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Editorial

The urgent global need to understand port and harbour ecosystems

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Human populations and economic activity are increasingly skewed towards the coast (Hinrichsen 1999). Three-quarters of all large cities are located on the coast (Tibbetts 2002), 40% of the global population live within 100 km of the coast, and 90% of global trade occurs by sea (IMO 2012). The centres of people and trade, and the areas that must adapt the fastest to support societal demands, are our ports and harbours. It is in these places where both the world's wealth and the world's population are concentrated (Hinrichsen 1999). In the US alone, 21 million people move to the coastal counties every year. In China, 60% of the nation's 1.2 billion people live in 12 coastal provinces. Some countries are already almost entirely coastal, such as Vietnam, Bangladesh, Australia, Japan and the Philippines (Hinrichsen 1999). Even Africa, the only continent where there are more people living inland than near the coastline, is witnessing a rapid coastal transition. This movement is driven by work opportunities that are concentrated in urban areas. In addition, climatic changes and agricultural change legacies render inland areas less hospitable, aggravating the exodus to coastal zones (Tibbetts 2002).

With burgeoning populations and the growth of economic development of coastal areas has come substantial change and development. Unfortunately, in many countries we now have a substantial legacy of environmental impact and there is a scarcity of political motivation, expertise or money to plan and implement comprehensive coastal conservation and management plans (Hinrichsen 1999; Li 2003). This, combined with a lack of understanding of the full implications of these demographic and resource trends, results in ports and harbours around the globe being subjected to myriad ongoing stressors. These issues are not specific to any one nation, region or city. Coastal communities worldwide are facing the same problems (Tibbetts 2002). Artificial structures such as ports, pilings and seawalls have replaced much of the natural shoreline reducing native biodiversity (Bulleri and Chapman 2010) and land has been reclaimed changing the hydrodynamics of the waterways (e.g. Suh *et al.* 2014). Contaminants exist as legacies of industrial waste disposal practices rendering local seafood toxic to consumers and diffuse inputs from concretised catchments cause ongoing water quality problems alongside the degradation of marine vegetation (Kennish 1997; Birch 2000). Shipping activities bring many non-indigenous species that may be acting to homogenise port biota into a single, global, species pool (Ruiz *et al.* 1997).

All this has caused much damage to our waterways and the question becomes – can we recover, restore, re-use or retrofit? Can we transform these places of industry and trade, to places that facilitate multiple uses and values including recreation and biotic diversity? Can we restore damaged ecosystems and the services they provide?

There is an urgent need to take stock of the current biophysical state of port and harbour ecosystems and the threats they are facing. We must do this so we can make better predictions and decisions for the future. Knowledge can inform our path, but only if it is remembered, synthesised, translated and embedded into policy and regulation. Current understandings from multiple fields of research must be gathered together, and built into frameworks for decision-making (Wooldridge *et al.* 1999). Identifying the status and threats to ecological components and processes is the crucial first step in this process that underpins ecological risk analyses and the establishment of management strategies with integrated monitoring programs (Burgman 2005).

In this edition of *Marine and Freshwater Research* we present two major reviews of what is possibly the world's most biologically diverse port. Sydney Harbour is renowned for its natural beauty, emanating from a complex series of natural embayments and rocky headlands. The estuary sits at the heart of a vast urban metropolis, home to almost 5 million people. But for too long, we have accepted a patchwork approach to managing its natural resources. The lack of cooperation and synthesis is surprising given how important the Harbour is to the commercial and social prosperity of the city, the region and the nation more generally. This is the first systematic review of published biophysical information on Sydney Harbour and pulls together, not only a comprehensive assessment of its habitats, diversity and ecosystem functioning (Johnston *et al.* 2015), but also a detailed inventory and interpretation of threats and stressors (Mayer-Pinto *et al.* 2015).

Sydney Harbour is a drowned river valley; carved into Hawkesbury sandstone some 25–29 million years ago and filled by a rising sea 17 000–6000 years ago (Roy 1981).

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This geological history has given rise to myriad embayments, steep rocky shores, deep pools and sandy bottoms that host a diverse range of habitats. Mangroves (and previously saltmarshes) fringe the harbour foreshore, whereas seagrasses and subtidal reefs can be found throughout the oceanic areas. More than 586 species of fish have been recorded from Sydney Harbour (Booth 2010), an extremely high number even when compared to nearby, more pristine, estuaries. Intertidal rocky banks, supporting oyster reefs and complex invertebrate assemblages, fringe what is left of the natural shoreline. Like many other highly urbanised harbours around the world, this great diversity is threatened by myriad stressors. Concentrations of metal, metalloid, and non-metallic contaminants in sediments are among the highest recorded globally (Davis and Birch 2010). Artificial structures, such as seawalls and pilings, have now replaced over 50% of the natural shoreline (Chapman and Bulleri 2003). These artificial structures support a greater number of non-indigenous species and less diversity than their natural equivalents. Further, biological communities within Sydney Harbour cannot escape the threats posed by a changing climate. Air and sea temperatures in the Sydney region are predicted to rise quicker than other areas due to a strengthening East Australian Current (Wu *et al.* 2012). This poleward current is rapidly extending the southern range of many keystone predators and grazers that are expected to ‘tropicalise’ the system in a matter of decades.

Sydney Harbour has a prominent place in the psyche of many Australians and it has become a global icon. Clearly, it is important to understand the ecological dynamics of such an important estuary and the threats it faces. Synthesising current knowledge is the first step in establishing a coordinated, strategic and comprehensive management plan. The threats and multiple use issues summarised for Sydney Harbour are common to major urban and industrialised estuaries around the globe. Now, more than ever, it is necessary to develop and implement evidence-based management strategies that protect vital coastal ecosystems and the services they provide, while enabling economic activity and improving human well being.

References

Birch, G. F. (2000). Marine pollution in Australia, with special emphasis on central New South Wales estuaries and adjacent continental margin. *International Journal of Environment and Pollution* **13**(1–6), 573–607. doi:10.1504/IJEP.2000.002334

Booth, D. (2010). Natural history of Sydney’s marine fishes: where south meets north. In ‘The Natural History of Sydney’. pp. 143–153. (Royal Zoological Society of New South Wales: Sydney, NSW, Australia.)

Bulleri, F., and Chapman, M. G. (2010). The introduction of coastal infrastructure as a driver of change in marine environments. *Journal of Applied Ecology* **47**(1), 26–35. doi:10.1111/J.1365-2664.2009.01751.X

Burgman, M. A. (2005). ‘Risks and Decisions for Conservation and Environmental Management.’ (Cambridge University Press: New York.)

Chapman, M. G., and Bulleri, F. (2003). Intertidal seawalls – new features of landscape in intertidal environments. *Landscape and Urban Planning* **62**(3), 159–172. doi:10.1016/S0169-2046(02)00148-2

Davis, B., and Birch, G. (2010). Comparison of heavy metal loads in stormwater runoff from major and minor urban roads using pollutant yield rating curves. *Environmental Pollution* **158**(8), 2541–2545. doi:10.1016/J.ENVPOL.2010.05.021

Hinrichsen, D. (1999). ‘Coastal Waters of the World: Trends, Threats, and Strategies.’ (Island Press: Washington, DC, USA.)

IMO (2012). International Shipping Facts and Figures – Information Resources on Trade, Safety, Security, Environment. International Maritime Organization, London, UK.

Johnston, E. L., Mayer-Pinto, M., Hutchings, P., Marzinelli, E. M., Ahyong, S. T., Birch, G., Booth, D., Creese, R., Doblin, M. A., Figueira, W., Gribben, P. E., Pritchard, T., Roughan, M., Steinberg, P. D., and Hedge, L. H. (2015). Sydney Harbour: what we do and don’t know about this highly diverse estuary. *Marine and Freshwater Research* **66**(12), 1073–1087. doi:10.1071/MF15159

Kennish, M. J. (1997). ‘Pollution Impacts on Marine Biotic Communities.’ (CRC Press: Boca Raton, FL, USA.)

Li, H. (2003). Management of coastal mega-cities – a new challenge in the 21st century. *Marine Policy* **27**(4), 333–337. doi:10.1016/S0308-597X(03)00045-9

Mayer-Pinto, M., Johnston, E. L., Hutchings, P., Marzinelli, E. M., Birch, G., Booth, D., Creese, R. G., Doblin, M. A., Figueira, W., Gribben, P. E., Pritchard, T., Roughan, M., Ahyong, S., Steinberg, P. D., and Hedge L. H. (2015). Sydney Harbour: a review of anthropogenic impacts on the biodiversity and ecosystem function of one the world’s largest natural harbours. *Marine and Freshwater Research* **66**(12), 1088–1105. doi:10.1071/MF15157

Roy, P. S. (1981). Geology of the Sydney Basin. *Geological Survey of New South Wales Quarterly Notes*, 41–91.

Ruiz, G. M., Carlton, J. T., Grosholz, E. D., and Hines, A. H. (1997). Global invasions of marine and estuarine habitats by non-indigenous species: mechanisms, extent, and consequences. *American Zoologist* **37**(6), 621–632. doi:10.1093/ICB/37.6.621

Suh, S. W., Lee, H. Y., and Kim, H. J. (2014). Spatio-temporal variability of tidal asymmetry due to multiple coastal constructions along the west coast of Korea. *Estuarine, Coastal and Shelf Science* **151**, 336–346. doi:10.1016/J.ECSS.2014.09.007

Tibbetts, J. (2002). Coastal cities: living on the edge. *Environmental Health Perspectives* **110**(11), 674–681. doi:10.1289/EHP.110-A674

Wooldridge, C. F., McMullen, C., and Howe, V. (1999). Environmental management of ports and harbours – implementation of policy through scientific monitoring. *Marine Policy* **23**(4–5), 413–425. doi:10.1016/S0308-597X(98)00055-4

Wu, L., Cai, W., Zhang, L., Nakamura, H., Timmermann, A., Joyce, T., McPhaden, M. J., Alexander, M., Qiu, B., Visbecks, M., Chang, P., and Giese, B. (2012). Enhanced warming over the global subtropical western boundary currents. *Nature Climate Change* **2**(3), 161–166. doi:10.1038/NCLIMATE1353