. It is therefore critical that Australian ports remain effective for the industries they serve.

Results of the Training Needs Analysis: Ports and Shipping

How does this review of the issues for ports compare with industry understanding and perception of what the issues are? The following section sums up the range and breadth of these issues (Table 2).

This summary shows that in relation to the physical impacts of climate change in ports there is a diversity of opinion, both within the industry and the literature about it, about what the needs are in responding to the problem. To clearly identify appropriate adaptation and mitigation strategies, this diversity needs to be incorporated. For example, different components of the industry will have different needs. A climate change response strategy within a single port, may in fact, then, be a composite of many different types of adaptation and mitigation mechanisms, appropriate to the different needs of the sub-components of the whole. Within Australia, different ports are in fact looking at different strategies. The Port of Melbourne, for example, is developing a climate change policy, and the Port of Sydney is developing a climate change risk assessment and has instituted the practice of considering climate change mitigation factors in development applications.

This summary also shows that there is a diversity of issues confronting professionals working in the ports area. Interestingly, while there was variability in emphasis about these issues across different ports, (i.e. for one port, infrastructure might be of greater importance than navigation), there was little conflict within the sector about the issues per se. While our review did not cover the relationship between port personnel and other stakeholders, future research might reflect on whether the resolution of some of these issues and needs may not only affect others outside the industry but provide an opportunity to engage with others in a profitable manner, hence avoiding potential conflict. It would also be worth reflecting on the question of at what level training or skills development might occur. It is important to distinguish between different levels of interest in training, and who might undertake it.

Reflection on the results of stakeholder workshops from a related project examining vulnerability and ports is, however, instructive (Nursey-Bray et al. in review). In this case, potential for conflict between ports in Australia, originating from the differing perceptions of port personnel over the nature of the climate change threat,

Table 2 Summary of issues raised in needs analysis of ports and shipping in relation to climate change

Impact	Need
Sea level rise	• Conduct specific risk/hazard and vulnerability assessments to determine how these climate change hazards will affect the shipping industry
	• Durability of port coastal infrastructure needs examination, monitoring to determine its resilience to sea level rise and associated impacts
	• Development of the appropriate adaptation strategies (retreat, protection) to reduce infrastructure impacts
Managing extremes	• Risk assessment/hazard training needed
	• Raising structures and services above expected inundation levels
	• Building a dyke or levee to keep the rising sea back
Warmer seas	• Increase quarantine measures against the risk of introducing invasive marine species
	• Develop and adapt strategies for the monitoring and management of both ballast water and anti-fouling/hull fouling systems
Change in wind conditions	• Potentially increase birthing time at docks causing economic impacts for shipping companies and time delays for ports
	• Invest in boat designs that handle increases in wave height as result of warming
	• New locations for terminals
	• New emergency responses to enable stability when departing and entering marinas and terminals
Changes in sea chemistry	• Monitoring strategies for increased salinity levels
	• Adapt coastal structures that may be affected by corrosion or degradation
Navigation	• Need to understand the varied affects and impacts climate change will have on the sectors related to navigation
	• Need to consult the stakeholder groups (port, coastal, offshore and vessels) that operate within the industry
Infrastructure	• Increased understanding of methods for reducing impacts to existing and future marine and coastal infrastructure
	• Risk assessment
	• Ongoing research capability
	• Retrofitting
	• Need new and efficient climate-sensitive building designs and methods for old and new buildings
	• Relocation of marinas and wharfs
Vessel impacts	• Alternate routes for entering ports and adjusting docking procedures
	• Research to develop methods for reducing turbulent seas reducing port closure allowing vessels to dock or depart safely

(continued)

Table 2 (continued)

Impact	Need
Port closures	• Examine gaps in knowledge and improve methods and designs for the implementation of adaptation measures to reduce these disruptive impacts
Reduction in emissions (from vessels, handling of bulk products, and transport operations undertaken by port customers)	• Fuel efficiency measures or alternate fuel and energy source • Ship/port operational changes for improved efficiency and fuel savings • Market-based instruments to encourage behavioural change
Stakeholder consultation	• Training professionals in how to consult with community, stakeholders and partners

Industry recommendations based on needs analysis

- Appropriate adaptation training needs to be provided to maritime professionals so they can develop clear objectives, strategies and actions
- Train professionals in adaptation responses, policy requirements and implementing, risk assessment and response training and managing and conserving coastal regions and their infrastructure
- Management plans regarding infrastructure and operations should be adapted to allow for protection at all levels from climate impacts
- The use of adaptation tools such as Geographical Information Systems (GIS) to monitor any changes in sea level rise or topography of coastal areas in order to monitor vulnerable areas and adapt any plans accordingly
- Buildings that are in danger of being impacted by climatic events should be retrofitted to the highest standards
- Establish communication channels between scientists, stakeholders and maritime professionals. This will include creating partnerships with key research agencies, including CSIRO
- Coastal development needs much stronger regulation and monitoring
- Identify priority areas for action on adaptation and mitigation. Development of a climate change strategy to assist ports in developing actions, goals, strategies and targets for mitigating against and adapting to the impacts of climate change
- Identify any future information requirements and fund research studies to reduce any gaps in knowledge

and therefore need to respond to it. It was clear in this instance that some port managers evinced a higher order of scepticism than others. Moreover, those who were concerned about the impacts of climate change expressed a high conviction in the ability of ports to respond to change because they "always had". Thus, for them, the need for training, delivered by external parties, was not necessarily prioritized.

Taking the Next Step: Managing for Change…

This training needs analysis has implications for port personnel, not least in establishing what level of adaptation and mitigation needs to be implemented at what level. For example, an appropriate training programme for a port worker will not be the same as that for a port manager. There are clear lines of management, delegation

and responsibility that need working out, as well as the funding investment required to build adaptation and mitigation options at all levels. Port authorities and the heads of shipping industries often prepare management plans for specific areas such as infrastructure, vessels and port operations. These plans are intended to guide decisions about how these areas should be managed in a balanced way and may include detailed recommendations for setbacks for development, as well as designating specific areas for particular uses. In the case of climate change, the analysis highlighted that management options will now need to incorporate adaptation and mitigation strategies to reduce the impacts of climate change to the region.

While our review highlights a number of issues that will affect the industry and merit inclusion into a climate change adaptation training course, we argue that there are two areas where priority attention is vital. The first is the need to invest in research, development and implementation of adaptation strategies for the following:

1. the vulnerability of ports to extreme weather events;
2. increased monitoring of coastal zone and infrastructure;
3. implications of coastal erosion, sea level rise and increased storminess;
4. looking at potential dredging requirements; increasing the height of dykes;
5. relocation of ports and industries;
6. examining impacts of increased storminess on vulnerable shipping routes;
7. adapting existing building codes to ensure that long-term infrastructure will be buffered against future climate risks;
8. updating of disaster management strategies;
9. implications of coastal erosion, sea level rise and increased storminess.

The second need is to train ports and shipping professionals in risk and vulnerability assessment techniques. It is important that maritime industry planners and professionals are able to rate the probability of climate change impacts in order to assess the social, ecological, political, economic and legal consequences of that particular impact. The use of risk and vulnerability assessments allows professionals to identify areas in their industry most susceptible to climate impacts in order to establish priorities and incorporate these into the strategic planning process (Nursey-Bray and Ferrier 2009). The ability of planners, managers and professionals to be competent in the use of information collected during a vulnerability/risk assessment to estimate the consequence, probability and resulting risk of specific climate change impacts to systems in a planning area will become vital in coming years.

There is much experience in this area to draw upon, as the term vulnerability has multiple definitions. Adger (2006), and Cutter et al. (2003) provide good overviews of its history and intellectual precedents. Füssel (2007), for example, outlines a suite of approaches within vulnerability research including (i) classical approaches, (ii) risk-hazard approaches (Downing and Patwardhan 2004), (iii) political economy approaches (Adger and Kelly 1999), (iv) pressure and release model which defines risk as a product of hazard and vulnerability (Blaikie et al. 1994), (v) integrated approaches which combine the above such as

Cutter's model, which combines exposure to hazards with the interaction with the social profile of communities (Cutter et al. 2003), and (vi) the resilience approach, based on the idea of exploring vulnerability in the context of social-ecological resilience (Folke 2006).

Füssel (2007) notes that the United Nations outlines four groups of vulnerability factors that are relevant in the context of disaster reduction (and of relevance to the ports sector): physical factors (i.e. external stressors to which people/property are exposed), which describe the exposure of vulnerable elements within a region; economic factors, which describe the economic resources of individuals, populations groups and communities; social factors, which describe non-economic factors that determine the well-being of individuals, population groups and communities, such as the level of education, security, access to basic human rights and good governance; and environmental factors, which describe the state of the environment within a region.

All of these factors describe properties of the vulnerable system or community rather than of the external stressors. However, they cannot be simply adopted; professionals need additional training and expertise to undertake such assessments. This is best summed up by a comment from the submission presented by the Port of Enfield in Adelaide, South Australia, to a Federal government inquiry on climate change and coastal communities arguing that "regional coastal vulnerability assessments (incorporating economic, social, and environmental impact assessment) be undertaken in accordance with a nationally consistent framework, with the flexibility to include particular issues of local interest or concern" (Port of Enfield 2008, p. 3).

Summary: Responding to Change

This paper reported on a training needs analysis conducted on the ports industry in Australia. The analysis highlighted that (i) the industry needs to make some key investments in research so as to ensure the knowledge about how to address climate change issues are addressed, and (b) that the industry would benefit from training in vulnerability assessments so as to identify key issues, and build ongoing adaptive capacity. In this way ongoing resilience will buffer the ports and shipping sector against the potentially sudden perturbations of climate, and the ongoing stresses caused by climate change.

The ports and shipping industry is not a stranger to change, nor responding to it over time. However, there is less time now to adapt, and a greater imperative to build resources from within to cope with external stressors. Both mitigation and adaptation strategies are required in order to effectively respond to the idea of climate change, and investments in the research and training needed to build understanding of vulnerability over time. Then the industry will build the skills essential to ensuring it has ongoing capacity to address climate-induced risks in the future.

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