Journal of the Marine Biological Association of the United Kingdom, 2016, 96(1), 5–12.
doi:10.1017/S0025315415002209

The 'Blue Gym': What can blue space do for you and what can you do for blue space?

M.P. WHITE[1], S. PAHL[1,2], B.W. WHEELER[1], L.E.F. FLEMING[1] AND M.H. DEPLEDGE[1]

[1]European Centre for Environment and Human Health, University of Exeter Medical School, Knowledge Spa, Royal Cornwall Hospital, Truro TR1 3HD, UK, [2]School of Psychology, Plymouth University, Portland Square, Plymouth PL4 8AA, UK

The Blue Gym Initiative was created in the UK in 2009 to explore: (1) whether blue space environments might be positively related to human health and well-being; and (2) whether the public could be encouraged to preserve and protect these environments. Whilst the wider initiative considers all blue spaces including inland bodies of water (e.g. lakes, rivers and canals as well as the coasts and oceans), to date the focus has been primarily on marine and coastal environments. In this paper, we provide a brief history of the Blue Gym Initiative, and outline some of the research that has emerged to date. An important early finding was the observation that individuals living near the coast are generally healthier and happier than those living inland; much subsequent work has tried to understand why this might be. More recently we have begun to focus on how to promote pro-marine behaviours (e.g. sustainable fish choice, reduction of plastic use, avoidance of littering). This strand is still very much work in progress but highlights the importance of understanding public awareness, values and attitudes and the power of visualization in communicating the marine sustainability issues. We conclude with a brief discussion of some of the implications of the findings and future research needs.

Keywords: Blue space, Health and well-being, Pro-marine behaviours

BACKGROUND: WHERE DID THE IDEA ORIGINATE AND WHAT PROGRESS HAS BEEN MADE SO FAR?

The environment as a source of both disease and good health

Perhaps the greatest advance in public health was the realization that the environments in which people live and work are important determinants of ill health and disease (DiGiulio & Monosson, 1996; Rayner & Lang, 2013). Swamps breed malaria-carrying mosquitoes; poor sewage treatment can encourage the spread of cholera. Since these early realizations, the field of public health has taken enormous steps in identifying a range of potential sources and vectors of disease in the environment, and implementing strategies to reduce risks to people. This perspective sees the environment, natural and human-made, as a potential problem for health that needs to be managed; the emphasis is on the disease-causing aspects of the built and natural environment. Despite the obvious importance of this perspective an alternative, yet also complementary, perspective sees the environment as a potential source of good health. This salutogenic (health creating) perspective notes, for instance, the importance of exposure to sunlight for vitamin D synthesis and the role of urban design, e.g. provision of cycle paths, in facilitating health-promoting physical activity. This second perspective sees the environment, natural and human-made, as a potential way of promoting health and well-being.

Corresponding author:
M.P. White
Email: mathew.white@exeter.ac.uk

A brief history of the Blue Gym Initiative

The Blue Gym Initiative developed from this second perspective (Depledge & Bird, 2009). With support from the National Health Service (NHS), Natural England and the UK Environment Agency, its first aim was to understand the potential of 'natural' aquatic environments (e.g. ponds, rivers, lakes, canals, coastlines etc.) to enhance and promote human health and well-being more broadly. In this respect, the initiative built deliberately on the earlier 'Green Gym' initiative which was trying to encourage people to engage in environmental volunteering in green spaces such as parks and woodlands (Yerrel, 2008). This programme, run by the British Trust for Conservation Volunteers (now, The Conservation Volunteers), was intended to have the dual benefits of both being good for participants' health and well-being and also good for the environment. However, it was also clear that 'blue space' environments posed very different risks (e.g. drowning, harmful algal blooms [HABs], etc.) and potential benefits from terrestrial green spaces. At this early stage in the concept there was very little understanding of exactly what these benefits might be; and in particular what benefits might be lost if: (a) people began reducing their exposure to these environments in an attempt to avoid the real and perceived risks; and (b) the present rate of degradation of these ecosystems continued (through habitat destruction, pollution, etc.). However, in the last five years, significant steps forward have been made in understanding some of these issues and these are reviewed below.

The second aim of the Blue Gym Initiative Programme was to encourage a wider public debate and therefore develop and promote more public awareness and direct involvement in the more responsible use of blue space environments with benefits both to human health and to these often fragile ecosystems. For example, could public engagement be used to encourage

enjoyment of the shoreline or riparian zones without concomitant negative impacts on species and habitats? Could marine or river 'champions' be identified and supported to 'spread the word', encourage greater participation, and help link and coordinate organizations that were already doing some of these activities but often in isolation?

To support these latter outcomes in particular, the Blue Gym Initiative established an internet-based 'social network', the aim of which was to foster an organic social movement to deliver these goals, and also to provide a platform for researchers in this area to promote robust, evidence-informed, practice. The early days of this network were highly encouraging with hundreds of individuals and organizations joining and contributing (see for instance early videos: https://www.youtube.com/watch?v=Jq44KhBSgQA). However, it quickly became apparent that there were many challenges to running and organizing a social network community, not least disruptive internet practices, which, in hindsight, the Blue Gym team did not have the resources to deal with. In particular, updating, monitoring and moderating the site became an ever greater challenge as its popularity grew. Since we did not have the means necessary to maintain the early high standards as the site grew, we decided to scale back this aspect and focus on our research objectives. Our decision to do this was primarily pragmatic; we still believe that there is a potential role for this kind of public engagement activity if sufficient resources are allocated and maintained over the long term.

Two emerging strands of interconnected research

As greater effort was focused on the research component, it also became apparent that two parallel, though interconnected, strands were emerging that were broadly in line with the two aspects noted above. In his inaugural presidential address, President Kennedy famously said 'ask not what your country can do for you, but what you can do for your country'. Paraphrasing this, the two strands were essentially asking: '(a) What can blue space do for you and (b) what can you do for blue space?' The first strand looked at the potential benefits to health and well-being of different blue space environments. The second strand looked at how people could be encouraged to protect and conserve such environments by looking at issues such as public awareness of the issues and how best to communicate the problems. Our discussion below is broadly structured around these two issues.

Driven by connections with existing projects and for geographic reasons, most of the research that has been conducted under the Blue Gym banner has focused on marine and coastal environments. Based in the South West of England, the research team had (and continues to have) excellent access to a variety of coastal settings and coastal populations. It is not yet clear how some of our findings might relate to inland waterways, and we have identified this as a key research priority going forward. We are also aware of the excellent work on these topics that has been, and continues to be, carried out by others in the UK and around the world (e.g. Ronan Foley in Ireland, https://www.maynoothuniversity.ie/geography/our-people/ronan-foley; Adi Hanein and Kelly Biedenweg in the USA, http://www.eopugetsound.org/articles/well-being-indicators-puget-sound-basin; Robin Kearns in New Zealand, http://sustainablecities.org.nz/members/robin-kearns/; Sebastian Voelker in Germany http://www.ihph.de/english/Sebastian-Voelker.php; and Adrian Bauman in Australia http://sydney.edu.au/medicine/people/academics/profiles/adrian.bauman.php). The current review focuses principally on research that has emerged as part of the research programme centred in the South West UK. Recent, more extensive overviews of historical influences and current global research are provided elsewhere (e.g. Wheeler *et al.*, 2014; White *et al.*, 2016a, b, see also Völker & Kistemann, 2011, 2013). Where relevant, we cross-reference to other work that is cognate with that reviewed here.

WHAT CAN BLUE SPACE DO FOR US – HEALTH AND WELL-BEING

Identifying the questions

Research into landscape preferences has long documented the appeal of aquatic environments, both inland and coastal, over other landscapes (Hubbard & Kimball, 1967; Zube, 1974; Ulrich, 1983; Herzog, 1985; Kaplan & Kaplan, 1989). Indeed in some studies, aquatic landscapes are actually excluded because preferences for them are so strong as to distort the findings related to natural settings in general (Herzog *et al.*, 2003).

These preferences manifest themselves in practical ways. Estate agents and hoteliers, for instance, are well aware that people are willing to pay more for homes and hotel rooms with blue space views (Luttik, 2000; Lange & Schaeffer, 2001). Those who cannot afford such views still seek closeness to these environments in their free time. For instance, coastal resorts are, by far, the most popular holiday destination in the EU with over 16 million tourist beds (Collett, 2010). People like blue space and are willing to spend time and money to be near it. These findings constitute the basis of our (and others') research questions. We assumed that the reason that people like these environments – and are prepared to pay to experience them – is because they derive some kind of benefit from them. What is then important to determine is what exactly the benefits might be, how widely available they are, how they might arise, who might benefit the most, and what the relationships are between the types and quality of different blue space environment and positive outcomes. Put simply, would any coast or river do, or did, for instance, the visual aesthetic, cleanliness and biodiversity of the site also play an important role?

Early studies – identifying the potential benefits

The first study used a very simple paradigm adapted from environmental psychology and landscape preference research (White *et al.*, 2010). The approach involved asking participants to sit in a research laboratory and view a series of 120 still photographs of different environments. Their task was to imagine sitting in each environment and state how they thought being there would make them feel or help to combat mental fatigue. Previous studies had shown that people are relatively good at tasks of this nature, and that

https://doi.org/10.1017/S0025315415002209 Published online by Cambridge University Press

their rank order preferences in the laboratory closely tally with their reports *in situ*. People know which kinds of environments stimulate which kinds of emotions they experience. What was original about this study was that the amount of water visible in the scenes was carefully controlled, along with a range of potential confounders (e.g. the number of people, animals, and human-made objects such as cars).

In addition to replicating earlier work that found that people preferred aquatic landscapes, and were willing to pay more for hotel rooms with aquatic views, we further showed that *urban* landscapes containing water are associated with positive outcomes broadly similar to those of rural green space environments without water. Previous work had concluded that rural environments are generally better than urban environments, but these reports had not controlled for the presence of water. To give an indication of the magnitude of these effects we report the mean preference ratings for three sets of urban images; those with no green/blue space visible (all buildings, roads etc.), those with roughly one third green space visible, and those with roughly one third blue space visible (for all nine environment types see figure 2 in White *et al.*, 2010). Preferences were based on two items asking about how attractive the scene was and how willing to visit the scene respondents were on scales from 0 'Not at all' to 10 'Extremely'. Compared with urban settings with no natural elements ($M = 3.66$), preferences were significantly higher for urban scenes with both green space ($M = 4.89$, $P < 0.001$) and blue space ($M = 5.96$, $P < 0.001$). However, as can be seen from the means, preferences for urban images with some blue space were also significantly higher ($P < 0.001$, reflecting over a 1 point difference on an 11 point scale) than those for urban images with some green space. Moreover, these preferences for urban images with some blue space were not significantly different from images of open countryside and woodlands with no visible built content ($M = 5.83$), hinting at the potential importance of water for preferences in urban settings. A further novel finding was that images of aquatic margins (e.g. the coast, $M = 7.68$) were associated with significantly higher preferences than open water ($M = 7.40$; $P < 0.01$), suggesting an important role for the land-water interface. Three subsequent studies using the same paradigm showed that these preferences are not simply due to colour (i.e. more 'blue'); they persisted using black and white images, or different types of weather, since aquatic landscapes are still preferred in rainy/stormy weather. Furthermore, underwater scenes are also highly rated (White *et al.*, 2014a).

We reasoned that high levels of habitual exposure to these environments should manifest itself in some way. More specifically, given the extensive evidence linking positive mental states and physical health (e.g. Pressman & Cohen, 2005), we reasoned that people who lived near the coast should be experiencing high levels of positive emotion, and in turn this should be apparent in their general levels of health. To test this hypothesis, we used the English 2001 census data (~48 million adults), and analysed the frequency with which people in ~30,000 neighbourhoods responded 'Good' to the following question: '*Over the last 12 months would you say your health has on the whole been, Good, Fairly Good or Not Good?*' (Wheeler *et al.*, 2012). Due to geographic variation in population age/sex structure, we calculated directly standardized rates of good health in these neighbourhoods. Although this self-reported health variable is a simple measure, answers to this question are strongly correlated with objective measures of health (people generally know if they are in poor health; Kyffin *et al.*, 2004); and had previously been used in green space research (Mitchell & Popham, 2007). Due to identification restrictions in the census data it was only possible to make an approximate estimation of how close individuals lived to the sea, based on how close to the coast their neighbourhood was (each ~1500 people and 4 km^2 on average), rather than the actual location of their dwelling.

Allocating coastal distance into one of five categories broadly reflecting access potential (e.g. 0–1 km = walking distance; 2–5 km = cycling/short drive distance etc.), and looking at the sample overall, we found a relatively steady coastal proximity gradient. The closer a neighbourhood was to the coast, the better, on average, its residents' overall self-reported health. Although the effects were relatively small, they potentially apply to many people. For example, there was only a 1.13% increase in those reporting 'good health' among those who lived in urban areas within 1 km of the coast compared with those who lived in urban areas over 50 km from the coast. However, the number of people who live within 1 km of the English coast is ~3 million which suggests a potentially important cumulative effect. Moreover, when the level of neighbourhood deprivation (Noble *et al.*, 2004) was stratified, we found that this proximity gradient was strongest among the most deprived neighbourhoods and weakest in the least deprived neighbourhoods. That is, living near the sea seemed to confer the greatest health-related benefit on those living in the poorest areas; a similar finding for urban green space was reported by Mitchell & Popham (2008). There are a number of possible explanations for this finding, and one of these might be that the coast offers a range of relatively cost-free, health-promoting opportunities (e.g. stress reduction and physical activity) in an attractive environment that individuals with limited economic resources could nonetheless profit from. Wealthier individuals, by contrast, may have broader access to health-promoting opportunities wherever they live and may also be more mobile, so that close proximity to the coast may be less important.

A limitation of the study is that it is open to the possibility of an 'ecological fallacy', i.e. inferring individual level association from group/area associations. A good example of this would have been to have assumed that wealthier voters were more likely to have voted Democrat in the 2004 US presidential election because John Kerry won more wealthy States than George Bush, even though wealthier individuals were actually more likely to have voted for Bush. The problem of inferring individual relationships from area associations with respect to local area greenspace has been noted previously with respect to US cities (Richardson *et al.*, 2012). A further limitation is the cross-sectional nature of the data which meant that it was not possible to control for selection effects (i.e. healthier people might move to the coast rather than the coast promoting the health of those who live nearby).

To counter these problems, a subsequent study used data from the British Household Panel Survey (BHPS; White *et al.*, 2013a). The BHPS is a nationally representative longitudinal survey that ran annually from 1991 to 2008 and included over 5000 households. Importantly, some people moved home during their participation in the panel survey, sometimes nearer to the coast and sometimes further from the coast. By comparing individuals' self-reported health (and mental well-being) in years when they lived at different distances

https://doi.org/10.1017/S0025315415002209 Published online by Cambridge University Press

from the sea, it was possible to control for a range of potential individual level confounds which might be affecting selection effects. Extending the census findings it was found, using a sample of 109,844 observations from 15,471 individuals, that people did indeed report better mental and physical health in years when they lived closer to the sea (see also Brereton *et al.*, 2008). Again, although the absolute size of the effects was small, the relative effects compared with other things that are widely cited as important for health and well-being were nonetheless telling. For instance, living within 5 km of the coast (compared with further inland) was associated with 0.22 times the beneficial effect of being employed rather than unemployed, suggesting coastal living can have meaningful impacts on health. Moreover, this finding was not simply due to a 'healthy retiree effect' as the same pattern was found among the working age population. Although this study reduced the possibility of a selection bias in coastal living, it still sheds little light on the mechanisms underlying these apparent benefits.

Examining the mechanisms

In their extensive review of the factors linking natural environments more broadly with health outcomes, Hartig *et al.* (2014) discussed four key potential mechanisms: stress reduction, physical activity, social interactions and environmental quality (in particular air quality). Broadly speaking, they argued that the reason why people who live in greener areas (e.g. near parks or woodlands) are generally healthier is that they are: (a) less stressed, (b) exercise more, (c) have more positive social interactions and (d) the environment in which they live is of a better quality for health promotion (i.e. has lower levels of air pollution). Similar indicators were used in an attempt to help explain our findings from the Census and BHPS data.

To determine whether coastal and marine environments might be especially good for stress reduction, data from Natural England's national survey of outdoor leisure visits, the Monitor of Engagement with the Natural Environment (MENE) was examined. Focusing on 4255 visits where people reported how the visit had helped them to feel calm, relaxed, refreshed and revitalized (i.e. less stressed), emotional experiences during visits to urban green spaces, the rural countryside and the coast (White *et al.*, 2013b) were compared. Two key findings emerged. First, people who lived nearer the coast were more likely to have visited it within the last 7 days, supporting the contention of the earlier studies that living near the coast is associated with greater exposure to the coasts (see also Schipperijn *et al.*, 2010). Second, coastal visits were associated with significantly greater feelings of stress reduction than either of the other two environmental categories of urban parks and countryside (see also MacKerron & Mourato, 2013). Although the average differences across environment types were relatively small, they pertained to just a single visit. Given that coastal dwellers visit the coast more frequently, these small gains from any given visit are likely to accumulate over time.

Data from the MENE survey was further used to assess the potential of the coast to encourage physical activity, but this time using a much larger sample, N = 183,755 (White *et al.*, 2014b). Using the same neighbourhood approach as in the census analysis, it was estimated how close each individual lived to the sea and to what extent they achieved the government's recommended guidelines of at least 5 days a week of 30 minutes or more physical activity. A pronounced coastal proximity gradient was evident, even after controlling for a range of potential confounders (such as age, gender and socio-economic status). Specifically, compared with living more than 20 km from the coast, a person living within 1 km of the coast was 8% more likely, and a person living between 1–5 km from the coast was 4% more likely, to be meeting recommended weekly physical activity levels (see also Bauman *et al.*, 1999; Humpel *et al.*, 2004; Witten *et al.*, 2008). Moreover, the frequency with which they visited the coast appeared to mediate this effect, that is, the increased level of physical activity did indeed seem to be occurring at the coast. Intriguingly, however, there were marked regional differences. Although a relatively strong coastal gradient was evident in both the south and north-west of England, no such gradient was seen in the north or south-east. There are no obvious historical, geographic, meteorological or socio-economic reasons for this finding, although this possibility is being investigated further.

In order to examine the potential benefits of coastal environments for social interactions, a very different approach was employed (Ashbullby *et al.*, 2013). Specifically, in-depth interviews were conducted with 15 families including individual interviews with parents and children aged 8–11. Interviews provide extremely rich data about highly complex phenomena, e.g. social interactions, which are hard to capture with the kind of secondary survey data discussed above. The aim was to listen to parents and children (separately) about their experiences of spending time at the coast together as a family or on other occasions. What were their motivations for visiting, what were the barriers and, crucially, what kinds of interactions took place and what did they lead to? Expected barriers included the weather, time, and 'packing up the car'. After visits had been made, one of the striking things was how the children, in particular, saw the beach as a setting where the whole family played together in ways that did not occur in other outdoor settings such as a park. As one boy aged 11 put it: 'Instead of the adults just sitting somewhere on a bench while the kids do activities, they get up and they play frisbee or cricket and football and sometimes go swimming with them.' Although far from providing a comprehensive overview, these interviews have offered much greater insight into the kinds of questions we need to ask in the future as we continue to explore the role of social interactions on the coast.

Finally, we have also begun to explore possible differences in the range of environmental factors at the coast that may also be contributing to better health (Cherrie *et al.*, 2015). In particular, regional differences in ultraviolet radiation (UVR) exposure were examined. Although potentially harmful in terms of skin damage, this is nonetheless important because higher exposure UVR promotes the synthesis of vitamin D, which itself is important for a range of health outcomes (e.g. autoimmune diseases, cardiovascular disease and certain cancers; Holick, 2004). Importantly, coastal dwellers appeared to experience more UVR due to the effects of topographic forcing on clouds, meaning that more sunshine 'gets through' at the coast. Data from 7295 participants in the British1958 Birth Cohort study showed that those who lived closer to the coast exhibited higher levels of 25(OH)D, a marker of vitamin D status, especially in autumn and winter when vitamin D synthesis is at its lowest level in the UK. In

https://doi.org/10.1017/S0025315415002209 Published online by Cambridge University Press

other words, coastal dwellers visit the coast more often than those who live inland, and during these visits they are more likely to receive doses of UVR, especially in the autumn and winter, that help to produce vitamin D, which itself is important for a range of potentially positive health outcomes.

On-going research

Clearly, research in this area is at an early stage, and there is still much to learn. For instance, although we have started to look at environmental factors such as UVR, other, potentially more important factors such as air pollution levels and cultural factors have yet to be explored. Moreover, little is known about the relative importance of the various mechanisms or how they might operate in synergistic or antagonistic ways. It seems likely that the marginal effects on all these outcomes for any given exposure are likely to be quite small. Thus, cumulative coastal exposure over the mid to long term may be crucial. Furthermore, in the research presented above, it has been assumed that the coast is a homogeneous environment and barely considers different types and quality of coastal environment. This latter issue has been explored more recently and is discussed below. Furthermore, the focus to date has been on what blue space, especially marine and coastal environments, can do for 'us' rather than on what 'we' can do for blue space environments.

WHAT CAN WE DO FOR BLUE SPACE – A CLOSER LOOK AT VARIATIONS IN BLUE ENVIRONMENTS, AND THE DEVELOPMENT OF PRO-MARINE LIFESTYLES

This review summarizes considerable evidence for the health and well-being benefits of spending time in blue environments. This developing research agenda raises additional questions. One critical issue is how these benefits play out in blue environments that vary in state or type, and that are increasingly threatened or damaged. Do benefits differ between sandy, muddy and rocky shores, or between tidal states? Are benefits maintained with coastlines that are littered, altered by sea level rise, or experiencing loss of biodiversity? Are there critical thresholds for these types of effects, and does it matter whether the cause is natural or human-made, whether the harm is visible (e.g. litter, harmful algal blooms (HABs), etc.) or hidden requiring communication and knowledge (e.g. microplastics, microbial and chemical pollution)? Moreover, health benefits will need to be considered in terms of the potentially detrimental impacts on the sustainability of marine ecosystems. For example, if many more people visited a sensitive sandy shore, is this likely to damage the flora and fauna in this habitat. A closely related question concerns how people can be engaged and motivated to protect the blue environment.

Variations in blue environments

Blue environments vary over time, e.g. in terms of season, tides, erosion, litter present on the shoreline, etc. Hipp & Ogunseitan (2011) investigated psychological restoration in more than a thousand visitors to beaches near urban areas in California. They were particularly interested in linking the effects of current variations in temperature and air quality to future predicted changes due to climate change. People rated their visits as more restorative on days that were cooler than in future climate change scenarios, during low tide, and when air quality was better (i.e. 'good' ground level ozone according to objective environmental data – in other words, low concentrations of ozone). No relationship was observed between perceived restoration and objective water quality, wind speed or humidity. Building on this work, a laboratory study systematically manipulated photographic stimuli and found that higher restorativeness was associated with pristine rather than littered coastal scenes (Wyles *et al.*, in press). More importantly, it was specifically visitor litter that was seen as detrimental, as opposed to fishing litter. Participants reported that visitor litter indicated lack of care and deliberate behaviour on the part of the litterers. These studies suggest that while overall weather conditions may not change overall preferences for blue space (White *et al.*, 2014a), there are definitely variations in the state of the blue space that affect visit experiences.

Trade-offs also need to be considered between recommending visits to blue space and the potential adverse impacts these can have on these environments. Wyles *et al.*, (2014) began investigating this by asking both regular visitors and experts to rate a range of visitor activities on rocky shores in terms of both the benefits to people and the risks to the habitat. Reasonable agreement was found between visitors and experts overall (although the former focused on littering, whereas the latter focused on rock-pooling as the biggest hazard to the habitat). By plotting activities according to risk and benefit ratings, this study attempted an integrated analysis. For example, swimming was characterized as good for people with little impact on the environment, and therefore potentially an activity to encourage. While this analysis is preliminary and perception-based, it offers a promising methodology to develop further.

Towards protecting blue space

If the state of the environment is important, it becomes vital that Blue Gym activities include protection of and reduction of harm to blue environments. Wyles *et al.* (2013) suggested the term 'marine mind-set' to describe 'a mental readiness to address marine environmental problems'. This encompasses pro-marine awareness and attitudes (e.g. it is important to protect the ocean; the ocean is at risk), as well as intentions (e.g. 'I will reduce my use of plastics to ultimately reduce shoreline litter'). Such self-report attitudes and intentions help to predict actual behaviour (see meta-analysis by Kormos & Gifford, 2014).

A few studies have indicated that people who live closer to the coast have greater knowledge and report higher awareness of coastal ecosystems (Steel *et al.*, 2005a, b; Fletcher & Potts, 2007). Hartig *et al.* (2001) showed that feeling 'restored' in a freshwater environment was associated with willingness to protect this environment. Feelings of connectedness and place attachment have also been linked to environmental concern and self-report behaviour (e.g. Mayer & Frantz, 2004), although it is unclear whether there is evidence that applies to blue environments specifically. Other predictors of pro-environmental behaviour include values and norms supporting the behaviour, and ascribing responsibility to

https://doi.org/10.1017/S0025315415002209 Published online by Cambridge University Press

oneself (e.g. Dietz *et al.*, 1999), but these have typically not yet been investigated specifically for pro-marine issues.

Some evidence exists surrounding specific interventions or contexts that address marine mind-set outcomes. Wyles *et al.* (2013) found that visiting an aquarium was associated with enhanced attitudes and behavioural intentions for both littering and fish sustainability. In addition, giving a subset of visitors a leaflet with recommendations specifically targeting fish consumption in this study increased that group's reported intentions further. Hartley *et al.* (2015) gathered data from 8- to 13-year-olds surrounding a marine litter education event. Although children were already aware of a number of marine litter issues, at a one-week follow-up, they reported greater understanding of the causes and consequences of littering, more concern, and more pro-environment actions.

The intervention studies so far have focused on the British context which is clearly a limitation. The European MARLISCO project (www.marlisco.eu) is tasked with the evaluation of the impacts of a range of activities (including video competitions with schools, training for educators, public exhibitions and national debates) on increasing awareness around the issues associated with marine litter. These results will be available soon. The final international example is a highly innovative citizen science project entitled Científicos de la Basura (Litter Scientist; Eastman *et al.*, 2013; Hidalgo-Ruiz & Thiel, 2013). The programme works with school children throughout Chile and Easter Island who are taught how to collect and interpret samples of microplastics. Hidalgo-Ruiz & Thiel (2013) suggest that this type of involvement can enhance scientific literacy, awareness, and attitudinal change regarding microplastics. Koss & Kingsley (2010) close the circle by investigating the well-being benefits reported by marine volunteers, which include feelings of enjoyment and positive connections with other volunteers.

Overall, these examples show increasing activity, and a burgeoning field of interdisciplinary research that is beginning to quantify effects where possible and further elucidate the underlying mechanisms of health and well-being from coastal interactions for humans and marine ecosystems.

CONCLUSIONS/SUMMARY

Early results from the Blue Gym Initiative are encouraging on two fronts. First, they demonstrate that alongside the well-known risks (e.g. drowning, exposure to pathogens and pollutants) are numerous potential opportunities to improve health and well-being arising from interactions with marine, coastal and other aquatic environments. Moreover, the pathways for these effects are consistent with those seen linking other natural environments (e.g. green space) to better health (e.g. physical activity, stress reduction and positive social relations; Hartig *et al.*, 2014). This reinforces confidence in the findings. Nevertheless, exactly why marine and coastal settings seem to be particularly beneficial, even compared with green spaces, is still unclear and needs further exploration. The photo studies that showed continued coastal preferences using monochrome images and poor weather conditions (White *et al.*, 2014a) have begun to rule out some relatively obvious possibilities (e.g. preferences for the colour blue, or an association of coastal environments with pleasant weather) but have not managed to reveal specific mechanisms or a clear explanation. Elsewhere (Wheeler *et al.*, 2014; White *et al.*, 2014a), we have discussed possible evolutionary, cultural and individual factors that may be important, but these need to be evaluated systematically.

Second, early results from the second strand of research suggest that carefully designed interventions, especially those that actively engage the public in innovative ways, could foster a 'marine mind-set' which itself could actively encourage people to adopt increasingly pro-marine behaviours and apparently greater health and well-being benefits from marine-human interactions. Much of the degradation of marine and coastal environments is anthropogenic (e.g. European Environment Agency, 2007) and thus human action is required both at the individual and policy levels to tackle these problems.

Early data appear timely and are starting to be recognized by the meta-discipline of Oceans and Human Health (Moore *et al.*, 2013; Bowen *et al.*, 2014; Fleming *et al.*, 2014; Fleming *et al.*, 2015). In October 2014, the European Marine Board's 'Rome Declaration' stated that Europe urgently needed: 'A coordinated, cross-disciplinary and integrated programme on Oceans and Human Health, targeted at understanding and managing the risks and benefits to human physical and mental wellbeing from interactions with the seas'. The Blue Gym's aim is help play a part in developing this programme.

The stakes are high. Approximately 43% of all EU citizens (~218 million people) live in one of its 446 'coastal regions', including 194 coastal cities, across 22 member states (Collet, 2010). The coast is also the EU's primary tourist destination, with some 16 million 'tourist beds' attracting large numbers of non-coastal residents, including an estimated 170 million tourists annually to the Mediterranean alone (European Environment Agency, 2007). Understanding the direct benefits to health and well-being people receive from these environments, and the impairment of their health and well-being from degradation to these same environments, is thus of high importance. Given the central role of anthropogenic influences on the changes in the marine environment, it should also be clear that we not only need to better understand what the marine environment can do for us, but also how we can encourage people to ask themselves what they can do for the marine environment. The Blue Gym Initiative will continue to link with other research programmes, stakeholders and policy makers within the EU and beyond to explore these fundamentally important issues.

REFERENCES

Ashbullby K.J., Pahl S., Webley P. and White M.P. (2013) The beach as a setting for families' health promotion: a qualitative study with parents and children living in coastal regions in Southwest England. *Health and Place* 23, 138–147.

Bauman A., Smith B., Stoker L., Bellew B. and Booth M. (1999) Geographical influences upon physical activity participation: evidence of a 'coastal effect'. *Australia and New Zealand Journal of Public Health* 23, 322–324.

Bowen R.E., Depledge M.H., Carlarne C.P. and Fleming L.E. (eds) (2014) *Oceans and human health: implications for society and well-being*. Chichester: John Wiley & Sons.

Brereton F., Clinch J.P. and Ferreira S. (2008) Happiness, geography and the environment. *Ecological Economics* 65, 386–396.

https://doi.org/10.1017/S0025315415002209 Published online by Cambridge University Press

Cherrie M.P.C., Wheeler B., White M.P., Sarran C.E. and Osborne N.J. (2015) Coastal climate is associated with elevated solar irradiance and higher 25(OH)D level in coastal residents. *Environment International* 77, 76–84.

Collett I. (2010) *Portrait of EU coastal regions. Eurostat: Statistics in focus*. Available at http://ec.europa.eu/eurstat

Depledge M.H. and Bird W.J. (2009) The Blue Gym: health and well-being from our coasts. *Marine Pollution Bulletin* 58, 947–948.

Dietz T., Abel T., Guagnano G.A. and Kalof L. (1999) A value-belief-norm theory of support of social movements: the case of environmentalism. *Human Ecology Review* 6, 81–97.

DiGiulio R.T. and Monosson E. (1996) *Interconnections between human and ecosystem health*. London: Chapman & Hall.

Eastman L., Nunez P.N., Crettier B. and Thiel M. (2013) Identification of self-reported user behaviour, education level, and preferences to reduce littering on beaches – a survey from the SE-Pacific. *Ocean and Coastal Management* 78, 18–24.

European Environment Agency (2007) Marine and coastal environment. In *Europe's environment: the fourth assessment*. Available at http://www.eea.europa.eu//publications/state_of_environment_report_2007_1

Fleming L.E., Depledge M.H., McDonough N., White M.P., Pahl S., Austin M., Goksoyr A., Solo-Gabriele H. and Stegman J.J. (2015) The oceans and human health. In *Oxford research encyclopedia of environmental sciences*. Oxford: Oxford University Press.

Fleming L.E., McDonough N., Austen M., Mee L., Moore M., Depledge M., White M.P., Philippart K., Bradbrook P. and Smalley A. (2014) Oceans and human health: a rising tide of challenges and opportunities for Europe. *Marine Environmental Research* 99, 16–19.

Fletcher S. and Potts J. (2007) Ocean citizenship: an emergent geographical concept. *Coastal Management* 35, 511–524.

Hartig T., Kaiser F.G. and Bowler P.A. (2001) Psychological restoration in nature as a positive motivation for ecological behaviour. *Environment and Behavior* 33, 590–607.

Hartig T., Mitchell R., De Vries S. and Frumkin H. (2014) Nature and health. *Annual Review of Public Health* 35, 207–228.

Hartley B.L., Thompson R.C. and Pahl S. (2015) Marine litter education boosts children's understanding and self-reported actions. *Marine Pollution Bulletin* 90, 209–217.

Herzog T.R. (1985) A cognitive analysis of preferences for waterscapes. *Journal of Environmental Psychology* 5, 225–241.

Herzog T.R., Maguire C.P. and Nebel M.B. (2003) Assessing the restorative components of environments. *Journal of Environmental Psychology* 23, 159–170.

Hidalgo-Ruiz V. and Thiel M. (2013) Distribution and abundance of small plastic debris on beaches in the SE Pacific (Chile): a study supported by a citizen science project. *Marine Environmental Research* 87, 12–18.

Hipp J.A. and Ogunseitan O.A. (2011) Effect of environmental conditions on perceived psychological restorativeness of coastal parks. *Journal of Environmental Psychology* 31, 421–429.

Holick M. (2004) Vitamin D: importance in the prevention of cancers, type 1 diabetes, heart disease, and osteoporosis. *American Journal of Clinical Nutrition* 79, 362–371.

Hubbard H.V. and Kimball T. (1967) *An introduction to the study of landscape design*. Boston, MA: Hubbard Educational Trust.

Humpel N., Owen N., Iverson D., Leslie E. and Bauman A. (2004) Perceived environment attributes, residential location and walking for particular purposes. *American Journal of Preventive Medicine* 26, 119–125.

Kaplan R. and Kaplan S. (1989) *The experience of nature: a psychological perspective*. New York, NY: Cambridge University Press.

Kormos C. and Gifford R. (2014) The validity of self-report measures of proenvironmental behavior: a meta-analytic review. *Journal of Environmental Psychology* 40, 359–371. doi: 10.1016/j.jenvp.2014.09.003.

Koss R.S. and Kingsley J.Y. (2010) Volunteer health and emotional well-being in marine protected areas. *Ocean and Coastal Management* 53, 447–453.

Kyffin R.G., Goldacre M.J. and Gill M. (2004) Mortality rates and self reported health: database analysis by English local authority area. *British Medical Journal* (*Clinical Research Ed.*) 329, 887–888.

Lange E. and Schaeffer P.V. (2001) A comment on the market value of a room with a view. *Landscape and Urban Planning* 55, 113–120.

Luttik J. (2000) The value of trees, water and open space as reflected by house prices in the Netherlands. *Landscape and Urban Planning* 48, 161–167.

MacKerron G. and Mourato S. (2013) Happiness is greater in natural environments. *Global Environmental Change* 23, 992–1000.

Mayer F.S. and Frantz C.M. (2004) The connectedness to nature scale: a measure of individuals' feeling in community with nature. *Journal of Environmental Psychology* 24, 503–515.

Mitchell R. and Popham F. (2007) Greenspace, urbanity and health: relationships in England. *Journal of Epidemiology and Community Health* 61, 681–683.

Mitchell R. and Popham F. (2008) Effect of exposure to natural environment on health inequalities: an observational population study. *Lancet* 372, 1655–1660.

Moore M.N., Baker-Austin C., Depledge M.H., Fleming L., Hess P., Lees D., Leaonard P., Madsen L., Owen R., Pirlet H., White M.P., Vasconcelos V., Boase N., Osborne N. and Viarengo A. (2013) *Linking oceans and human health: a strategic research priority for Europe. Marine board position paper 19*. Ostend: Marine Board-ESF.

Noble M., Wright G., Dibben C., Smith G.A.N., McLennan D., Anttila C., Barnes H., Mokhtar C., Noble S., Avenell D., Gardner J., Covizzi I. and Lloyd M. (2004) *The English indices of deprivation 2004*. London: Office of the Deputy Prime Minister.

Pressman S. D. and Cohen S. (2005) Does positive affect influence health? *Psychological Bulletin* 131, 925.

Rayner G. and Lang T. (2013) *Ecological public health: reshaping the conditions for good health*. London: Routledge.

Richardson E.A., Mitchell R., Hartig T., de Vries S., Astell-Burt T. and Frumkin H. (2012) Green cities and health: a question of scale? *Journal of Epidemiology and Community Health* 66, 160–165.

Schipperijn J., Ekholm O., Stigsdotter U.K., Toftager M., Bentsen P., Kamper-Jørgensen F. and Randrup T.B. (2010) Factors influencing the use of green space: results from a Danish national representative survey. *Landscape and Urban Planning* 95, 130–137.

Steel B.S., Lovrich N., Lach D. and Fomenko V. (2005a) Correlates and consequences of public knowledge concerning ocean fisheries management. *Coastal Management* 33, 37–51.

Steel B.S., Smith C., Opsommer L., Curiel S. and Warner-Steel R. (2005b) Public ocean literacy in the United States. *Ocean and Coastal Management* 48, 97–114.

Ulrich R.S. (1983) Aesthetic and affective response to natural environments. In Altman I. and Wohlwill J.F. (eds.) *Human behaviour and environment. Behaviour and the natural environment*, Volume 6. New York, NY: Plenum Press, pp. 85–125.

Völker S. and Kistemann T. (2011) The impact of blue space on human health and well-being – salutogenic health effects of inland surface

https://doi.org/10.1017/S0025315415002209 Published online by Cambridge University Press

waters: a review. *International Journal of Hygiene and Environmental Health* 214, 449–460.

Völker S. and Kistemann T. (2013) "I'm always entirely happy when I'm here!" Urban blue enhancing human health and well-being in Cologne and Düsseldorf, Germany. *Social Science and Medicine* 78, 113–124.

Wheeler B., White M.P., Fleming L.E., Taylor T., Harvey A. and Depledge M.H. (2014) Influences of the oceans on human health and wellbeing. In Bowen R. (ed.) *Seas, society and human well-being*. Chichester: Wiley, pp. 4–22.

Wheeler B., White M.P., Stahl-Timmins W. and Depledge M.H. (2012) Does living by the coast improve health and wellbeing? *Health and Place* 18, 1198–1201.

White M.P., Alcock I., Wheeler B.W. and Depledge M.H. (2013a) Coastal proximity and health: a fixed effects analysis of longitudinal panel data. *Health and Place* 23, 97–103.

White M.P., Bell S., Elliot L., Jenkin R. and Wheeler B. (2016a). Blue exercise in the UK. In Barton J., Bragg R., Wood C. and Pretty J. (eds) *Green exercise: linking nature, health and well-being*. London: Routledge-Earthscan.

White M.P., Cracknell D., Corcoran A., Jenkinson G. and Depledge M.H. (2014a) Do preferences for waterscapes persist in inclement weather conditions and extend to sub-aquatic scenes? *Landscape Research* 39, 339–358.

White M.P., Pahl S., Ashbullby K.J., Herbert S. and Depledge M.H. (2013b) Feelings of restoration from recent nature visits. *Journal of Environmental Psychology* 35, 40–51.

White M.P., Smith A., Humphryes K., Pahl S., Snelling D. and Depledge M. (2010) Blue space: the importance of water for preference, affect and restorativeness ratings of natural and built scenes. *Journal of Environmental Psychology* 30, 482–493.

White M.P., Wheeler B., Pahl S. and Depledge N.H. (2016b) Blue landscapes and public health. In van den Bosch M. and Bird W. (eds) *Landscape and public health*. Oxford: Oxford University Press.

White M.P., Wheeler B.W., Herbert S., Alcock I. and Depledge M.H. (2014b) Coastal proximity and physical activity. Is the coast an underappreciated public health resource? *Preventive Medicine* 69, 135–140.

Witten K., Hiscock R., Pearce J. and Blakely T. (2008) Neighbourhood access to open spaces and the physical activity of residents: a national study. *Preventive Medicine* 47, 299–303.

Wyles K.J., Pahl S. and Thompson R.C.T. (2014) Perceived risks and benefits of recreational visits to the marine environment: integrating impacts on the environment and impacts on the visitor. *Ocean and Coastal Management* 88, 53–63.

Wyles K.J., Pahl S. and Thompson R.C.T. (in press) Factors that can undermine the psychological benefits of coastal environments: exploring the effect of tidal state, presence and type of litter. *Environment and Behaviour*.

Wyles K.J., Pahl S., White M.P., Morris S., Cracknell D. (2013) Enhancing the "Marine Mindset": the effects of an aquarium visit and information booklet on attitudes and intentions about fish sustainability and marine pollution. *Visitor Studies* 16, 95–110.

Yerrel P. (2008) *National evaluation of the TCV's green gym*. Unpublished report, School of Health and Social Care, Oxford Brookes University. Available at: http://www.tcv.org.uk/sites/default/files/green-gym-evaluation-full.pdf

and

Zube E.H. (1974) Cross-disciplinary and intermode agreement on the description of evaluation of landscape resources. *Environmental Behaviour* 6, 69–89.

Correspondence should be addressed to:
M.P. White
European Centre for Environment and Human Health University of Exeter Medical School, Knowledge Spa, Royal Cornwall Hospital, Truro TR1 3HD, UK
email: mathew.white@exeter.ac.uk

https://doi.org/10.1017/S0025315415002209 Published online by Cambridge University Press