Eco-engineering in urbanised coastal systems: consideration of social values

Rebecca L. Morris*, Gemma Deavin, Stephanie Hemelryk Donald and Ross A. Coleman

Rebecca Morris is a PhD candidate and Ross Coleman is an Associate Professor and Director at the Centre for Research on Ecological Impacts of Coastal Cities, School of Biological Sciences, The University of Sydney (NSW 2006, Australia. Email. rebecca.morris@sydney.edu.au, Tel. +6129351 4053; Email. ross.coleman@sydney.edu.au, Tel. +6129351 2590). Gemma Deavin carried out this research as a project officer at the Institute for Sustainable Solutions, The University of Sydney (NSW 2006, Australia. Email. deavin.gemma@abc.net.au, Tel. +6142200 1170). Stephanie Hemelryk Donald carried out this research as a Professor at the Department of Media and Communications, The University of Sydney (NSW 2006, Australia. URL. www.stephaniedonald.info). This research arose from two projects at the Centre for Research on Ecological Impacts of Coastal Cities investigating the use of eco-engineering in the management of seawalls in Sydney Harbour, Australia.

Corresponding Author:
Rebecca Morris, Centre for Research on Ecological Impacts of Coastal Cities, School of Biological Sciences, The University of Sydney, NSW 2006, Australia. Email. rebecca.morris@sydney.edu.au, Tel. +6129351 4053

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Summary

Loss of marine habitats due to urbanisation has been met with growing research efforts to mitigate ecological impacts through eco-engineering. Research in this area has focused on scientific and engineering outcomes, not considering that seawalls are a socially-driven insertion into the environment. Further, management concerns when employing eco-engineering projects include public opinion regarding the aesthetic value of enhanced structures. It is therefore important for ecologists working in urban systems to understand how the public connects with the environment. Here, we used surveys to quantify perceptions of marine environmental issues and attitudes towards an example of eco-engineering research from Sydney Harbour, Australia. We also evaluated the effect of disclosing the costs of enhancing seawalls to participants regarding their support for the initiative. Results showed there was high support for applied management to improve biodiversity. This result is promising for the implementation of future eco-engineering projects. Understanding social values towards our coastlines and new conservation initiatives will provide end users with the tools to optimise coastal management plans. In summary, consideration of public values in urban conservation is essential for effective management.

Key words: ecological enhancements; biodiversity; seawalls; development; urban; public perceptions; survey

Introduction

A consequence of coastal urbanisation is the proliferation of artificial structures, such as seawalls to defend infrastructure, in the coastal environment. Seawalls lining estuaries and harbours have substantial ecological impacts, including loss of habitat diversity that would have been provided by natural shorelines (reviewed in Bulleri and Chapman 2010). Ecological engineering aims to mitigate these impacts through re-designing the structures to be multifunctional, benefiting both humans and nature (reviewed in Dafforn et al. 2015). Much work has been done globally to try and improve artificial structures in respect of biodiversity. For example, in Sydney Harbour, Australia, researchers have investigated the addition of flowerpot enhancements to seawalls to increase diversity (Browne and Chapman 2011; Browne and Chapman 2014). These enhancements retain water at low tide, and are designed to increase the range of habitat types present on seawalls, with positive effects on biodiversity (Browne and Chapman 2011; Browne and Chapman 2014; R. Morris, R. Coleman, M.G. Chapman and L. Firth, June 2015, unpubl. data).

The missing aspect is, however, that research on the ecology of seawalls is generally conducted without acknowledging that seawalls are a socially-driven insertion within the environment. Fundamentally, it is people who want or need seawalls. It is therefore important for ecologists working in urban systems to understand how the public perceives and values the environment in which anthropogenic structures interact with and modify biodiversity. Social analysis in coastal green infrastructure research has been recognised as a large knowledge gap (Sutton-Grier et al. 2015).

A number of potential benefits are considered to potentially flow from greater public awareness and understanding of problems in the marine environment; including an acceptance of responsibility and involvement in marine conservation, increased pressure on politicians and decision makers, better ocean management and more support for environmental initiatives (Fletcher and Potts 2007). For example, community engagement projects educating the public about the ecological value of coastal habitats, particularly shellfish reefs, have led to thousands of community volunteers participating in restoration projects across the United States (Schrack *et al*. 2012). In addition, outcomes of these community-based projects helped to inform policy to

improve restoration and conservation, which led to state level legislature that created an oyster sanctuary program (Schrack *et al*. 2012).

Delivery of eco-engineering projects requires the permission of different management agencies that have simultaneous interests such as costs, the public and other values associated with infrastructure e.g. heritage and aesthetics. Francis and Hoggart (2008) have highlighted a number of management concerns regarding the installation of enhancement structures. These include potential damage to the property/defence structure and negative effects on the aesthetic value of walls, which would be displeasing to the public. Managers must therefore consider the trade-off of these concerns versus the value of increasing biodiversity in urban areas (Francis and Hoggart 2008). Working effectively with engineers should minimise concerns for the integrity of enhanced structures. To gain insight into public perceptions regarding this issue, however, the qualitative (aesthetic, emotional, social) values that people attach to that particular environment need to be quantified. This will allow informed management decisions when evaluating trade-offs between different scenarios such as alternative development, management and conservation strategies (Pike et al. 2010).

In a U.S. survey that addressed public attitudes toward marine environmental issues, almost half of respondents said that they would engage in personal action, such as litter picking at the beach, to protect the ocean, but far fewer would be prepared to pay higher water bills to build better sewage treatment plants (Spruill 1997). This strongly suggests that the costs of marine conservation could influence public support for a particular management initiative. Studies of urban greening globally have, however, shown that a majority of people surveyed have a strong connection to greener cities. Further, a high percentage of the public would be prepared to pay increased taxes for the maintenance of green infrastructure (Blaine and Lichtkoppter 2004; Chen et al. 2006; Lo and Jim 2010; Londono Cadavid and Ando 2013; Mell et al. 2013). This information needs to be evaluated for marine urban greening to provide local officials with information to optimise coastal management initiatives and outcomes. Where there is increasing pressure on local governments to put a larger proportion of financial resources into environmental programs, local officials can be put in a conflicting position. This is particularly the case if managers do not have information on how the local community feels about that program (Blaine and Lichtkoppter 2004).

Here, we were interested in understanding values and perceptions of the public in order to use the information to inform current and future management initiatives to improve marine habitat in estuarine seawall systems. We collaborated with local government authorities to investigate public perceptions of marine environmental issues and attitudes towards the use of ecological engineering in the management of coastal foreshores in Sydney Harbour, Australia using surveys. The flowerpot rock pool enhancements in Sydney were used as a case study. Specifically, it was hypothesised that more respondents would have high concern for the marine environmental issues listed than low concern. Further, it was proposed that different levels of importance would be placed on values related to the Sydney Harbour marine environment. We also tested the effect of knowing the costs of a management project in regards to support for that initiative, the hypothesis tested was that when the costs of the flowerpots were disclosed to participants, more people would respond with low interest and low importance to ecologically engineered structures.

Methods

Study area

We did two separate public surveys, which matched the two flowerpot enhancement trials in Sydney Harbour, Australia. The first survey (hereafter Survey 1) was done in collaboration with North Sydney Council in November 2009 – August 2010, this was during 'phase 1' of the flowerpot project (Browne and Chapman 2011; Browne and Chapman 2014). The second survey (hereafter Survey 2) was done in collaboration with City of Sydney Council in September 2014 – March 2015, which was during 'phase 2' of the flowerpot project (R. Morris, R. Coleman, M. G. Chapman and L. Firth, June 2015, unpubl. data).

Survey 1 was part of a wider project investigating the connection between people and iconic landscapes (aspects of the environment that have been endowed with strong cultural and social meaning) in Australia, where Sydney Harbour and the flowerpot project was one case study in the questionnaires. We only used the data from this survey that was relevant to the coastal environment, and this was used to inform the design of Survey 2, which focused on

public engagement with coastal environmental issues and eco-engineering to sustain marine habitat in Sydney Harbour.

Survey Distribution

The target demographic for each survey was individuals aged 18 years and over living in Sydney, Australia with foci on two areas; North Sydney (Survey 1) and City of Sydney (Survey 2). Questionnaires were self-administered online via 'Survey Monkey', or provided in hard copy. We invited people to participate in a number of ways: (1) letterbox drop of flyers (Survey 1); (2) letter to local community groups (Survey 2); (3) advertisement in local newspapers (Survey 1 and 2); (4) distribution of questionnaires at community events in Sydney (Survey 1 and 2); and (5) City of Sydney promoted Survey 2 using social media and their website. We pre-tested Survey 2 for language clarity on 11 people, and modified the questionnaire according to their comments before we gave it to Sydney residents. Both surveys were done in compliance with human ethics procedures at The University of Sydney.

Survey design and analysis

We designed the questionnaires using similar methods to existing public survey research in the literature (e.g. Spruill 1997; Neff and Yang 2013). We developed Survey 1 (Appendix S1) and 2 (Appendix S2, 3) using primarily closed questions that contained a mixture of Likert-type scale answers, check boxes and rankings. Whilst closed questions provided standardisation, Survey 1 also used two open questions which allowed unprompted responses from the public (Stoneman et al. 2013). These were: "List three threats to the health of the natural environment in your local area"; and "In a word or short sentence what comes to mind when you think about the harbour coastline". We coded the open questions to provide some uniformity, and illustrated the responses using word clouds.

We asked questions in both surveys which covered three themes: 1. coastal habitat destruction as an environmental issue; 2. the value of Sydney Harbour marine environment and 3; attitudes towards eco-engineering research; in addition to some initial demographic questions (age and suburb in Survey 1, age, sex, suburb, area participants have spent the majority of their

life, employment and primary recreational activity in Survey 2). In Survey 2, we adapted the questions that aimed to quantify the relevance to the community of coastal habitat destruction from a previous study on U.S. public attitudes toward marine environmental issues (Spruill 1997); all other questions were designed specifically for these surveys. Where answers were on a Likert-type scale with four or five choices, two of the answers were in favour of the hypothesis proposed and two were against the hypothesis proposed, (e.g. Sydney Harbour is extremely or somewhat valuable in comparison to not too or not at all valuable). Using the same method as Widmer et al. (2002), the frequencies of the answers for and against the hypothesis were pooled and the null hypothesis that these two frequencies would not differ was tested using χ^2 tests. Where participants were given a choice of five answers, we did not use the middle answer, as this was neutral with respect to the hypothesis. To test the null hypothesis that valuations (aesthetic, recreation and health, social/lifestyle, economic reasons and wildlife) were independent of the frequency of ranks from one to five, a χ^2 Test of Independence was used.

We used Survey 2 to test whether the cost of the flowerpots would have an effect on public support for the enhancement projects. We had two treatments that corresponded to two slightly different questionnaire designs, which were randomly assigned to individuals. In the first treatment, the costs of the flowerpots were not disclosed in the project information given, in the second treatment the costs were detailed as $300 per flowerpot, and this was put into context related to the budget for the Urban Ecology Strategic Action Plan implemented by City of Sydney council to protect biodiversity over the next 10 years (City of Sydney 2014). A χ^2 contingency test examined the effect of disclosing the costs of the management initiative to participants where the factor cost (known or not known) was tested against the pooled frequencies for and against the null hypothesis as before.

Results

The study group

A total of 243 people completed Survey 1 and 174 people completed Survey 2. For the second survey, there were 83 respondents from the first treatment where costs were not disclosed in the questionnaire and 91 from the second treatment where costs were detailed in the questionnaire.

This number of respondents is consistent with those from other public perception studies in the literature (e.g. Neff and Yang 2013; Faleyimu 2014; Friedrich et al. 2014; Gray and Campbell 2009). Of the 174 respondents in Survey 2, 61% were female and 39% were male. Most of the respondents (83%) have spent the majority of their life in a big city, defined as having a population size of more than 1 million, and were employed in a variety of different job sectors. Further, almost half of respondents (45%) stated that outdoors and nature was their primary recreational activity. In Survey 2, the age groups of participants were fairly evenly distributed ranging from 25 and above, whereas the lowest age category from 18-24 was least represented with 17 respondents. In Survey 1, the age categories 18-24 and 34-44 were least represented, with only 7 and 1 respondents respectively.

Environmental issues

Development and pollution were listed as the top environmental issues in Survey 1 (Appendix S4) in unprompted responses. In Survey 2, coastal habitat destruction and the degradation of oceans was not a top priority for the most important environmental problem facing Australia, the majority of respondents (40%) chose climate change to be the biggest issue currently (Figure 1). Despite this, respondents showed significantly high concern for all marine environmental issues, including coastal habitat destruction (Table 1).

Values

All respondents stated that the Sydney Harbour marine environment was valuable to them in Survey 2, and significantly more respondents stated that Sydney Harbour marine environment was valuable to them in Survey 1 ($\chi^2 = 212.05$, d.f. = 1, $P < 0.001$). There were differences in the reasons for the importance of the harbour coasts to the local community (Survey 1; $\chi^2 = 422.67$, d.f. = 16, $P < 0.001$, Survey 2; $\chi^2 = 840.59$, d.f. = 16, $P < 0.001$). Half of respondents (51%) in Survey 1 ranked aesthetics as the most important reason for the harbour coasts being valued (Figure 2a), whereas in Survey 2 wildlife was the top valuation for 48% of participants (Figure 2b). Similarly in Survey 1, when respondents were unprompted, 'beauty' was the most commonly cited value for Sydney Harbour (Appendix S5). Respondents showed concern for the

Sydney Harbour coastal environment (Survey 1; $\chi^2 = 178.78$, d.f. = 1, $P < 0.001$, Survey 2; $\chi^2 = 134.91$, d.f. = 1, $P < 0.001$), and believe that community participation is important in maintaining the health of the environment (Survey 1; $\chi^2 = 218.60$, d.f. = 1, $P < 0.001$, Survey 2; $\chi^2 = 159.21$, d.f. = 1, $P < 0.001$).

Perceptions of eco-engineering

Prior to each survey, 17% (Survey 1) and 35% (Survey 2) of participants had heard of the flowerpot enhancement project. Information on the project was received via the media (42%) or seeing the pots (25%). In Survey 1, participants thought that it was important for the design of artificial structures to be aesthetically pleasing and good for the environment ($\chi^2 = 116.69$, d.f. = 1, $P < 0.001$). Disclosing the costs of the ecological enhancement project to participants did not have an effect on support for the management initiative (Table 2). Respondents stated that they would be interested in learning more about eco-engineering (Table 2), and this was the same result in Survey 1 ($\chi^2 = 82.07$, d.f. = 1, $P < 0.001$). People thought that it was important for coastal managers to design artificial structures to be better as marine habitat (Table 2). Respondents also specified that it was important for artificial structures to be visually pleasing (Table 2), although 95% of participants would be willing to compromise the appearance of a structure to enhance marine life (Table 2). There was high support for local governments to invest in ecological enhancement projects (Table 2).

There was no significant difference in the number of respondents that agreed and disagreed with the statement ‘we should not build new infrastructure, there is not enough natural habitat as it is’. Although half of respondents supported the development of infrastructure, all participants thought that we should try and maximize the habitat for species when designing artificial structures and costs should not be a priority (Table 3). The majority of participants disagreed that people should come before marine life, and agreed that further research is needed to minimise the impacts of infrastructure on biodiversity before continued development (Table 3).

Discussion

Development was listed as the greatest environmental concern for those surveyed. This did not necessarily appear to be linked to coastal habitat destruction, however, as this issue did not rank as a top priority with participants. This was a similar result to the outcomes of a U.S public opinion poll nine years prior to our study (Spruill 1997). Nevertheless, there was high concern for all the listed human impacts on the marine environment, including coastal habitat loss caused by urban sprawl. Sydney Harbour marine environment was valuable to the majority surveyed, with aesthetic appeal and wildlife ranked highest as the most important reasons. It seems evident that the public does show concern for marine ecosystems. That said, it has recently been discussed that there may be a disconnect between the public and the ocean, resulting in few people acting in support of the marine environment as a priority conservation issue (Jefferson et al. 2014, Vincent 2011).

This study provided no evidence that the costs of ecological enhancement projects affected support for the management initiative. A majority of respondents showed high support for their local government to invest in eco-engineering projects. Further, respondents did not agree that costs of marine infrastructure should be a priority. This contrasts to Spruill's (1997) study where a low percentage of Americans were willing to pay higher water bills for better sewage treatment plants to reduce marine pollution. This difference may be because in our survey the costs of the flowerpots were not directly attributed to individuals as an increase in their taxes to pay for the pots. That said however, it has been shown that the public does place high value on urban greening projects (e.g. Blaine and Lichtkoppter 2004). Further, the flowerpots are cheap to install in comparison with other conservation initiatives, which could equally be the reason why costs were not considered to be important in our research. For example, there is a widespread support for the plastic bag levy in Ireland, even though the tax causes a small expense to public and retailers, because of the perceived benefits to the environment (Convery et al. 2007).

In our first survey, respondents placed high importance on artificial structures designed to be visually pleasing and a better habitat for marine life. In Survey 2, we found that the aesthetic value was far outweighed by the value of structures for wildlife, with most people stating that they would be willing to compromise the appearance of a structure for it to be better for marine life. This result may not be surprising as nature and wildlife were values consistently ranked high in both surveys, and could be promising for the support of future eco-engineering projects in

Australia, and worldwide. One limitation of this study however is that the sampled group was self-selecting, and although represented a variety of suburbs, ages and employment sectors, this sample may be biased towards more outspoken residents or those with a particular interest in ecological issues. Though results may not representative of the Greater Sydney public, the group sampled may be more likely to engage with marine environmental issues in their local area, and place pressure on local government authorities for a change in conservation policy. The significance of public support in the application of eco-engineering has been recently recognized (Dafforn et al. 2014). Eco-engineering research to date has been directed at scientific and engineering outcomes; however seawalls are part of the environment of the inhabitants of a city. The installation of ecological enhancements involves the redesign of these structures, which is why managers show concern regarding public opinion in this area of research; therefore we must consider public values in their application. This managerial concern is not limited to Australia, with Francis and Hoggart (2008) citing this as a barrier to enhancements in the UK, and is likely to apply worldwide.

The relevance of engaging the public and quantifying social values in urban management is twofold. Firstly, an engaged and informed public may be more likely to exert pressures on local authorities and policymakers to address environmental concerns, such as marine habitat loss (Fletcher and Potts 2007). Secondly, research that quantifies public support may decrease the concerns felt by managers about public disapproval of certain conservation initiatives. Understanding social values towards our coastlines and new conservation initiatives will therefore provide end users with the tools to optimize coastal management plans, and could potentially influence policy making. With increasing urban sprawl along our coastlines globally, there is a call for multifunctional marine infrastructure to be adopted in national coastal defense planning and policy (Sutton-Grier et al. 2015; Dafforn et al. 2015). For instance, in the US there has been an increase in federal interest in natural or green infrastructure for coastal resilience since the devastation, both socially and economically, of Hurricane Sandy (Sutton-Grier et al. 2015). Further, Europe released a strategy to promote the use of green infrastructure to mitigate biodiversity loss, with coastal engineering as one case study (European Commission 2013). In Australia, there are many policies that could support the implementation of enhancement projects, but a national strategy specific to the delivery of green infrastructure within existing legislation is needed (Dafforn et al. 2015).

Ecological engineering is a good area of marine conservation to connect the public with marine environmental issues. For example, a considerable number of people surveyed had already come into contact with the flowerpot enhancement project, mainly through the media. A recent article encouraged focusing on 'shallow ocean neighbourhoods' to capture the interest of the public in conservation issues (Vincent 2011). There was a global media interest in the flowerpot enhancement project (e.g. BBC News, 2014, Sydney Morning Herald, 2013, 2015, ABC Radio National, 2015, Channel 7 News, 2015). One reason for this is that the public can connect with the project, with concepts such as 'new homes for marine life' being able to be explained simply and effectively to a wide audience. People are able to engage with eco-engineering projects, as they can visit the structures for themselves; this coupled with information signage can be a great way to educate the community about concepts such as habitat loss and sea level rise.

The aim of this research was to assess the connection of the community with a significant environmental issue. The results from our study may be used in support for other eco-engineering projects both nationally and internationally, or as a starting point for other public perception studies in this area globally. Australia is one of the leaders in marine eco-engineering research; it is therefore a positive result that there are groups of people within the Sydney public that support these projects. Quantification of societal values in urban conservation is essential for effective management. Responsibility will then be with the end users to manage public views and values with the need to sustain biodiversity in urban areas, not forgetting the critical part ecologists should play in the dissemination of research and education.

References

Blaine T. W. and Lichtkoppter F. R. (2004) Willingness to pay for green space preservation: A comparison of soil and water conservation district clientele and the general public using the contingent valuation method. Journal of Soil and Water Conservation **59**, 203-208.

Browne M. A. and Chapman M. G. (2011) Ecologically informed engineering reduces loss of intertidal biodiversity on artificial shorelines. Environmental Science and Technology **45**, 8204-8207.

Browne M. A. and Chapman M. G. (2014) Mitigating against the loss of species by adding artificial intertidal pools to existing seawalls. Marine Ecoogy Progress Series **497**, 119-129.
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**, 26-35.
Chen B., Bao Z. and Zhu Z. (2006) Assessing the willingness of the public to pay to conserve urban green spaces: The Hangzhou City, China, case. Journal of Environmental Health **69**, 26-30.
City of Sydney. (2014) Urban ecology strategic action plan. Sydney, NSW, Australia.
Convery F., McDonnell S. and Ferreira S. (2007) The most popular tax in europe? Lessons from the Irish plastic bags levy. Environmental and Resource Economics **38**, 1-11.
Dafforn K. A., Glasby T. M., Airoldi L., Rivero, N. K., Mayer-Pinto, M. and Johnston, E. L. (2015) Marine urbanization: An ecological framework for designing multifunctional artificial structures. Frontiers in Ecology and the Environment **13**, 82-90.
Dafforn K. A., Mayer Pinto M., Morris R. L. and Waltham, N. J. (2015) Application of management tools to integrate ecological principles with the design of marine infrastructure. Journal of Environmental Management **158**, 61-73.
European Commission. (2013) Building a green infrastructure for Europe. European Commission, Belgium.
Faleyimu O. I. (2014) Public perceptions of urban forests in Okitipupa Nigeria: Implication for environmental conservation. Journal of Applied Sciences and Environmental Management **18**, 469-478.
Fletcher S. and Potts J. (2007) Ocean citizenship: An emergent geographical concept. Coastal Management **35**, 511-524.
Francis R. A. and Hoggart S. P. G. (2008) Waste not, want not: The need to utilize existing artificial structures for habitat improvement along urban rivers. Restoration Ecology **16**, 373-381.
Friedrich L. A., Jefferson R. and Glegg G. (2014) Public perceptions of sharks: Gathering support for shark conservation. Marine Policy **47**, 1-7.
Gray N. J. and Campbell L. M. (2009) Science, policy advocacy, and marine protected areas. Conservation Biology **23**, 460-468.

Jefferson R. L., Bailey I., Laffoley D. d'A., Richards, J. P. and Attrill, M. J. (2014) Public perceptions of the UK marine environment. Marine Policy **43**, 327-337.

Lo, A.Y. and Jim, C.Y. (2010) Willingness of residents to pay and motives for conservation of urban green spaces in the compact city of Hong Kong. Urban Forestry and Urban Greening **9**, 113-120.

Londono Cadavid, C. and Ando A.W. (2013) Valuing preferences over stormwater management outcomes including improved hydrologic function. Water Resources Research **49**, 4114-4125.

Mell I. C., Henneberry J., Hehl-Lange S. and Keskin B. (2013) Promoting urban greening: Valuing the development of green infrastructure investments in the urban core of Manchester, UK. Urban Forestry and Urban Greening **12**, 296-306.

Neff C. L. and Yang J. Y. H. (2013) Shark bites and public attitudes: Policy implications from the first before and after shark bite survey. Marine Policy **38**, 545-547.

Pike, K., Johnson, D., Fletcher, S., Wright, P. and Lee, B. (2010) Social value of marine and coastal protected areas in England and Wales. Coastal Management **38**, 412-432.

Pike, K., Johnson, D., Fletcher, S. and Wright, P. (2011) Seeking Spirituality: Respecting the Social Value of Coastal Recreational Resources in England and Wales. Journal of Coastal Research **61**, 194-204.

Schrack, E., Beck, M., Brumbaugh, R., Crisley, K. and Hancock, B. (2012) Restoration works: Highlights from a decade of partnership between The Nature Conservancy and the National Oceanic and Atmospheric Administration's Restoration Center. The Nature Conservancy, Arlington, VA, USA.

Spruill V. N. (1997) U.S. Public attitudes toward marine environmental issues. Oceanography **10**, 149-152.

Stoneman P., Sturgis P. and Allum N. (2013) Exploring public discourses about emerging technologies through statistical clustering of open-ended survey questions. Public Understanding of Science **22**, 850-868.

Sutton-Grier A. E., Wowk K. and Bamford H. (2015) Future of our coasts: The potential for natural and hybrid infrastructure to enhance the resilience of our coastal communities, economies and ecosystems. Environmental Science and Policy **51**, 137-148.

Vincent A. C. J. (2011) Saving the shallows: Focusing marine conservation where people might care. Aquatic Conservation-Marine and Freshwater Ecosystems **21**, 495-499.

Widmer W., Underwood A. and Chapman M. (2002) Recreational boating on Sydney Harbour: Public perception of potential environmental impacts. Natural Resource Management **5**, 22-27.

Table 1: χ^2 tests for responses to questions regarding the importance of coastal habitat destruction as an environmental issue. χ^2 tests compared high and low concern only.

		Frequency	%	d.f.	χ^2	P
Marine animals are being killed:						
	High concern	131	75	1	99.03	<0.001
	Medium concern	31	18			
	Low concern	12	7			
Coastal habitat is being destroyed:						
	High concern	132	76	1	95.37	<0.001
	Medium concern	28	16			
	Low concern	14	8			
Environmental pollutant contamination:						

	High concern	135	78	1	102.92	<0.001
	Medium concern	27	16			
	Low concern	12	7			
Mangrove forest destruction:						
	High concern	143	82	1	125.97	<0.001
	Medium concern	25	14			
	Low concern	6	3			
Overfishing of world's fish stocks:						
	High concern	161	93	1	149.39	<0.001
	Medium concern	9	5			
	Low concern	4	2			

Table 2: χ^2 tests for responses to questions regarding respondent interest and support for enhancement projects in two treatment groups; 1. costs of the enhancements were not disclosed in the questionnaire to participants and 2. costs of the enhancements were disclosed in the questionnaire. Medium support was removed for χ^2 tests (see text).

	Frequency	**%**	**d.f.**	**χ^2**	**P**
Interest in enhancement projects:					

Costs not known						
	Interested	77	95	1	0.03	>0.05
	Not interested	4	5			
Costs known						
	Interested	86	95			
	Not interested	5	5			
Importance of enhancing structures:						
Costs not known						
	Important	79	96	1	1.16	>0.05
	Not important	3	4			
Costs known						
	Important	87	99			
	Not important	1	1			
Importance of visually pleasing structures:						
Costs not known						
	Important	71	86	1	0.85	>0.05
	Not important	12	14			
Costs known						
	Important	82	90			
	Not important	9	10			
Compromise aesthetics for environment:						
Costs not known						
	Yes	79	96	1	0.33	>0.05
	No	3	4			
Costs known						
	Yes	86	95			
	No	5	5			
Support for enhancement projects:						
Costs not known						
	High support	67	81	1	0.03	>0.05
	Medium support	11	13			
	Low support	5	6			
Costs known						

	High support	83	91
	Medium support	6	7
	Low support	2	2

Table 3: χ^2 tests for responses to questions regarding the perspective of respondents to the development of infrastructure and the ecological enhancement of artificial structures in the coastal environment. χ^2 tests compared agree and disagree only.

		Frequency	%	d.f.	χ^2	P
We should not build new infrastructure:						
	Agree	67	39	1	0.81	>0.05
	Neither agree nor disagree	47	27			
	Disagree	57	33			
People should come before marine life:						
	Agree	5	3	1	122.7	<0.001
	Neither agree nor disagree	29	17			
	Disagree	137	80			
We should design structures for nature:						
	Agree	172	99	-	-	-
	Neither agree nor disagree	1	1			
	Disagree	0				
We need more research before continued development:						
	Agree	119	69	1	74.46	<0.001
	Neither agree nor disagree	35	20			
	Disagree	18	10			
Costs should be the priority:						
	Agree	24	14	1	55.19	<0.001
	Neither agree nor disagree	37	22			
	Disagree	110	64			

Figures

Figure 1: The percentage of respondents that answered each environmental problem to be (a) the most important environmental issue facing Australia (black bars), and (b) the second most important environmental issue facing Australia (grey bars).

Figure 2: The percentage of respondents for each rank (1 – most important, 5 – least important) and reason that the Sydney Harbour coastline is important in the local area in (a) Survey 1 and (b) Survey 2.

Supplementary Material

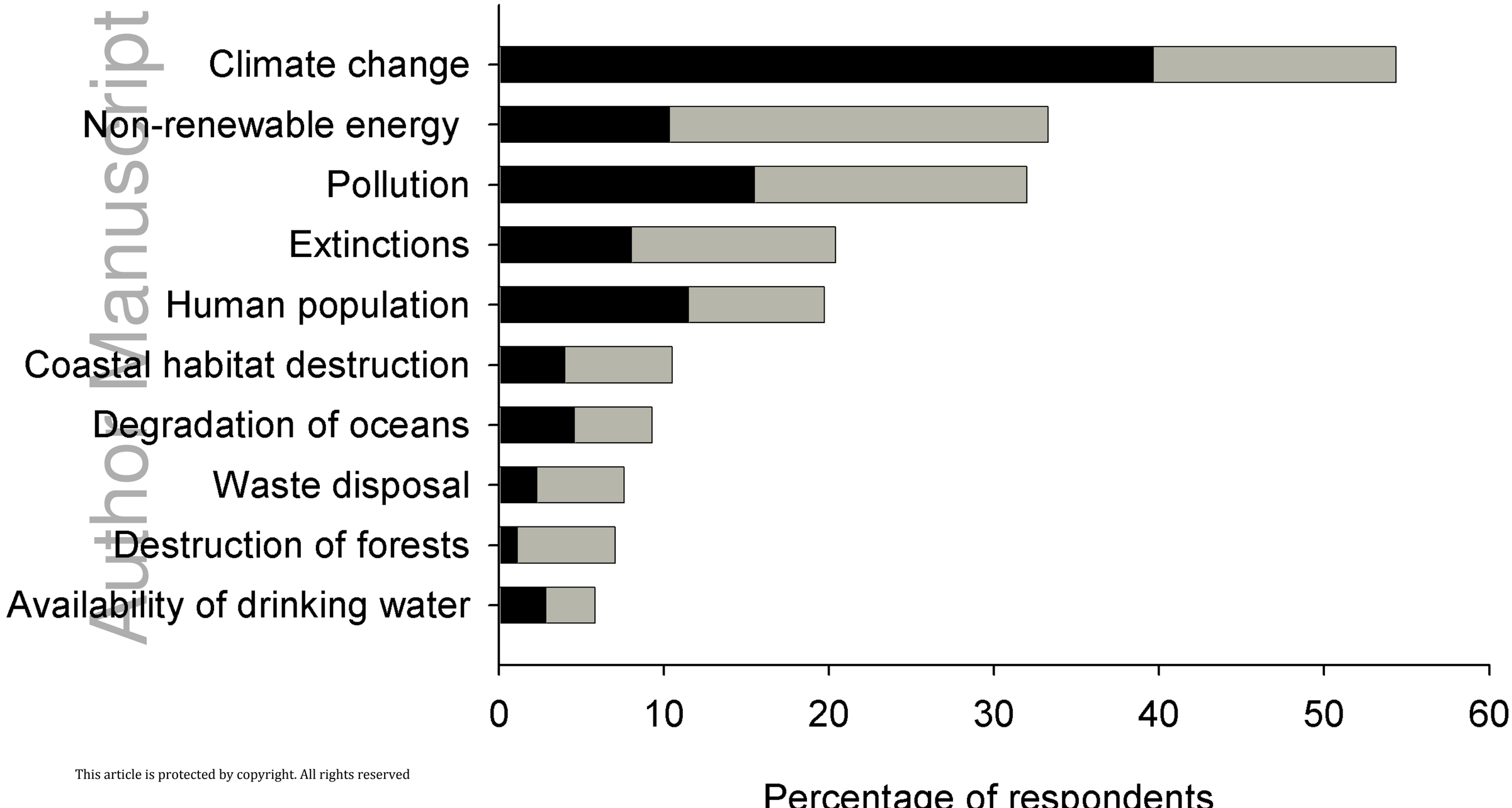
Appendix S1: Survey 1 in collaboration with North Sydney Council.

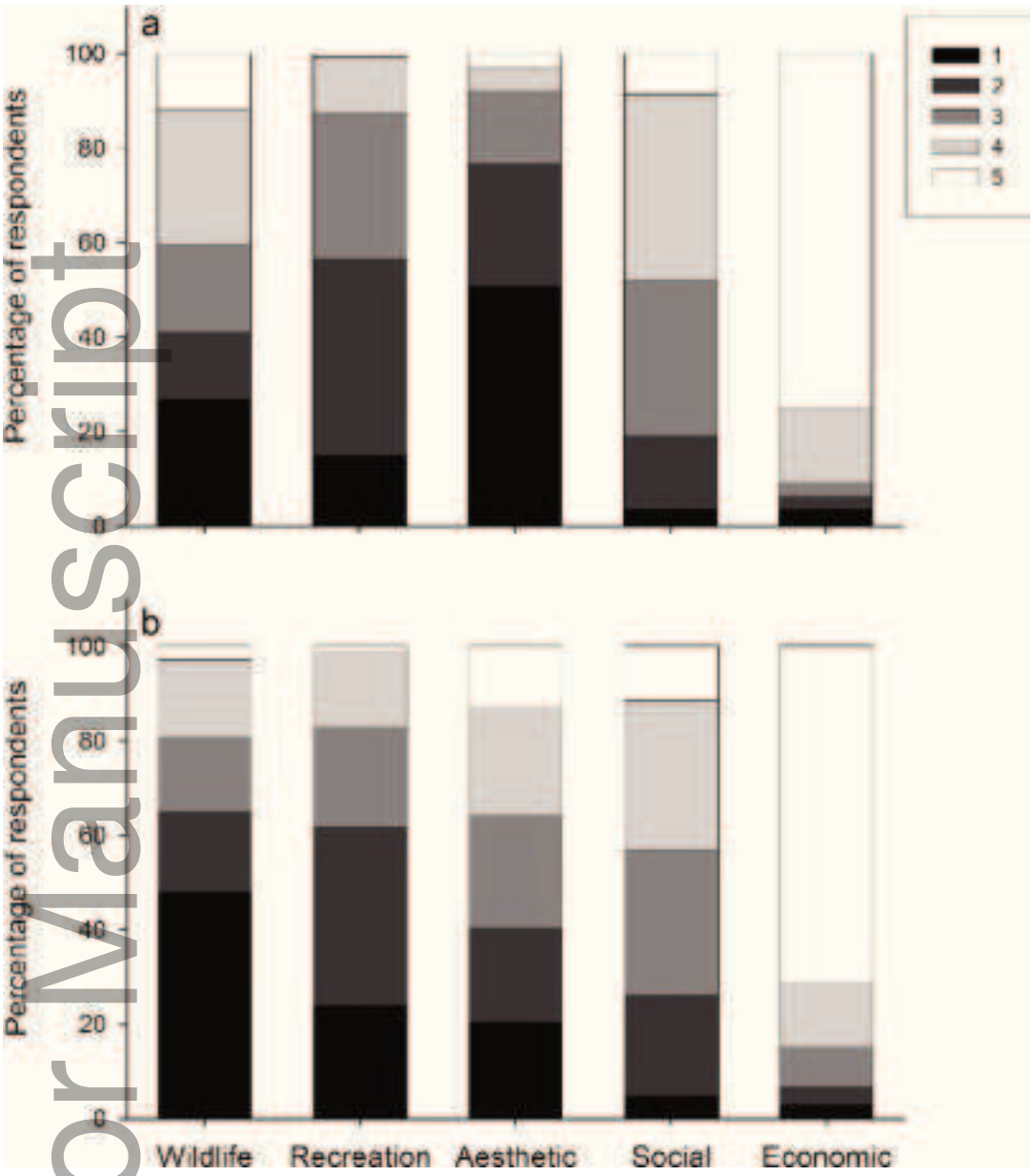
Appendix S2: Survey 2 in collaboration with City of Sydney Council where costs of the flowerpots were not disclosed to participants.

Appendix S3: Survey 2 in collaboration with City of Sydney Council where costs of the flowerpots were disclosed to participants.

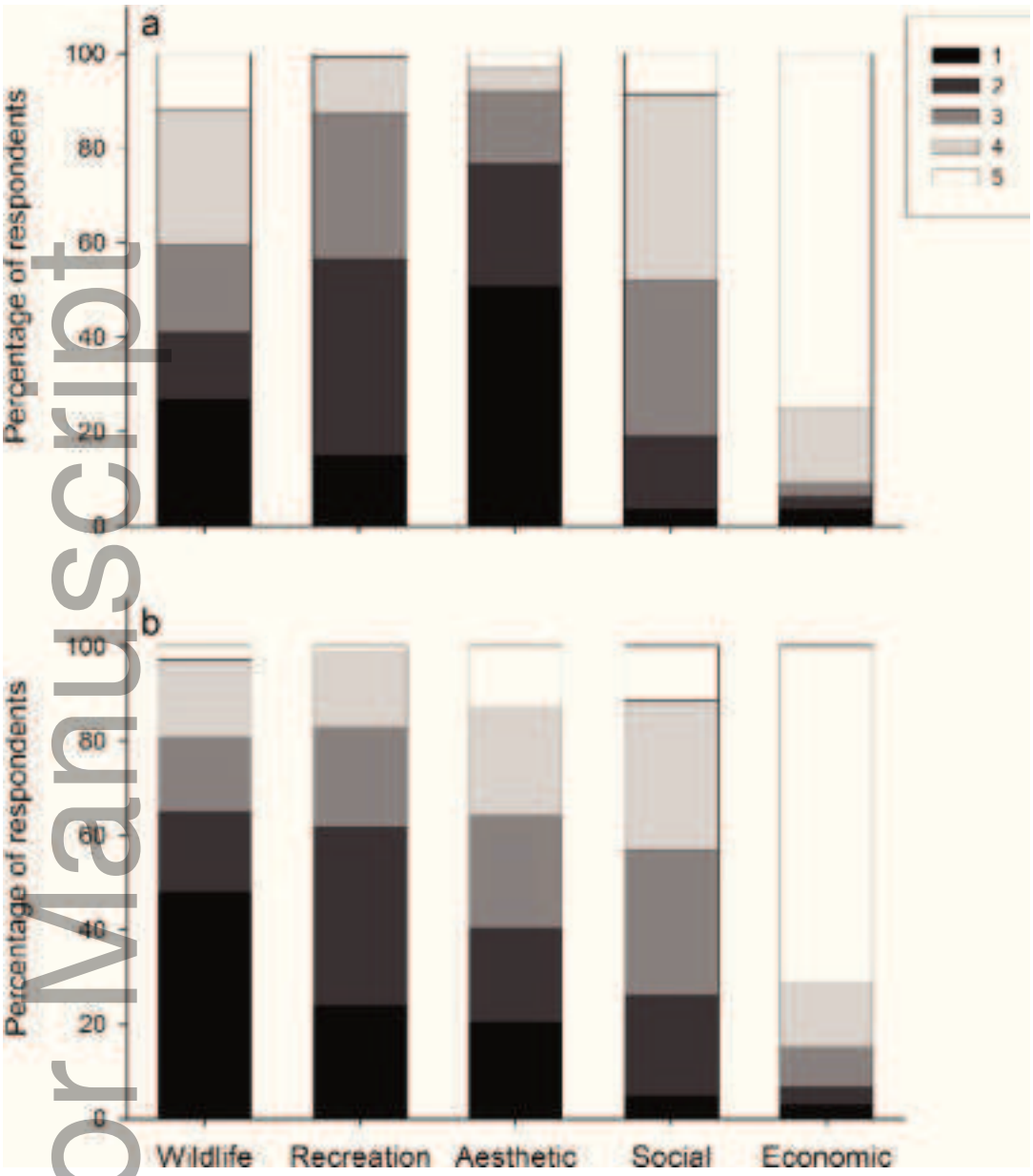
Appendix S4: Word cloud of environmental threats. Participants were asked “List three threats to the health of the natural environment (plants, wildlife and waterways) in your local area”. The threats listed most often are largest in font size.

Appendix S5: Word cloud of values of Sydney Harbour. Participants were asked “In a word or short sentence what comes to mind when you think about the harbour coastline”. The values listed most often are largest in font size.





emr_12200_f2.tif



emr_12200_f2.tif