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# Ecological engineering in the coastal seascape

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ABSTRACT

This editorial describes a 12-paper special issue that began with a symposium at EcoSummit 2016 in Montpellier France in August/September 2016 with a focus on ecological engineering and spatial planning in coastal seascapes. The papers in this issue review ideas around experimental design for testing and application of eco-engineering to reduce the impacts of coastal infrastructure and improve ecological outcomes. Similarly, the need for early integration of ecological principles into engineering designs (eco-design) is highlighted as a key factor in the success of impact mitigation (2 papers). Ideas are presented on spatial planning for coastal infrastructure to mitigate and offset impacts at regional scales (3 papers). At more local scales, empirical evidence is presented to support the manipulation of physical complexity on coastal infrastructure through the addition of artificial rock pools and turf mimics, as well as complex crevice and ledge habitat (3 papers). Chemical manipulations of substrate (concrete) are also explored (3 papers) with the aim of increasing the sustainability of structures and improving specific ecological outcomes. While increasing human pressure has pushed our oceans out of balance, this special issue provides practical solutions, supported by case studies and empirical data to begin helping the "feng shui" of our coastal seascape.

## 1. Introduction

The modern-day seascape comprises a mix of important natural ecosystems, along with an expanding footprint of built infrastructure due to population growth and the threat of climate change to coastal assets (Dafforn et al., 2015b; Duarte et al., 2012; Waltham and Sheaves, 2015). While the addition of artificial or built infrastructure such as seawalls and groynes provide an important protective function, these structures can also have unintended ecological consequence from the loss or modification of habitat, altered hydrology and ecological flows, as well as the retention of contaminants and facilitation of invasive species (Bishop et al., 2017; Dafforn et al., 2012; Glasby et al., 2007; Heery et al., 2017). In addition, many of these engineered structures have been randomly built with little consideration of broader spatial planning or impact mitigation integrated at any stage of construction. The undeniable creep of built infrastructure along the coastline has therefore been linked to fragmentation, and reduced extent of natural coastal defences such as intertidal mudflats (Murray et al., 2014; Murray et al., 2015) and coastal vegetation (Spalding et al., 2007).

While there is a growing body of evidence that quantify the impacts of some of these structures (Bulleri and Chapman, 2010; Dafforn et al., 2015a; Firth et al., 2014; Glasby et al., 2007; Moschella et al., 2005), less is known about potential strategies to mitigate these impacts, and how to improve the overall sustainability of coastal developments. Furthermore, there is an urgent need for scientists and managers to consider the spatial challenges associated with approving more coastal development (Waltham and Connolly, 2011), at the cost of natural ecosystem and lost cultural values and amenity (Dafforn et al., 2015b; Domínguez-Tejo et al., 2016). Emerging data that considers eco-friendly engineering solutions in the design of development projects is showing promise in achieving a more balanced approach to urban expansion (Browne and Chapman, 2014; Browne and Chapman, 2011; Chapman and Underwood, 2011; Firth et al., 2016a; Firth et al., 2016b; Strain et al., in review). Ecological engineering of marine infrastructure represents an opportunity to design developments with a reduced ecological footprint, a chance to offset the impact, and increase the provision of services (Dafforn et al., 2015a; Mayer-Pinto et al., 2017).

This special issue brings together scientists from multiple disciplines to discuss new ideas and research in the field of marine planning and eco-engineering, with a particular focus on expanding coastal development.

## 2. Marine Eco-Engineering and Spatial Planning at EcoSummit 2016

The papers in this special issue are the result of presentations at a special session (symposium) held at the 5th International EcoSummit held in Montpellier, France on August 29–September 1, 2016 (Table 1). The papers in this special issue focus on ecological engineering from reviews of current understanding to the use of spatial planning for the management of future structures and including manipulative experiments to test physical and chemical modifications to infrastructure for positive ecological outcomes. These are presented by ecologists, eco-economists and geographers from Australia, United Kingdom, Israel, United States, France, Hong Kong and Chile (Fig. 1).

### 2.1. Where have we been and where are we going with eco-engineering in coastal seascapes?

The eco-engineering of coastal infrastructure and developed

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**Table 1**
Presentations at EcoSummit 2016 in Special Session 49 "Ecological Engineering of Sustainable Landscapes" in Montpellier, France, August 31, 2016. Presenter indicated by*.

| Presentation title | Oral presentation or poster | Authors | Special issue titles |
|---|---|---|---|
| 1. Burgeoning coastal development in the Great Barrier Reef catchment area: marine spatial planning challenges and green engineering solutions | Oral | N. Waltham*, M. Sheaves | Eco-engineering rock pools to a seawall in a tropical estuary: microhabitat features and fine sediment accumulation |
| 2. Ecological implications of boating infrastructure in complex urban waterways | Oral | L. Hedge*, S. Macolino, B. Lanham, A. Poore, A. Verges, S Simpson, K. Dafforn, E. L. Johnston | |
| 3. Reducing the ecological footprint of coastal and marine infrastructure | Oral | S. Perkol-Finkel*, L. Sella | |
| 4. Home is where the heart is: implications for the design of artificial reefs | Oral | V. Komyakova*, S. Swearer, G. Jones | |
| 5. Spatial complexity enhances anthropogenic litter accumulation and residence time potential in coastal urban breakwaters | Oral | M. Aguilera*, B. R. Broitman, M. Thiel | Artificial defences in coastal marine ecosystems in Chile: opportunities for spatial planning to mitigate habitat loss and alteration of the marine community structure |
| 6. Effects of ocean sprawl on ecological connectivity: impacts and solutions | Oral | M. J. Bishop* | |
| 7. Seawalls modify wrack dynamics in mangrove forests | Oral | L. Critchley*, M. J. Bishop | |
| 8. Attractively artificial: how the built environment influences community development and invasion | Oral | A. Lee*, K. Dafforn, E. Johnston, P. Hutchings | |
| 9. Moving beyond patterns: the effect of grazing in eco-engineered rock pools | Oral | R. Morris*, A. S. Martinez, R. A. Coleman | Can coir increase native biodiversity and reduce colonisation of non-indigenous species in eco-engineered rock pools? |
| 10. Application of management tools to integrate ecological principles with the design of marine infrastructure | Oral | K. Dafforn*, T. M. Glasby, L. Airoldi, N. K. Rivero, M. Mayer-Pinto, E. L. Johnston | |
| 11. Building 'blue': an eco-engineering framework for urban seascapes | Oral | M. Mayer-Pinto*, A. Bugnot, L. Airoldi, T. M. Glasby, E. L. Johnston, K. A. Dafforn | |
| 12. Use of eco-engineering to enhance bivalve communities in Sydney Harbour | Oral | E. Strain*, M. Bishop, V. Cumbo, A. Buegot, K. Da1fforn, M. Mayer-Pinto, R. Morris, R. Coleman, E. L. Johnston | Increasing microhabitat complexity on seawalls can reduce fish predation on native oysters |
| 13. Ecologically sensitive approaches to coastal defence - challenges and opportunities | Oral | L. Airoldi*, M. Abbiati, F. Ferrario, S. Perkol-Finkel, M. Ponti, E. M. Strain, J. X. W. Wong | |
| 14. Maximising the efficacy of species transplants for improving the ecological value of seawalls | Oral | V. Cumbo*, E. M. A Strain, E. L. Johnston, M. J. Bishop | |
| 15. Seascape architecture–incorporating ecological considerations in design of coastal and marine infrastructure | Oral | S. Perkol-Finkel*, L. Sella | Seascape architecture â€ incorporating ecological considerations in design of coastal and marine infrastructure |
| 16. Ecological engineering and restoration for marine ecosystems: limits and opportunities for their implementation within the mitigation hierarchy | Oral | C. Jacob*, A. Buffard, S. Pioch, S. Thorin | Marine ecosystem restoration and biodiversity offset |
| 17. Integrating meta-analysis with conscious design of foreshore structures | Oral | A. Bugnot*, M. Mayer-Pinto, E. L. Johnston, K. A. Dafforn | Learning from nature to enhance Blue engineering of marine infrastructure |
| 18. Eco-design of marine infrastructure: concepts and examples to enhance environmental integration of coastal human construction | Oral | S. Pioch*, C. Jacob, J. C Souche | Enhancing eco-engineering of coastal infrastucture with eco-design: moving from mitigation to integration |
| 19. The world harbour project and ecological engineering of coastal infrastructure: a design for life | Poster | K. O'Shaugnessy | |
| 20. Conserving intertidal habitats: What is the potential of ecological engineering to mitigate impacts of coastal structures? | Poster | M. Perkins | |
| 21. Impacts of coastal armouring on sedimenary communities vary with wave exposure | Poster | L. Critchley | |
| | Invited | A.Shabtay*, M. E. Portman, Y. Carmel | Incorporating principles of reconciliation ecology to achieve ecosystem-based marine spatial planning |
| | Invited | R. McManus*, N. Archibald, S. Comber, A. M. Knights, R. C. Thompson, L. B. Firth | Partial replacement of cement for waste aggregates in concrete coastal and marine infrastructure: a foundation for ecological enhancement? |
| | Invited | G. Chapman*, M. Browne, T. Underwood | An assessment of the current usage of ecological engineering and reconciliation ecology in managing alterations to habitats in urban estuaries |
| | Invited | H. Dennis*, A. J. Evans, A. J. Banner, P. J. Moore | Reefcrete: reducing the environmental footprint of concretes for eco-engineering marine structures |

seascapes has now been progressing for a number of years, spurred on in the early stages by successful partnerships between researchers such as Chapman and Browne, and managers such as the City of Sydney Council. Such relationships allowed for experimental testing on a large spatial scale of seawall interventions designed to increase biodiversity and support ecological communities that more closely approximated