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The Restorative Potential of Public Aquariums: Psychological and Physiological Effects of Viewing Sub-Aquatic Environments

by

Deborah Louise Cracknell

A thesis submitted to Plymouth University in partial fulfilment for the degree of

Doctor of Philosophy (PhD)

School of Psychology (Faculty of Health and Human Sciences)

Plymouth University, United Kingdom

In collaboration with the National Marine Aquarium

October 2016

“All animals are equal, but some are more equal than others” – *Animal Farm*, George Orwell (1945).

Abstract

The Restorative Potential of Public Aquariums: Psychological and Physiological Effects of Viewing Sub-Aquatic Environments

Deborah Louise Cracknell

The role of natural environments, especially ‘green space’, in promoting human health and well-being is well-researched. However, less is known about the benefits of ‘blue space’ (e.g. the coast) or ‘managed’ nature (e.g. zoos). In this thesis, six studies investigated the restorative potential of sub-aquatic settings, specifically public aquariums and the biological diversity within them. Studies 1 and 2 investigated preferences for, affective responses to, and the restorative potential of, five built and natural settings (i.e. built, green space, blue space, natural underwater and public aquariums). Using the same measures, Study 3 focused solely on people’s responses to aquarium exhibits, sub-categorised by geographic region, level of species richness and abundance, and taxonomic group. Study 4 examined behavioural, physiological and psychological responses to one aquarium exhibit during three stages of restocking. Finally, to establish how perceptions of species richness and abundance influenced well-being outcomes, people viewed and evaluated either one (Study 5) or two (Study 6) large aquarium exhibits. These studies found that natural sub-aquatic and aquarium settings were as preferred, and perceived as potentially restorative, as green space environments, and different exhibits elicited different responses: ratings were higher for tropical exhibits (vs. temperate), high abundance (vs. low) and vertebrates (vs. invertebrates), although findings for species richness were mixed. Within one exhibit, higher stocking levels resulted in increased attention and interest, greater improvements in mood, and some physiological evidence of relaxation (e.g. decreased heart rate). Broad levels of marine life could be distinguished but estimates of actual numbers were poor. Viewing one or two exhibits tended to improve mood, decrease arousal and be perceived as restorative; any differences between the two exhibits were more evident when both had been viewed. Overall, findings suggest that engaging with different types of managed nature may provide valuable perceived human health and well-being benefits.

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Author's Declaration

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

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Chapter 1.

Introduction

1. Overview

Mental health is conceptualized as a state of well-being whereby an individual can realise their potential, work productively, cope with life's stresses and contribute to their community (World Health Organization, 2013). However, there is a whole, interlinking, array of conditions surrounding mental ill health and psychological well-being that can affect an individual and also place a huge economic burden on a nation. It was estimated that the total cost of mental ill health in England amounted to over £105 billion in 2009/2010 (Centre of Mental Health, 2010). Although administering medication can help alleviate some mental ill health symptoms, there is increasing interest from the healthcare sector in alternative treatments that can complement the traditional medical approach. One such alternative is the use of natural environments as a 'cure' (Health Council of the Netherlands and Dutch Advisory Council for Research on Spatial Planning, Nature and the Environment, 2004). This is not surprising as, anecdotally, many people respond to stress and mental fatigue by seeking out natural environments in which they can relax and psychologically recover (e.g. Bowler, Buyung-Ali, Knight & Pullin, 2010): it is something that humans have been doing throughout history (Velarde, Fry & Tveit, 2007).

There now exists a considerable body of evidence to support these anecdotal observations and research suggests that many people value natural settings as they can provide elements of psychological well-being such as positive emotions, reduced stress and cognitive fascination, particularly when compared to built settings (see reviews Bowler et al., 2010; Bratman, Hamilton & Daily, 2012; Gascon, Triguero-Mas, Martinez, Dadvand, Forns, Plasència & Nieuwenhuijsen, 2015; Hartig, Mitchell, De

Vries & Frumkin, 2014; Velarde et al., 2007). However, although the volume of research exploring the health and well-being benefits of nature is considerable, there are still some areas of this broad subject that have received comparatively little attention. First, the majority of previous research exploring the health benefits of natural, compared to built, environments has used 'green space' as a setting, most commonly parks and relatively green university campuses (Bowler et al., 2010). In contrast, few studies have specifically considered the health promoting properties of 'blue space', that is, aquatic environments (Volker & Kistemann, 2011). Second, most of these studies have not sub-categorised environments: landscapes have tended to be classified simply as 'natural' or 'urban' (Velarde et al., 2007). However, environments can be extremely varied in composition and a failure to investigate a variety of different settings makes it difficult to determine which particular elements within a setting contribute most, or at all, to positive health outcomes (Pearson & Craig, 2014). Finally, as most studies tend to focus on the actual or perceived health and well-being outcomes following exposure to 'natural' and 'urban' settings, the potential for alternative settings, such as museums and zoos, to offer restorative experiences has largely been overlooked. This is a potential oversight as some of these more accessible, and less weather-dependent, places may provide an alternative avenue for reducing stress and an alternative means of accessing the well-being benefits, and potential co-benefits, that exposure to or engagement with 'nature' may offer.

In view of the relatively sparse research into alternative environments and 'blue space', research for this thesis investigated the perceived health and well-being benefits of exposure to an alternative, potentially restorative 'blue space' setting, namely public

aquariums[1], and examined how a feature of this setting, its marine life, influenced perceived restorativeness and related well-being outcomes.

1.1 Nature and Health

1.1.1 The Economic Cost of Mental Ill Health

'Health' is defined by the World Health Organisation as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO, 1946, p. 100). Good mental health means that a person is able to realise his or her own abilities, is capable of coping with the usual stresses of everyday life, is able to work productively and can make a contribution to their community. There are, however, many factors that can affect a person's mental health. Some of these factors depend on the individual's own traits and characteristics, such as their ability to manage their thoughts, emotions and behaviours, and how they interact with others. Other influences are more contextual and may include social, cultural, political and economic factors, such as national policies, living standards and working conditions (WHO, 2013). Any of these factors can affect a person's mental health and when these effects are negative, mental health problems can occur.

Mental disorders (e.g. depression, anxiety disorders, bipolar affective disorder, schizophrenia, intellectual disabilities, dementia, and developmental and behavioural disorders) carry a high disease burden. Individuals with mental disorders experience much higher rates of disability and mortality than the general population. For instance, people with major depression and schizophrenia have a 40-60% greater chance of dying prematurely, due to physical health problems (e.g. cancers, cardiovascular diseases and diabetes) that are frequently left unattended (WHO, 2013). Certain individuals or groups

[1] Although 'aquaria' and 'aquariums' are both acceptable plurals of aquarium, I shall use 'aquaria' when referring to home aquaria and 'aquariums' when referring to public aquariums, as this latter term is more common in the industry.

of individuals in society may be at higher risk than others, depending on circumstances. For example, people who live in poverty or have chronic health problems, infants and children who have been mistreated or neglected, members of minority groups, the elderly, people experiencing discrimination and human rights violations, people persecuted for their sexuality (e.g. gay, lesbian, transgender), and people exposed to conflict and natural disasters, may all be more vulnerable than the general population (WHO, 2013).

Stress, unemployment and overwork are also of increasing concern (WHO, 2013). Stress is 'a state of mental or emotional strain or tension resulting from adverse or demanding circumstances' (Oxford dictionary, 2016) and can manifest in a variety of emotional, cognitive, behavioural and physical symptoms. Psychologically, a stressful situation may result in emotions such as anger, fear and sadness, feeling overwhelmed, becoming easily agitated or having low self-esteem. Physiological reactions may result as an individual's cardiovascular, skeletomuscular and neuroendocrine systems are mobilised to cope with the situation: physical symptoms of stress include low energy, headaches, stomach problems, muscle tension and pain. Mobilization of these bodily systems uses resources and energy that, particularly if prolonged, can contribute to fatigue. Behaviourally, there may be a variety of responses ranging from avoidance of the stressful situation, poorer performance on tasks or a reliance on harmful substances, such as alcohol or nicotine, to cope (NHS, 2012; Ulrich, Simons, Losito, Fiorito, Miles, & Zelson, 1991). Although a small amount of stress may help our performance in some situations, long-term levels of chronic stress associated with everyday life can cause prolonged, dramatic physiological responses that can lead to mental health disorders, such as anxiety and depression, as well as other health problems such as raised blood pressure, and increased risk of heart disease and stroke (Wallace, Sanders & Ferl, 1991).

Mental health disorders and the effects of stress are not only a serious concern

for the individual, but can also place a huge economic burden on a country (HSE, 2007). These costs may not only be associated with treating the individual (e.g. GP consultations, cost of medication) but also the wider effects that their health issues can have on others (e.g. employers, family). In the UK one-in-five trips to a GP are related to mental health problems such as anxiety, stress and depression (NHS, 2014), and although medication (e.g. antidepressants) can help alleviate symptoms for some individuals, it is extremely costly and can cause undesirable side effects (e.g. feeling anxious, sick, dizzy). Furthermore, they do not work for large numbers of individuals in the medium to long-term.

Depression is one of the largest single causes of disability globally and accounts for 4.3% of the total disease burden worldwide. In terms of lost economic output, it is estimated that between 2011 and 2030, the cumulative global impact of mental disorders will amount to over US$ 16 million million (WHO, 2013). The prescribing of antidepressant drugs in the UK, and other Western nations such as Australia and Canada, is now at much higher levels than in previous decades (Moore, Yuen, Dunn, Mullee, Maskell & Kendrick, 2009), potentially due to a greater willingness to seek treatment. The Health and Social Care Information Centre reported in 2012 that antidepressant prescriptions account for the largest rise in items dispensed in the community annually with nearly 46.7 million prescriptions being dispensed in England – almost a 10% increase on 2010 figures.

In 2005/6 work-related mental health issues associated with stress, depression and anxiety cost Great Britain in excess of £530 million (HSE, 2007). In 2014/2015, the Labour Force Survey found that 9.9 million working days were lost due to work-related stress, depression and anxiety and, on average, each person suffering took an estimated 23 days off work in that 12 month period. Stress accounted for 35% of all work-related cases of ill health and 43% of all working days lost as a result of ill health (HSE, 2015).

The occupations that reported the highest rates of work-related stress were health professionals, health and social care associate professionals, and education and teaching professionals. A report by the Centre of Mental Health (2010) estimated that the overall economic and social cost of mental ill health in England in 2009/10 was £105.2 billion. This figure included the costs of health and social care for people with mental health problems, the lost output in the economy (e.g. from sickness absence), and the human costs of a reduction in quality of life. Nevertheless, despite these staggering statistics, absenteeism is not necessarily an employer's greatest concern. Figures from the Centre for Mental Health (2011) show that the majority of people suffering with stress continue to work but are less productive because they struggle to concentrate and have difficulties making effective decisions. The reduced productivity resulting from this 'presenteeism' is estimated to cost UK businesses £15.1 billion per year. This is almost double the cost of absenteeism which has an annual cost of approximately £8.4 billion.

1.1.2 Mental Health and Well-being, Nature and Restoration

While the pressures of everyday life can clearly increase levels of stress and impact on general well-being, it has also been proposed that the process of urbanisation itself, i.e. the migration of people from rural to urban settings during the past 200 years, has contributed to an overall reduction in people's ability to cope with stress. As people become increasingly removed from nature, they are less exposed to nature's protective influences on health (Hughes, Pretty & Macdonald, 2013; Miller, 2005; St Leger, 2003). Since 1950, the urban population of the world has grown rapidly from 746 million to 3.9 billion (United Nations, 2014). Currently, over half the world's population (54%) live in urban, rather than rural, areas: a rise of 24% since 1950. Although the percentage of urbanisation across the world differs (e.g. 82% in North America vs. 40% in Africa), it is anticipated that all regions will become more urbanised over the coming years and,

overall, will reach 66% by 2030 (UN, 2014). However, it is not just the numbers of people migrating to more urban settings that gives cause for concern; it is the speed in which, from an evolutionary perspective, this has occurred. Millions of years of evolution in the natural world have resulted in humans developing automatic reactions to elements in nature that aid, or compromise, survival and well-being (e.g. generally, humans respond positively to water and vegetation, and negatively to snakes). In comparison, we have spent only a fraction of our history in built environments and, as such, have not yet evolved comparable responses to situations in urban landscapes (Ulrich, 1983).

Aside from the provisioning and regulating 'ecosystem services' that nature provides, natural environments can contribute to health and well-being through four key pathways: a setting containing less pollutants and noise; a location for physical activity; an environment for social activity and engaging with others, and, of relevance to this work, an escape from life's stressors (Bowler et al., 2010; Depledge & Bird, 2009; Gascon et al., 2015; Hartig et al., 2014). Although contact with nature involves all of these pathways, often simultaneously and with influence on each other, the current body of work focuses on just one pathway: the perceived improvements in health and well-being, especially via stress reduction.

Hence, considering the aforementioned human and economic impacts, the prospect of nature being able to provide a means of stress recovery and promote well-being is appealing and worthy of exploration. Anecdotally, we already know from historical art, literature and personal experiences that people have a fondness for nature and often respond to stress by seeking out natural environments in which they can relax and mentally 'take time out' (e.g. Bennett & Swasey, 1996; Hughes et al., 2013). It is a relationship between humans and nature that has existed for countless centuries and spans many cultures (Velarde et al., 2007). For instance, ancient Egyptian tomb

paintings, along with remains found in the ruins of Pompeii, confirm that people tended gardens and brought plants into their homes over 2,000 years ago (Grinde & Patil, 2009). The planting of gardens in monasteries for meditation or recuperation from illness, and the popularity of the Victorian seaside resorts are further examples (Hughes et al., 2013; Health Council of the Netherlands and Dutch Advisory Council for Research on Spatial Planning, Nature and the Environment, 2004).

This recognition that nature can provide a means of stress recovery and promote greater well-being has prompted much work in the area of 'restoration' and 'restorative environments'. Restoration is defined as "the process of renewing physical, psychological and social capabilities diminished in ongoing efforts to meet adaptive demands'' (Hartig, 2004, p. 2), and restorative 'effects' may include the physiological and psychological recovery from stressful situations, recuperation from understimulation or extremely low arousal, or the alleviation of cognitive fatigue (Ulrich et al., 1991). A 'restorative environment' is any surrounding or natural setting which assists in rejuvenation or recovery from tension or chronic fatigue (Psychology dictionary, 2016). A considerable body of evidence now exists that suggests that natural environments are perceived to be good for people's physical and mental health. For instance, Hartig, Evans, Jamner, David & Gärling (2003) compared psychophysiological stress recovery and directed attention restoration in natural and urban field settings, and found that walking in a nature reserve resulted, initially, in a greater drop in blood pressure (an indicator of stress when elevated), than did walking in an urban setting. Furthermore, at the end of the walk, an increase in positive affect and a decrease in anger were observed in those walking in the natural setting whereas the opposite was observed in those walking in the urban environment. Mayer, Frantz, Bruehlman-Senecal and Dolliver (2009) found that exposure to nature, either during a walk or when watching a video, increased attentional capacity, positive emotions and

the ability to reflect on a life problem more than exposure to an urban environment. Nisbet and Zelenski's (2011) work on affective forecasting studied participants who were randomly assigned to take walks either indoors, mainly via tunnels throughout the university campus, or outdoors in 'urban nature', along a canal path towards an arboretum. They found that participants who undertook the indoor walk reported less positive and more negative affect, and less relaxation and fascination, than those who took part in the outdoor walk. Indeed, Ulrich et al. (1991) mentioned that stress relief was cited as one of the most important perceived benefits of recreational experiences in wilderness and urban nature in over 100 studies.

However, studies like those above in which participants engage with real natural or urban environments are less common than the many studies that use simulated environments (e.g. photographs) to study restorative effects. This is not surprising considering the logistical problems that can be associated with undertaking field work. Nevertheless, research using simulated environments has frequently suggested that benefits can still be accrued from indirect experiences of nature, such as viewing images (Mayer et al., 2009). These studies have used a variety of media including photographs (e.g. Berto, 2005; Pretty, Peacock, Sellens & Griffin, 2005), videos (e.g. Laumann, Gärling & Stormark, 2001, 2003; Ulrich et al., 1991), virtual reality (e.g. Schneider & Hood, 2007; Tanja-Dijkstra et al., 2014) and art (e.g. Kweon, Ulrich, Walker, & Tassinary, 2008; Nanda, Eisen, & Baladandayuthapani, 2008), under the assumption that simulated environments will elicit similar effects as experiencing real environments (de Kort, Meijnders, Sponselee & Ijsselsteijn, 2006). As pointed out by Felsten (2009), irrespective of how the natural environment is experienced (i.e. natural settings or by viewing photographs, video or art), the types of settings perceived to be restorative are similar and, therefore, "it is reasonable to infer that the perception of restorative potential is a good predictor of actual restorativeness" (p. 166). Studies that have sought

to establish whether simulated environments can sufficiently represent real environments (e.g. Huang, 2009; Hull & Stewart, 1992; Kjellgren & Buhrkall, 2010; Mayer et al., 2009; Shafer & Richards, 1974 and a meta-analysis by McMahan & Estes, 2015) have, generally, found that whilst viewing simulated nature can provide a range of perceived health benefits, it cannot completely replicate or replace real nature which increases health benefits further.

1.1.3 Restoration 'Theories'

There are a number of approaches that aim to explain why humans are drawn to, and may gain benefit from, 'natural' environments. However, the aim of the current work is not to provide a comprehensive review of all literature covering this extensive field but instead to mention the three main approaches most relevant to this thesis: the Biophilia hypothesis, psychophysiological stress recovery theory (PSRT) and the attention restoration theory (ART). Although all three approaches maintain that people find natural environments more restorative than urban or artificial settings, their mechanisms and motivations appear to differ.

'Biophilia[2]', a term first used by Fromm in 1964 (Simaika & Samways, 2010), is the focus on lifelike processes and the "innately emotional affiliation of human beings to other living organisms" (Wilson, 1993, p. 31). Whilst not a 'theory', Wilson's Biophilia hypothesis proposes that throughout their evolution humans were inextricably involved with other species and over one million years of evolution has resulted in humans being genetically programmed to positively respond to natural environments that support success and survival and, conversely, response negatively to features of

[2] Joye and van den Berg (2011) use the term 'Phytophilic Response Module' (PRM) when referring to the cluster of positive affective processes that are activated by restorative nature as they feel that vegetation is a consistent presence in restorative environments. I prefer to use 'Biophilia', meaning "love for life", (rather than 'Phytophilia' – "love for plants") as this is more appropriate for my research into the restorative potential of sub-aquatic settings.

landscapes and certain animals that may be detrimental to survival and well-being. An innate fear of snakes, for instance, may appear logical for ancient hunter-gatherers and also for individuals in today's less developed countries who continue to be more reliant on traditional methods of gathering food and water. This response, however, may appear less rational for people in more industrialised countries, where contact with nature has diminished and the likelihood of an encounter with a snake is negligible. Nevertheless, as pointed out by Wilson (1993), these instinctive reactions remain.

As well as being innate and, hence, part of our evolved human nature, Biophilia is an "emotional response that can be an end in itself (feeling a sense of pleasure and well being) or it can stimulate emotions that motivate behaviors (interest motivates explorations)" (Heerwagen, 2010). Further, Wilson (1993) suggests that when human beings are removed from the natural environment, the "biophilic learning rules are not replaced by modern versions equally well-adapted to artefacts" (p. 31). It is suggested that contact with nature is a basic human need, rather than just a cultural amenity or individual preference (Heerwagen, 2009), and therefore, people's physical and mental well-being will be compromised unless contact with natural systems and processes is maintained (Kellert, 2008).

The PSRT was proposed by behavioural scientist Roger S. Ulrich, who also suggested an evolutionary basis for his theory that, through natural selection, humans have immediate and involuntary emotional and physiological responses to aspects of natural environments after stressful experiences (Hughes et al., 2013). Humans have precognitive responses to negative stimuli, commonly known as the 'fight-or-flight response. Yet while many studies focus, for instance, on individuals' responses to extreme environmental conditions (e.g. loud noises, heat stress, overcrowding), PSRT also explores whether different, everyday environments (e.g. those that are less physically extreme) can help or hinder recovery from stress (Ulrich et al., 1991). Ulrich

(1983) suggests that humans, as well as instinctively reacting to negative stimuli, equally, have a biologically prepared predisposition to recognise and positively respond to natural components (e.g. water, vegetation), and arrangements of these components that aid survival and alleviate stress (see also Ulrich et al., 1991). It is proposed that certain natural settings provide a valuable 'breather' from that stress by promoting a more positive emotional state, decreasing levels of physiological arousal and recharging energy needed to cope with the stressor (Ulrich, 1993; Ulrich et al., 1991). Further, although modern humans may be genetically prepared to quickly respond to, and gain restoration from, many unthreatening natural settings, humans have not yet evolved comparable responses to most urban settings.

Finally, ART refers to the recovery of directed attention fatigue. Directed attention is required when a certain object (e.g. a demanding task) does not automatically attract one's attention (Pals et al., 2007). According to Kaplan (1995, p.170), directed attention "requires effort, plays a central role in achieving focus, is under voluntary control (at least some of the time), is susceptible to fatigue, and controls distraction through the use of inhibition". Kaplan (1995) suggests that prolonged or intense periods of mental effort can lead to directed attention fatigue, the symptoms of which can include being easily distracted, irritable and impatient (Kaplan, Bardwell & Slakter, 1993). Direct attention fatigue can occur whether a task is boring, difficult or enjoyable, and while stressful circumstances can lead to directed attention fatigue, stress is not a necessary antecedent (Kaplan et al., 1993). According to ART, recovery from directed attention fatigue requires that directed attention is rested. Although sleep can help, it can be insufficient and it is therefore important that directed attention fatigue can also be rested when awake (Kaplan et al., 1993). Experiencing a 'restorative environment' can enable directed attention to rest (Herzog, Maguire & Nebel, 2003; Kaplan, 1995). For an encounter environment to support restoration it

should contain four key components: ‘Fascination’ (the environment holds one’s attention effortlessly but is not so riveting that no room is left for thinking about other things - ‘soft’ fascination); ‘Being Away’ (there is an element of ‘getting away from it all’ - the environment is psychologically or physically removed from a person’s daily routine); ‘Extent’ (the environment is rich and coherently connected and has enough content and structure to occupy the mind for a sufficient amount of time to allow directed attention to rest and recover) and ‘Compatibility’ (the environment is compatible with a person’s expectations and inclinations) (Kaplan & Kaplan, 1989). These components are usually associated with natural environments but may also be experienced in other settings, such as museums (Kaplan et al., 1993).

Although ART addresses the need to recover from mental fatigue and PSRT is prompted by the mitigation of psychological stress (Berto, 2014), these two antecedents are not mutually exclusive. Stress-induced physiological arousal or negative affect can occur in the presence or absence of attentional fatigue, and vice versa (Hartig et al., 2003; Kaplan, 1995). There is also some evidence that the underlying processes for these two restoration theories are associated with different parts of the brain. Voluntary, directed attention occurs in the right frontal cortex of the brain (Kastner, De Weerd, Desimone & Ungerleider, 1998) while the involuntary reaction to psychophysiological stress is located in the limbic system (Ulrich, 1983) – a complex system of nerves and networks in the brain concerned with motivations and emotions, particularly those that are connected to survival.

All of the three main approaches mentioned above are, to some extent, relevant to this work. Throughout this thesis, I have investigated people’s preferences for, and responses to, different ‘living things’ (Biophilia); taken physiological, as well as psychological, measurements before and after administering a stressor (PSRT), and then examined the restorative potential of aquarium exhibits using the four key components

central to ART. It should be noted, however, that these four components are not only relevant for attention restoration. For instance, PSRT proposes that certain natural environments can mitigate stress by effectively sustaining interest and attention ('soft fascination'), therefore diminishing stressful thoughts and providing more positively toned emotions.

1.2 Restorative settings: Gaps in the Literature

There exists a large body of empirical research into the actual and perceived health and well-being benefits of restorative environments. Some of this work has been relatively setting-specific. For instance, research into 'Healing Gardens' (e.g. Cooper Marcus, 2007; Stigsdotter & Grahn, 2002), as the name suggests, focuses on the positive influences that these gardens can have on those who visit them and particularly refers to gardens in healthcare settings. In contrast, other research has covered a broad range of environment types. The study of 'Therapeutic Landscapes' (e.g. Gesler, 2005), for example, includes various landscape types and, further, has expanded from simply focusing on places with a historic reputation for contributing to physical, mental or spiritual health (e.g. Lourdes), to encompassing numerous settings that may support and promote health and well-being (e.g. public libraries – Brewster, 2014), conceivably by supporting restoration.

Nevertheless, despite the considerable number of studies exploring restorative environments, there are at least three key sub-categories of this extensive subject that have tended to receive less attention: 'blue space' (e.g. aquatic environments), alternative restorative settings (e.g. museums) and biological diversity ('biodiversity'). Natural and built environments differ greatly in appearance, with varying proportions of water, plants, animals and human-made components, all of which may influence physiological and psychological responses. Only by investigating different settings, and

the influence of features within those settings, will it be possible to determine which features contribute to positive health outcomes (Pearson & Craig, 2014).

1.2.1 From Green to Blue Space

In a review of studies looking for the added benefits to health of exposure to natural environments, Bowler et al. (2010) commented that the most common types of natural environment were parks and 'relatively green' university campuses, with other studies focusing on forests, gardens, nature/wildlife reserves, wilderness areas or other, unspecified, 'green' environments. Purcell, Peron and Berto (2001) suggested that the emphasis on green environments may, in part, be a result of the large number of studies which relate to forest management (e.g. Shafer & Richards, 1974). As such, although theorists have suggested that aquatic scenes may be particularly restorative, systematic empirical research into these 'blue' environments appears to be relatively sparse. This appears surprising considering humans' inherent connection to water – drinking water for survival, irrigation for crops, provision of food such as fish and shellfish, transportation, and recreation (not to mention that around 71% of the earth's surface is water). The lack of systematic empirical research on the restorative potential of 'blue space' was highlighted in a study by White, Smith, Humphries, Pahl, Snelling[3] and Depledge (2010); this study pre-dated my PhD but formed its starting point.

White et al. (2010) had noted how the presence of water was a confounding factor in several studies comparing people's responses to natural and built settings. A couple of examples of studies they reviewed will illustrate this point. In a study by Berman, Jonides and Kaplan (2008), almost 80% (39 out of 50) of nature photos used contained water, whereas water did not feature in any of their urban photos. Similarly, over 75% (19 out of 25) of photos used in Berto's (2005) 'Restorative' category (all

[3] Snelling was my previous surname.

nature scenes) contained water, compared to less than 10% (2 out of 25) in the 'Unrestorative' category (all urban scenes). Considering that many town and cities are located near water, the lack of aquatic elements in visual stimuli representing urban settings appears a potential oversight (White et al. 2010).

Nevertheless, White et al. (2010) did identify some studies that sought to examine responses to aquatic features. For instance, Herzog (1985) examined preferences for a variety of waterscapes: 'swampy areas', 'rivers, lakes and ponds', 'mountain waterscapes' and 'large bodies of water', using length of viewing time and six predictors of preference ('spaciousness', 'texture', 'coherence', 'complexity', 'mystery' and 'identifiability'). Viewing times for mountain waterscapes were the longest and swampy areas were the shortest, although preference ratings revealed that large bodies of water were the second most preferred waterscape (after mountain waterscapes). Ulrich et al. (1991) compared people's self-ratings of affective states and physiological reactions to videos of two natural ('vegetation'; 'water') and four urban ('heavy'/ 'light' traffic; 'many'/ 'few' pedestrians) settings and found that stress recovery was faster in participants who watched one of the nature videos compared with the urban videos. However, White et al. (2010) suggest that Ulrich et al.'s (1991) finding that there was no difference in 'restoration' between the two nature videos is possibly due to four factors: i) the 'Water' video was dominated by trees and, therefore, was potentially a green space setting with some water rather than a large body of water; ii) the 'Water' video was louder and potentially more distracting; iii) there were too few participants to detect differences (20 per condition), and iv) only one water scene was used making it problematic to generalise. A study by van den Berg, Koole and van der Wulp (2003) also explored responses to videos of natural and built settings, with and without water. Once again, no effect of water was found on their measures ("affective restoration, concentration, beauty or naturalness", p. 141). However, White et al. (2010,

p. 483) point out that the water in the videos appears to be a “thin, dark brown, unattractive stream or canal” and therefore, as highlighted by the study’s authors themselves, was possibly too weak to influence participants’ restoration or preferences.

Volker and Kistemann (2011) undertook a scoping review of ‘blue space’ (“all visible surface waters in space as an analogy to green space, not as a sub-category”, p. 449) and human well-being research. They identified and summarised 36 articles that reported the impact of ‘blue space’ in the areas of perception and preference, landscape design, emotional benefits, restoration and recreational benefits, and direct health benefits. Nevertheless, following their qualitative meta-analysis, they concluded that, with the exception of landscape ecology research, water had not been fully recognised as a feature of the landscape in those previous research articles. Instead, Volker and Kistmann (2011) suggested that much of this evidence supporting the impact of ‘blue space’ (e.g. preferences for aquatic environments) was more an unintentional “by-product” of environmental psychology and environmental health research rather than any systematic research into the effects of ‘blue space’ on perceived health and well-being. They believe that “emotional and experiential responses to blue space have not yet been adequately recognised” (p. 458).

In view of the above, it appears that defining the influence of waterscapes on health and well-being outcomes has proved problematic. Aquatic features have either been a confound in studies (e.g. being more representative of natural settings that urban ones e.g. Berto, 2005); have been inadequately represented (e.g. van den Berg et al., 2003) or have been shown to be a preferred environmental variable in studies not specifically exploring preferences for aquatic environments (e.g. Han, 2007; Kweon et al., 2008; Purcell et al., 2001). In an attempt to redress the balance, White et al. (2010) sought to take a systematic look at ‘blue space’ as a discrete environment, rather than a sub-category of green space. For this work, an aquatic environment was defined as “any

environment, natural or urban, containing visible amounts of standing or running water (but not falling rain or settled ice or snow)" (p. 483). As well as including settings dominated by water (e.g. lakes and seas), they also included environments in which water was a secondary aspect (e.g. streams and fountains). Using two studies, they investigated people's preferences (e.g. attractiveness, willingness to visit) for, affective responses to, and the perceived restorativeness of, three environments: urban, green space and blue space. A photo set of 120 images of natural and built scenes, containing standardised proportions of 'aquatic', 'green' and 'built' environments (e.g. 1/3rd, 2/3^{rds}), was developed. They found that "both natural and built scenes containing water were associated with higher preferences, greater positive affect and higher perceived restorativeness than those without water" (p. 482). Furthermore, a number of 'dose-response' relationships became evident. For instance, an image which comprised 2/3^{rds} 'green' and 1/3rd 'built' was perceived as more restorative that an image containing 2/3^{rds} 'built' and 1/3rd 'green'. Similarly, an image containing 2/3^{rds} 'aquatic' and 1/3rd 'green' was perceived as being significantly more restorative than an image containing only a 1/3rd 'aquatic' and 2/3^{rds} 'green'. White et al.'s (2010) work is especially relevant to this thesis as it not only highlights the importance of water as a feature of restorative environments but clearly demonstrates that 'quantity' of water content can influence perceived restorative potential.

1.2.2 Alternative Restorative Settings

Many studies have focused on the physical characteristics of restorative and preferred settings but another approach may be to consider their function, such as a place to live or visit (Scopelliti & Giuliani, 2004). Korpela, Ylén, Tyrväinen & Silvennoinen (2010) investigated the restorative experiences that people had in everyday favourite places and examined the relationship between the use of people's

favourite places, restorative experiences, their determinants (e.g. duration and frequency of visit, daily worries, personality characteristics) and self-rated health. They analysed a sub-sample of postal questionnaires completed by a random sample of 1273 inhabitants, aged between 15 and 75 years, of two major cities in Finland (Helsinki and Tampere). They found that restorative experiences occurred in a variety of favourite built and green spaces, but these experiences were stronger in favourite outdoor exercise and activity locations, extensively managed natural settings (e.g. urban woodlands), and waterside settings, than in built or green space urban settings.

Citing previous work by Korpela and colleagues (e.g. Korpela, Hartig, Kaiser & Fuhrer, 2001), Scopelliti and Giuliani (2004) suggested that restorative experiences may be associated with enjoyment and excitement as well as relaxation. In their own work, Scopelliti and Giuliani investigated the association between restorative experiences, leisure behaviour and different age groups (young people, adults and the elderly). Participants were asked to list what they would usually do to feel restored under six scenarios (e.g. in free time after a working day, week or longer period, and characterised by monotonous vs. stimulating activities) and the reasons why they would feel restored. Restorative experiences were defined as experiences that allowed them to regain psychological well-being and effectiveness in everyday activities, and were categorised according to location: at home (e.g. reading a book); built outdoors (e.g. visiting a museum) and nature outdoors (e.g. a trip to the seaside). Reasons why they would feel restored were coded into restorative components and whether or not there were social relationships. They found that natural and built settings can have different restorative potential depending on life stage and time available for restoration. Social and affective dimensions most influenced restorative experiences and, generally, the scenarios described by participants tended to be relaxing, rather than exciting, with the exception of young men on holiday.

People have restorative experiences in a wide range of locations (e.g. botanical gardens – Ballantyne, Packer & Hughes, 2008; Bennett & Swasey 1996; public libraries – Brewster, 2014; houses of worship – Herzog, Ouellette, Rolens & Koenigs, 2010; museums – Kaplan et al., 1993; Packer & Bond 2010; Homes and neighbourhoods – Lindal & Hartig, 2013; zoos – Pals, Steg, Siero and van der Zee, 2009) and it is important that research into these other alternative environments is not neglected. Although these settings may contain varying amounts of nature, from significant (e.g. botanical gardens) to very little (e.g. museums), they may still fulfil the four key components of a restorative experience as described in ART (Kaplan 1995): Fascination, Being Away, Extent and Compatibility. As such, ART has formed at least part of the theoretical framework for several studies exploring alternative restorative environments.

Botanical gardens are one of the more natural settings that can support restorative experiences and stress recovery. For example, Bennett and Swasey (1996) found that relaxation and stress reduction were the two most important reasons for visiting two public gardens in New York, with 91% of respondents perceiving a reduction in stress levels following their visit. Visitors to Brisbane Botanical Gardens also cited restoration as the most important reason for their visit (Ballantyne et al., 2008). Building on Hartig, Korpela, Evans and Gärling's (1997) 'Perceived Restorativeness Scale' and Laumann et al.'s (2001) 'Restorative Components Scale', Pals et al. (2009) developed a 'Perceived Restorative Characteristics Questionnaire' with the aim of evaluating the perceived restorative characteristics of two zoo attractions - a butterfly garden and a baboon attraction. On investigating the associations between the visitors' experiences and the perceived restorative characteristics of the attractions, the authors found that, on the whole, visitors agreed that the zoo attractions possessed restorative components. Furthermore, perceived fascination and escape (the

psychological component of ‘being away’) were found to be significant predictors of the preferences for, and the pleasure experienced at, both attractions. This study is particularly pertinent to the current research since there are many commonalities between zoos and aquaria and thus, as described in more detail in Chapter 4, the restorativeness scale developed by Pals et al. (based heavily on Hartig et al.’s, 1997, ‘Perceived Restorativeness Scale’ and Laumann et al.’s, 2001, ‘Restorative Components Scale’), appeared particularly apt.

Museums are much less natural settings that, nevertheless, may serve restoration. Kaplan et al. (1993) were the first to hypothesise, theoretically, that a museum could provide restorative experiences for some people as museums can also potentially fulfil the four components central to ART. An art museum, for instance, has e*xtent* as it has a collection of art work, and not just one individual piece. Also, it is usually not part of someone’s daily life and therefore satisfies the criterion of *being away*. It is also likely that many visitors will find the items held within a museum *fascinating* and, as they will have chosen to visit the museum to experience and learn about art, it is *compatible* with their needs. Therefore, in order to explore the possibility that museums could be restorative environments, they conducted two studies. In the first, they re-analysed the comments from museum focus groups (collected for a different purpose). Content analysis of focus group comments revealed that the four components central to ART were expressed. For example, people commented that a visit was a “distraction from routine” (Being Away), they had a sense of an extended environment, as they felt like “they were in a different world” (Extent). A rich array of comments expressed a simple sense of Fascination – “interest”, “awe and wonder” and “excitement”. Fascination was also expressed by more cognitive comments, such as “being fascinated by a sense of history and/or culture”. Compatibility was highlighted by two main categories – orientation (e.g. “feeling lost”) and comprehension of the

content (e.g. needing “help understanding art”). Kaplan et al. (1993) also noted that a number of comments did not relate to the museum environment itself but instead referred to the participants’ psychological state. For instance, participants’ comments included feeling “calm/peaceful”, “positive” and “re-energized”. They also expressed “reflection”, for example, expressing that they had gained a new perspective on how to work out their life problems or even “just thinking”.

As their first study suggested that the museum environment could be restorative, they conducted a second study that employed a questionnaire to specifically explore the four ART components but also well-being aspects, such as how relaxed, rested or tired people felt. They found that, generally, visitors had a reasonably restorative experience, even if they sometimes felt slightly tired. Overall, they therefore concluded that museums may serve as restorative environments for those comfortable in museum settings, such as frequent or repeat visitors. Later work, conducted by Packer (2008), exploring the benefits of a museum visit ‘beyond learning’ (e.g. cognitive, introspective, social experiences), noted that 73% of respondents describing their museum experience referred to restorative components, such as Fascination and Being Away. Interestingly, although the majority of visitors commented that they found their visit “relaxing”, 11% preferred to highlight the stimulating and adventurous aspects of their experience.

Even studies that have not explicitly referred to ART as a theoretical framework, but have instead explored the motivations and derived benefits of visiting such settings, have also found them to be potentially restorative and conducive to greater well-being. Packer and Ballantyne (2002) administered a questionnaire in three informal learning settings (a museum, an art gallery and a public aquarium), with the intention of understanding what motivated people to visit public learning institutions. They found that motivational factors could be grouped into five subscales: ‘learning and discovery’, ‘passive enjoyment’,’ restoration’, ‘social interaction’, and ‘self-fulfilment’.

Furthermore, there were significant differences between sites for three of the subscales – learning and discovery, restoration and social interaction. For instance, the aquarium visitors were more likely to be motivated by social interaction and restoration, and less motivated by learning and discovery goals, than visitors to the museum or art gallery.

Even within one setting, visitors' experiences can differ. Pekarik, Doering and Karns (1999) investigated people's satisfying experiences within a single museum and found that different exhibitions facilitated different experiences (e.g. introspective, cognitive), and that these also varied depending on the particular visitor's characteristics (e.g. age, gender, and familiarity with museums). Other 'learning' type settings also appear to offer restorative experiences. Brewster (2014), for instance, explored the well-being benefits of a public library using a series of qualitative interviews. Brewster found that participants tended to find libraries comforting, calming and safe, and a place often visited as a direct response to acutely stressful situations.

Work by Packer and Bond (2010) also found museums to be one type of favourite place that people visit frequently for restoration. Using a number of scales, including Laumann et al.'s (2001) 'Restorative Components Scale', these authors explored the restorative potential of a number of different museum-type environments in Australia: a history museum, an art gallery, a botanical garden and, importantly for this thesis, an aquarium (UnderWater World, Queensland). Visitors to each site rated nine different types of setting – the four research sites, together with five other settings (national parks, beaches, zoos, cinemas and shopping centres) – on their ability to relax and restore the participants from the stresses of daily life. They found that, for some visitors, museums offered an alternative, restorative experience to natural environments – this was especially true for those who were frequent visitors (a factor also mentioned by Kaplan et al., 1993). A closer look at the four museum environments revealed that the natural heritage sites (the botanical garden and aquarium) "were considered more

restorative, both in attributes and benefits, than those focused on cultural heritage (the museum and art gallery)" (p. 431). Overall, the botanical garden was rated the most restorative 'museum' site, although it is interesting to note that the botanical garden contained significant 'blue space'; there were several different water features including a lake, lagoon and waterfall.

The above study by Packer and Bond (2010) is one of the few studies exploring whether people find public aquarium settings restorative and relaxing. The current work extended their study by taking physiological as well as psychological measures (in Study 4 only), exploring responses to different levels of the same type biological content (i.e. all temperate species), and by examining preferences for, affective responses to, and the restorative potential of, several different types of aquarium exhibit.

1.2.3 Landscape Features: Biodiversity

Many studies investigating the links between environment type and/or composition, and people's psychological responses, have revealed high correlations between preferences for natural environments and perceived restoration (e.g. Purcell et al., 2001; van den Berg et al., 2003). However, a review of literature linking human health and landscapes (Velarde et al., 2007) found that most studies only employed very broad environment categories, tending to simply classify landscapes as 'urban' or 'natural'. Relatively few studies used landscape sub-categories; for instance, differentiating between natural environments with and without water, or settings with a high vs. low level of openness or greenery. Yet different examples of one type of environment (e.g. green space) can vary markedly and may include different quantities of natural (e.g. trees, plants, water, rocks) and built (e.g. roads, buildings) features, and occur in very different geographic and climatic regions. Each individual feature may affect psychological and physiological responses, and therefore potentially influence

environmental preferences (Balling & Falk, 1982) and perceived restorativeness (van den Berg et al., 2003).

Failure to represent the variety of landscape types, and to systematically investigate the effects of the components within them, leaves it unclear as to exactly which elements of a setting have played a part in promoting positive health outcomes (Pearson & Craig 2014). Studies that have actually sub-categorised environment types, or individual settings, have revealed that people's experiences and responses can indeed vary. For instance, Tenngart Ivarsson & Hagerhall (2008) compared the restorativeness of two healing gardens that had been designed to be used by people with stress-related disorders. The two gardens differed in size and degree of natural and built characteristics: the larger of the two gardens featured fewer visible buildings than the smaller garden. They found that, although both gardens were perceived as restorative, the larger, more 'natural' garden was perceived as significantly more restorative than the smaller garden. Following their findings they too highlighted the inadequacies of using scene types that were too broad.

The above study highlights the importance of exploring environments in greater detail and there is already one specific landscape-related attribute that is attracting increasing interest: biodiversity. Biodiversity is defined as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (United Nations, Convention on Biological Diversity, 1992, p. 3). It is worth mentioning at this point that there appears some confusion regarding the term 'diversity'. In the ecological literature it has been used in several, conceptually different ways which has made defining and quantifying diversity problematic (see Tuomisto, 2010 for a discussion on this subject). Generally, biodiversity refers to the variety and variability of life, and in this thesis the use of the

term ‘biodiversity’ will refer to the different number of species and their abundance.

Humans are inextricably linked to biodiversity for ecological, economic, cultural, aesthetic, social, ethical and spiritual reasons (Díaz, Fargione, Chapin & Tilman, 2006; Edwards & Abivardi, 1998; Lindemann-Matthies, Junge and Matthies, 2010; Simaika & Samways, 2010). Biodiversity is essential for ecosystem processes; the physical, chemical and biological ‘supporting’ services that underpin all other ecosystem services that humans rely on for survival and well-being (Diaz et al., 2006; Fenical, 1996).

In short, biodiversity provides crucial, often unrecognised, benefits to people in their lives (Tilman, 2000) and while the focus of the present research is human health and well-being, it is important to note its potential relevance to biodiversity conservation. Despite our reliance on biodiversity, human activities are responsible for the dramatic and increasing global loss of plant and animal species (Rudd, 2011). Although the present rate of biodiversity loss is widely acknowledged, the ability to reverse this trend and conserve biodiversity appears to be lacking. As urbanisation escalates, many people already feel distanced from nature and therefore believe they are unaffected by changes to the natural world (Annan, 2008). If this ‘disconnect’ from nature continues, as the world’s population grows, public motivations to conserve biodiversity could be negatively affected (Miller, 2005). Importantly, this trend may be compounded by each subsequent generation as the degraded habitat and reduction in species for one generation becomes the norm for the next (Kahn, 2002). It has been suggested that people care more about what they know (Balmford, Clegg, Coulson & Taylor, 2002) and will only protect and conserve species and ecosystems of specific value to themselves (Stokes, 2007). If true, then increasing opportunities to connect with nature, and, importantly, identifying the elements in nature that promote well-being, may improve conservation efforts and help counter biodiversity loss (Hughes et

al., 2013).

Although it is acknowledged that biodiversity loss threatens the stability of ecosystems and impacts on the goods and services that ecosystems provide to humans (Millennium Ecosystem Assessment, 2005; Nijkamp, Vindigni & Nunes, 2008; Sandifer, Sutton-Grier & Ward, 2015), the effects that biodiversity has on the cultural ecosystem services (i.e. the non-material benefits such as the promotion of well-being through aesthetics and leisure) have received comparatively less attention (Hughes et al., 2013; Lovell, Wheeler, Higgins, Irvine & Depledge, 2014). This is changing, however, and the past few decades have seen an increase in the number of studies that have sought to determine the relationships between biodiversity and human health and well-being. For instance, Fuller, Irvine, Devine-Wright, Warren and Gaston (2007) examined the link between biodiversity and perceived human well-being measures in 15 areas of green space in Sheffield (UK). Following ecological surveys at each site, semi-structured interviews were completed by 312 green space users across the sites. The interviews explored the perceived species richness of three taxonomic groups (plants, butterflies and birds) and also the concept of green space as a source of psychological well-being (cognitive restoration, sense of identity and positive emotional bonds). They found that well-being measures were positively associated with species richness, although the strength of association varied between their three taxonomic groups. They also found that perceived species richness only increased strongly with sampled species richness for plants: this relationship did not exist for butterfly species and was only marginally, and non-significantly, positive for birds, suggesting that the ability to estimate species richness may depend on taxonomic group. Fuller et al. (2007) proposed that people most accurately assessed the plant species richness because plants are static and more visible than bird or butterfly species which can be difficult to see.

Dallimer et al. (2012) also undertook research in the Sheffield area, using 34

riparian green space sites. Once again, green space users were asked to estimate the species richness of plants, butterflies and birds, and well-being measures explored the ability of that environment to facilitate cognitive restoration and reflection, sense of identity and emotional attachments. In contrast to Fuller et al.'s (2007) findings, Dallimer et al. (2012) found no association between perceived and actual species richness for any of the three taxa, and no consistent relationship between positive well-being measures and actual species richness. They also noted that, with the exception of birds, people's ability to accurately assess the species richness around them was limited, although participants who performed better on their wildlife identification task were more likely to accurately gauge biodiversity levels than those with lesser identification skill and knowledge. They did, however, document a positive association between psychological well-being and *perceived* species richness for all three groups. In view of this, they suggested that perceived biodiversity may be a greater predictor of psychological benefits than actual species richness.

A related study by Luck, Davidson, Boxall and Smallbone (2011) explored the links between a number of ecological measures (species richness, abundance of birds, vegetation cover and density), and personal and neighbourhood well-being in 36 residential neighbourhoods in southeastern Australia. Responses from 1000 residents found that personal well-being was most strongly related to vegetation cover. Neighbourhood well-being was also positively linked to vegetation cover as well as to species richness and abundance of birds.

A preference for greater species richness has also been noted in studies investigating aesthetic appeal. Using two studies, Lindemann-Matthies and Bose (2007) examined aesthetic preferences for plant diversity. In the first study they asked visitors to a botanical garden to create their ideal patch of 'meadow' using 25 plants from a selection of 779 wild local plants (54 species); in the second they asked visitors to

mentally plan their dream meadow (100 m^2). In both cases visitors designed meadows that were structurally diverse and species rich, and stated that diversity was their main assemblage criterion. It was noted, however, that participants with good botanical knowledge created meadows that were more species rich than those with poor botanical knowledge. Later work by Lindemann-Matthies et al. (2010) found that appreciation of experimental arrays and natural meadows increased with true species richness, although the ability to judge species richness was often poor. Although these studies are not related to psychological well-being, they contribute to a greater understanding of the landscape features that influence environmental preferences which, ultimately, may determine the potential for an environment to provide restoration (see van den Berg et al., 2003).

Overall, while evidence exists of positive associations between biodiversity and self-reported well-being (and aesthetic appreciation), these relationships are far from clear or consistent. People vary in their ability to judge species richness, and hence well-being outcomes may vary depending on taxonomic group and respondents' demographics. Lovell et al. (2014) highlighted the inconsistent association between biodiversity levels and good health outcomes. In their systematic review of studies researching the health and well-being benefits of biodiverse environments, they cautioned against drawing the conclusion that greater biodiversity will (automatically) result in better health. Although they found evidence in 10 out of the 16 studies reviewed, that "exposure to or use of biodiverse environments does have some association with various indicators of better health and wellbeing" (p. 16) they concluded that much of the evidence was weak and equivocal. Nevertheless, they highlighted the value of further research into these relationships as strong and reliable evidence would be required to inform environmental or health policy (Lovell et al., 2014).

1.3 Biodiversity

1.3.1 Animal Preferences

While the term biodiversity can relate to *genes*, *ecosystems* and s*pecies* diversity, this thesis will focus only on s*pecies* diversity and, specifically, the diversity of marine vertebrates and invertebrates. It is estimated that there could be between 10 and 100 million species on the planet of which only around 1.4 million have been named (Wilson, 1993) and, of all the named species, relatively few are familiar to most humans. Nevertheless, preferences are evident for the species that are known to humans and many of these preferences, and also aversions, arguably stem from humans' evolutionary history and our subsequent feelings and responses to animals that have either helped or hindered survival in the past (Ulrich, 1993).

Kellert (1993) hypothesises that there are nine values have that are indicative of the worth humans' place on nature for survival and personal fulfilment: utilitarian, naturalistic, ecologistic-scientific, aesthetic, symbolic, humanistic, moralistic, dominionistic and negativistic. Of most relevance to this thesis are the naturalistic, aesthetic and humanistic values. Naturalistic values not only encompass the simple satisfaction derived from direct contact with nature, but also a sense of fascination, awe and wonder at the complexity and diversity of the natural world. Humans may also experience awe when overwhelmed by the aesthetic appeal of nature's physical beauty. This aesthetic response may be directed towards majestic mountains, spectacular sunsets, or living organisms, especially charismatic megafauna, such as whales (Kellert, 1993). Aesthetic experiences of landscapes may be especially important in engaging people with ecosystems: landscapes which people perceive to be aesthetically pleasing are more likely to be appreciated and protected than landscapes that are regarded as unremarkable or unattractive, irrespective of potential ecological importance (Gobster, Nassauer and Daniel, 2007).

Deep emotional attachments to distinct features of the natural environment are indicative of humanistic values. Although these feelings may be directed towards natural objects such as trees or a specific landscape, often, as in the case of aesthetic values, they are focused on larger vertebrates. This holds true whether the animals are close to home, such as 'companion' animals (e.g. cats, dogs), or are present in the wild. Although part of a human environment, companion animals are living things and simply owning a pet can be beneficial to health and well-being (see review on 'Animal-Assisted Therapy' (AAT) by Nimer & Lundahl, 2007). Further afield, encounters with wild animals can also improve well-being. Curtin (2009) interviewed participants who had taken part in wildlife excursions, including a whale and bird-watching trip, and found that the excursion participants often struggled to adequately express their feelings of these human-animal encounters. Following a whale-watching experience, one participant commented "…there are no words to describe what the whales were like. It is sort of a feeling that you have...a…real sense of wellbeing and positive rush" (p. 459). Of the thoughts and feelings expressed by participants, many resonated with the Biophilia hypothesis and ART. They expressed awe and wonder for nature's beauty and design, and felt an awakening of their senses and an altered sense of time (they experienced a state of 'flow'). The wildlife excursions lifted the spirits, facilitated contemplation and provided a time to 'stand and stare', and elicited feelings of deep joy and happiness. It is worth noting, however, that those participating in these wildlife excursions chose to do so and were excited about the prospects of seeing animals – this may have predisposed them to positive responses. Interestingly, this study by Curtin was the only non-terrestrial study identified by Lovell et al. (2014) during their review of research on the relationship between human health and biodiversity.

Whales and dolphins are often referred to as 'charismatic' animals (animals with widespread popular appeal) as they exhibit a number of the characteristics found to

make animals appealing. For instance, a study asking people to list their five least and most favourite animals, and the reasons for their choices, dolphins were the second most favourite animal, after domestic dogs (Woods, 2000). People qualified their choices by describing dolphins as intelligent, beautiful, serene and playful, and by mentioning how they move. When looking at the words people commonly used to describe their favourite animals, aesthetic features (e.g. beautiful, majestic) and character qualities (e.g. intelligent, friendly) predominated. Studies of animals popular with zoo visitors have highlighted similar preferences, e.g. big cats, primates, seals and penguins (Woods, 2000).

According to Stokes (2007), the physical traits of animals that humans appear to prefer include larger size and juvenile features (e.g. large eyes relative to rest of face). Stokes also suggests that similarity to humans, method of locomotion, shape, texture and colour also influence aesthetic preferences. In Woods' (2000) study, fish were 9th out of 30 most frequently mentioned favourite animals. This is intriguing as fish possess relatively few physical similarities to humans. However, the use of anthropomorphic words, such as 'beautiful', 'friendly', 'playful' or 'cute', to describe fish (and also dolphins), suggests that they possess human-like qualities that are admired (Woods, 2000). Perhaps it is these features that have made fish so popular as pets.

1.3.2 'Managed' Marine Life: A Brief History of Aquariums

Fish have been kept in captivity at least since around 2500 B.C., when the Sumerians kept fish in ponds for food. However, humans' appreciation of fish has gone beyond their utilitarian function of providing protein. As well as for food, the ancient Egyptians kept fish for their beauty, as did the ancient Romans who are acknowledged to be the first to keep marine fish in ponds supplied with fresh seawater (Bridges, 1970). The Romans paid great attention to their fish-ponds, sparing no expense in making them

as large and attractive as possible and stocking them with beautiful and valuable fish (Taylor, 1881). They were also the first to bring fish indoors: sea barbels were kept in small marble tanks underneath guest beds (Brunner, 2011). The Chinese are credited with the domestication of carp more than two thousand years ago and were the first to successfully breed fish. During the Sung Dynasty (960-1278) carp were selectively bred for purely decorative purposes and by the Ming dynasty were kept indoors as pets, in porcelain vessels. By the 1600s goldfish (*Cyprinusauratus* – later re-classified as *Carassiusauratus)* were introduced into Europe as ornamental living objects. By the Victoria era fish keeping was a popular hobby.

In 1853 the Zoological Society of London opened the world's first public aquarium: a "Fish House" in Regent's Park, sparking a craze for keeping fish in homes all over England (Bridges, 1970). Following the success of the "Fish House" similar public aquariums opened throughout England, France and Germany. In the United States, interest in keeping fish also rose and the government of the U.S. established the Smithsonian Institution's National Museum of Natural History. However, it was American showman, P.T. Barnum who first exhibited fish to the U.S. public in his American Museum in New York, in 1856 (Brunner, 2011). However, despite a number of temporary exhibits, it was not until 1896 that the United States had its first permanent public aquarium, the New York Aquarium (Bridges, 1970; Brunner 2011).

Today there are over 300 substantial public aquariums worldwide, with the number increasing each year (Penning et al., 2009). Our strong desire to engage with animals is highlighted by the fact that in the early 1990s, more people in the USA and Canada visited zoos and aquariums than attended sporting events (Wilson, 1993). This trend does not appear to have diminished: Penning et al. (2009) stated that at least 650 million people visit zoos and aquariums each year worldwide, making it a more popular mass public participation activity than football (soccer). Later data put this figure nearer

700 million people annually (Gusset & Dick, 2011).

More than 100 public aquariums have opened around the world since the early 1990s: by comparison, the rate of new, purely terrestrial zoos is much slower (Penning el al., 2009). However, viewing aquaria is not necessarily confined to the occasional family outing. Whilst there is some debate over whether keeping fish is a hobby or whether fish are classified as pets, fishkeeping at home is popular with millions of people world-wide. In the United States alone over 10% of households keep ornamental fish (Strecker, Campbell & Olden, 2011; Weis, 2011) - it is second only in popularity to stamp collecting as a hobby.

1.3.3 Aquariums, Health and Well-being

Given humans' overall relationships and affiliations with living things, it is unsurprising that public aquariums have the potential to provide restorative experiences. Furthermore, all three previously mentioned approaches that attempt to explain why humans may gain health and well-being benefits from natural environments may, to some extent, be relevant. Although not 'natural' environments, public aquariums certainly contain 'nature' and, as such, present opportunities to affiliate with living things (Biophilia). Also, aquariums potentially fulfil the four criteria of ART and are thus capable of providing restorative experiences. They hold an array of animals of all shapes, sizes and colours that may hold one's attention effortlessly (fascination), the setting is physically or conceptually removed from a person's everyday life (being away); there are many different live exhibits, interactive displays and educational panels to explore (extent); and they are a place a person has chosen to visit implying anticipated compatibility. Lastly, and of relevance to PSRT, aquariums may trigger physiological, as well as psychological responses, that are indicative of calming and stress-reducing experiences.

It is worth noting at this point, however, that a person's perception of what constitutes a 'natural environment' or 'nature' can vary considerably and may depend on a range of factors including age, cultural background, past experiences and daily routine (Özgüner & Kendle, 2006). Whilst a considerable body of empirical evidence suggests that people prefer 'natural' to 'built' settings, not all nature is viewed as benign, unthreatening and potentially restorative. For instance, dense woodland may feel intimidating to some as it could raise fears of being attacked, getting injured or becoming lost (Gatersleben & Andrews, 2013; Milligan & Bingley, 2007). Indeed, depending on personal preferences, some people may actually prefer a more formal, managed natural setting and could perceive naturalistic ('wild') environments as untidy or neglected (Özgüner & Kendle, 2006). According to Williams and Cary (2002), landscape architects have observed that manicured environments are often considered more attractive than natural ecosystems.

Public aquariums can certainly be viewed as benign and managed settings. While many people visit aquariums for entertainment or educational purposes (Packer & Ballantyne, 2002; Wyles, Pahl, White, Morris, Cracknell & Thompson, 2013), there is evidence to suggest that some people may also gain relaxation and psychological well-being from them (e.g. Falk, Heimlich & Bronnenkant, 2008; Packer & Bond, 2010). Falk et al. (2008) explored people's motivations[4] for visiting zoos and aquariums and found that, though diverse, overall, the people's reasons for visiting clustered into five visitor 'identities': 'Explorer', 'Facilitator', 'Experience Seeker', 'Professional/Hobbyist' and 'Spiritual Pilgrim'. Although this last category comprised the smallest percentage of visitors, comments during interviews revealed that this group

[4] It should be noted that establishing motivations to visit an environment may not necessarily relate to all perceived benefits. Irvine, Warber, Devine and Gaston (2013) highlighted a discrepancy between people's motivations to visit public green spaces (e.g. walking, green space qualities) and the derived effects (relaxation, positive emotions) of visiting these settings.

were primarily driven by restorative and/or contemplative experiences. Comments from participants included:

"I like the jellyfish. They were very soothing to watch…I would definitely come here by myself…very relaxing, so different than the craziness of the rest of the world" (p. 68).

"*I am very religious or spiritual and realized just how special each creature is made and how their unique characteristics make them special. Each creature has a different way of life, even though they may share the ocean environment. I learned to appreciate these gifts of God even more! In addition, I am more committed to making sure each species is protected and does not become extinct*." (p. 70);

"*Although I enjoyed the exhibits, I was struck by my girlfriend's response. She had been very anxious all day and finally relaxed while we were at the aquarium. It clearly moved her deeply*." (p. 70).

Comments from these participants' highlight the potential that public aquariums have for providing restorative experiences ("very relaxing") and how these experiences can be influenced by biodiversity ("soothing jellyfish"). These comments also demonstrate how aquariums can promote conservation-based intentions ("I am more committed to making sure each species is protected and does not become extinct."). Interestingly, although Falk et al.'s study was conducted at four sites, two zoos and two aquariums in the US, the majority of the Spiritual Pilgrim comments mentioned throughout their paper appear to relate to aquarium-based, rather than zoo-based, experiences[5]. Many of these comments directly relate to the three main theories of why people are drawn to nature for restorative experiences. For example, there is an appreciation of living things (Biophilia); a feeling of 'getting away from it all' (ART), and clear examples of stress recovery (PSRT).

[5] Interestingly, overall, the percentage of visitors entering each institution type (zoos vs. aquariums) with a single dominant identity-related motivation (i.e. Spiritual Pilgrim) was higher for the aquariums (M = 5.4%) than zoos (M = 3.6%).

It is also interesting to note, however, that one participant mentioned that he'd be willing to visit the aquarium alone – despite that fact that social experiences (e.g. a 'day out with family') are among one of the main motivations for visiting zoos and aquariums (Falk et al., 2008; Packer & Ballantyne, 2002; Wyles et al., 2013). Research suggests that when visiting natural environments the presence of others can influence restorative experiences. Depending on who the 'others' are (e.g. family, friends, strangers), their presence may *enable* a restorative experience to occur (e.g. making someone feel safer than if alone); *enhance* an experience (e.g. through pleasant company, shared experiences) or *degrade* an opportunity for restoration (e.g. through fear of personal attack or simply if the other person pulls one's attention away from the restorative effects of the physical environment) (Staats & Hartig, 2004). Interestingly, although company can facilitate restoration by providing safety (from getting lost, injured or attacked), Staats and Hartig (2004) found that when safety was not a worry, restoration was enhanced by the lack of other people present. Perhaps one of the reasons why aquariums enable restorative experiences is that they are places that can be safely visited alone – other people are present, yet there is little pressure to interact with these people, leaving a person free to immerse themselves more in their surroundings and potentially gain greater restorative benefits.

Also, one final point about safety in natural settings; aside from concerns about attack from other people, many individuals may be fearful of attack from predators or venomous animals. However, threats in nature can provide positive as well as negative emotions: a personal fear may be overcome in awe-inspiring nature (Gatersleban & Andrews, 2013). Aquariums contain animals that some people are afraid of (sharks, being the most obvious example), yet aquariums provide the opportunity to get close to these magnificent (and much maligned) animals in complete safety.

Generally speaking, however, research into the health and well-being benefits of

aquaria tends to centre on home aquaria and fish tanks in healthcare settings. In the home context, for instance, Kidd and Kidd (1999) surveyed 100 home aquaria owners and found that 94% of respondents reported that they benefited from their aquaria: only 6% saw their aquaria as room decoration only. Overall, 70% of respondents said that they found their fish calming, relaxing, and that they contributed to reducing stress and anxiety levels. Furthermore, a small number of male respondents mentioned that their doctors had suggested owning a home aquarium to help lower their blood pressure.

The assumption that fish tanks are often present in healthcare settings because of their potentially relaxing and calming properties has already prompted research in this area, although findings from some studies have been far from conclusive. For instance, Barker, Rasmussen and Best (2003) investigated the effect of an aquarium on the heart rate, blood pressure and self-reported 'feeling scales' of patients about to undergo electroconvulsive therapy and found a trend (p = .08) towards lower self-reported anxiety when patients were in a room containing an aquarium (vs. no aquarium present). In another study, DeSchriver and Riddick (1990) used a videotape of a tropical fish tank, as well as live fish in an aquarium tank, to explore the stress levels of elderly people. They found that, whilst not statistically significant, there was a tendency for pulse rate and muscle tension to decrease, and skin temperature to increase (suggestive of stress reduction), in the aquarium observers compared with the control group. Furthermore, they noted that there was a greater impact on those who watched the aquarium videotape compared to those observing the live fish. They suggest that this could be because watching a videotape may be more closely linked to a favourite pastime of the elderly, watching television, whereas watching live fish is more unusual and less common activity. An alternative explanation may relate to the differing content (i.e. biodiversity) and visual presentation of the two aquarium conditions. The live aquarium contained nine freshwater tropical fish whereas the videotape contained

"(almost exclusively in close-up shots) a variety of colourful fish" (p. 45), that participants may have found more relaxing or fascinating. Furthermore, the videotape contained an enhanced audio sound track of a trickling stream which may have influenced participants' responses (e.g. see Annerstedt, Jönsson, Wållergard, Karlson, Grahn, Hansen, & Währborg', 2013). Nevertheless, qualitative evaluations from these participants indicated that, overall, they found watching fish enjoyable and beneficial.

Cole and Gawlinski (1995), keen on exploring the potential stress-reducing benefits of animal-assisted therapy, gave a number of patients awaiting a heart transplant a fish tank to care for. The fish tanks created a positive visual stimulus for the patients, as well a sense of control, and provided a relaxing distraction from the hospital environment. Patients fed their own fish and enjoyed naming them. They "expressed a sense of delight, and described a sense of relaxation" (p. 532). A study by Edwards and Beck (2002), also AAT-based, observed beneficial changes in patients with Alzheimer's disease following the introduction of a fish tank into the activity/dining room. These researchers were interested in how the addition of a fish tank influenced patients' food intake, as weight loss is an extremely common problem in individuals with Alzheimer's disease, and can impact on health and quality of life. The researchers found that, following the introduction of a fish tank, nutritional intake increased significantly (21.1%: $p < .001$) and the need for nutritional supplementation decreased. Members of staff observed that patients who usually paced or wandered tended to spend more time sitting watching the fish whereas those patients where were usually lethargic became more alert in the presence of the aquarium. Both types of behaviour change resulted in increased food intake. Overall, most residents experienced some weight gain making this a particularly beneficial intervention.

Other studies have also produced significant results. For instance, Katcher, Segal and Beck (1984) found that participants who were instructed to contemplate an

aquarium before dental surgery experienced greater relaxation and reduced anxiety than other, potentially calming, conditions such as contemplating a colour poster of a mountain waterfall or sitting quietly in a chair (control). Riddick (1985) added an aquarium to the home of non-institutionalised elderly people (n = 7) to study the effect it had on their blood pressure, happiness, anxiety, loneliness and leisure satisfaction. At the end of the six month intervention period, the aquarium group experienced a significant decrease (p = .04) in diastolic blood pressure compared to two other groups who did not have a fish tank to care for (a 'visitor', n = 8 and a 'control' n = 7 group). The aquarium group also experienced a trend towards positive change in their leisure satisfaction, particularly regarding relaxation (p = .06). Katcher, Friedman, Beck and Lynch (1983) observed significant decreases in blood pressure in participants (hypertensive and normotensive) who watched a tropical fish tank following a stressor task (reading aloud). The authors also suggested that watching fish may have reduced participants' responses to stress. When instructed to read aloud for a second time, the increase in participants' blood pressure was considerably less than when participants were given the same task earlier in the experiment. Although it could be suggested that lower blood pressure measured after repeating the stressor task may be a result of the participants being more familiar and less fearful of the task, a study by Wells (2005) also suggests that viewing animals may provide a buffer to cognitive stress. Wells employed the same stressor (reading aloud) and found that participants watching videotapes of animals (fish, birds or primates) experienced significantly (p < .001) lower levels of heart rate and blood pressure increase than participants exposed to the two control conditions (a videotape of a soap opera and a blank television screen).

Whilst a number of these studies found statistically significant differences between study groups for a variety of dependent variables, some studies would certainly benefit from replication using larger sample sizes. For instance, DeSchriver and Riddick

(1990) used nine participants for each of the three conditions in their study (a live fish aquarium, a videotape of a tropical fish swimming in an aquarium, or a 'relaxation' videotape, a placebo that was actually television lines and static) and pointed out that any replication of their study should be undertaken using larger sample sizes. Katcher et al. (1984) also used similar sized groups: eight patients for each of the four intervention groups and ten patients for the non-intervention control. Furthermore, these studies have predominately been carried out in a laboratory (Katcher et al., 1983; Wells, 2005) or clinical setting (DeSchriver & Riddick, 1990; Edwards & Beck, 2002; Katcher et al., 1984). There appear to be few studies that have explored the psychological and physiological health and well-being benefits of a human's to exposure to real or simulated public aquarium exhibits, and similarly, little work on how different sub-aquatic species, or abundance and configurations of such species, may influence health outcomes.

1.3.4 Preferences for Marine Biodiversity

There is currently a lack of research relating to the health and well-being benefits of aquatic environments (Sandifer et al., 2015) and, in particular, sub-aquatic settings. This is understandable when considering that natural underwater habitats are not readily accessible environments for many people. However, although people may be less likely to visit sub-aquatic environments than terrestrial ones, the tens of thousands, possibly millions, of people who learn to SCUBA dive (PADI, 2015), visit public aquariums (Gusset & Dick, 2011), own their own aquaria or watch underwater television documentaries, is testament to their appeal. Moreover, precisely because most people will not regularly encounter these species and ecosystems, there is a need to understand what benefits they provide to ensure we understand the value they confer.

The few studies that have explored people's preferences and responses to natural

underwater environments have tended to focus on the implications for marine conservation, rather than human health and well-being considerations. For instance, studies have examined the biological features that contribute most to divers' enjoyment of coral reefs (Uyarra et al., 2009) or the biological elements that divers would be most willing to pay to conserve (Polak & Shashar, 2013). As conservation efforts are frequently motivated by people's aesthetic preferences, particularly for charismatic megafauna such as pandas and tigers, human preferences will likely influence whether a specific species, or group of animals, are valued and protected (Stokes, 2007).

Uyarra, Watkinson and Côté (2009) noted that studies exploring tourists' perceptions of environmental features (e.g. water quality, coral damage) have generally relied on the tourists' opinions of these attributes during post hoc surveys – the ability of tourists to accurately recall these features is rarely measured. Therefore, in order to investigate the relationship between divers' preferences and the actual condition of the coral reefs, they asked 200 divers to choose their most and least favourite dive sites around the Caribbean island of Bonaire, and then compared these preferences to the actual condition of the reefs, determined by ecological surveys. They found that the three key features that contributed most to divers' enjoyment of the coral reefs were fish abundance (specifically, fish species richness and number of fish schools), followed by bright reef colour and healthy coral. Furthermore, they found that diver perceptions tended to match actual conditions for the majority of biological attributes. For instance, fish abundance – the key attribute to affect diver enjoyment of a site – was significantly higher at dive sites perceived as having a greater number of fish than sites perceived as having fewer fish, although this only applied to two of the three measures of fish abundance (i.e. number of fish schools and fish species richness).

Work by Polak and Shashar (2013) used the contingent valuation method (CVM) to investigate divers' willingness to pay (WTP) for changes in fish and coral

qualities over an artificial reef. In environmental studies, the CVM is a commonly used method of deriving non-market values by using hypothetical scenarios to evaluate people's use of an amenity. Divers were presented with seven biological scenarios: 'Total richness of fish and corals', 'Total abundance of fish and corals', 'Coral species richness', 'Fish species richness', 'Coral size', 'Coral abundance' and 'Fish abundance'. Analysis of 261 interviews found that divers' WTP was higher for conservation efforts that increased the overall level of biodiversity (total richness and abundance of both fish and coral species), and least likely to pay for increases in fish abundance alone.

Comparing fish with corals, they noted that divers would pay more for fish species richness than fish abundance but the same was not true of corals. When examining WTP for abundance alone, they found corals were rated higher in value than were fish. They suggest that one possible explanation for this could be that corals of the same species look more diverse than fish of the same species which are more uniform in appearance. Polak and Shashar (2013) suggested that the ability to recognise and measure biodiversity accurately is usually restricted to specialists such as ecologists. Therefore, they were encouraged to find that non-specialists were able to discriminate between the various biological attributes featured in their scenarios. Furthermore, the fact that the general public were willing to pay for biodiversity, demonstrates the importance attached to it by the public. Although these studies employed different methodologies, in essence, they found that divers generally preferred greater species richness and abundance.

As well as being worthy of investigation in their own right as 'restorative settings', aquariums provide a useful proxy for natural underwater environments that can be logistically challenging to study. Public aquariums usually display a variety of large and small-sized tropical and temperate exhibits. Exhibits may house a single

interesting specimen (e.g. Giant Pacific Octopus, *Enteroctopus dofleini*[6]); a mixed community (e.g. representative of a coral reef); or feature large numbers of the same species (e.g. Northern anchovies, *Engraulis mordax*). Some exhibits feature typically 'charismatic' species, such as seahorses, *Hippocampus spp.* (Jefferson, Bailey, Laffoley, Richards & Attrill, 2014) whereas other exhibits may contain anecdotally less appealing animals, such as crabs ('invertebrates' - see Kellert, 1993; Woods, 2000). It is apparent from observing aquarium visitors (personal observations) that people have preferences for certain exhibit types and that dissimilar exhibits elicit different emotional responses (e.g. awe, calm, excitement). Establishing which exhibit characteristics prompt which response is important to identify. Considering that public aquariums worldwide welcome millions of visitors annually (Gusset & Dick, 2011), and smaller aquaria are present in homes, healthcare settings and businesses, the potential of aquariums worldwide to provide psychological benefits is considerable.

Identifying the environmental cues and clues that lead to improved health and well-being in these settings may be especially important for those who rarely go outside or who have limited access to natural environments, such as the elderly or infirm (Depledge, Stone & Bird, 2011). For these people, opportunities to engage with nature in 'managed' environments or to bring nature indoors ('indoor nature exposure' – INE: see review by McSweeney, Rainham, Johnson, Sherry & Singleton, 2015), could provide psychological and physiological health benefits that may be particularly important in urban spaces. Aquariums may therefore be important for delivering psychological well-being, enhancing perceptions of the value of sub-aquatic environments, and ultimately encouraging support for conservation efforts in the wild (Schultz, 2011).

[6] Throughout this thesis, all species names have been checked against, and comply with, the World Register of Marine Species (WoRMS http://marinespecies.org/).

1.4 Overview of thesis

1.4.1 Aims of Thesis

The research reported in this thesis had four key aims. In consideration of the relative lack of research into 'blue space' settings, the first aim was to explore preferences for, and the restorative potential of, natural and artificial underwater environments compared with more extensively researched environments such as urban and green space, and, more recently, above water aquatic scenes (blue space). Second, as a limited number of previous studies have established preferences for different examples of a similar setting (e.g. healing gardens - see Tenngart Ivarsson & Hagerhall, 2008), I have investigated whether people have preferences for different aquarium exhibits. Third, using one exhibit in which the marine life increased over time, I explored psychological and physiological responses to these changes in biota level to ascertain whether there was a 'dose-response' effect. In other words, to investigate whether people's psycho-physiological reactions changed (i) over a period of time (10 minutes), and (ii) in response to increasing levels of marine life. Finally, I examined how accurate people's perceptions of species richness and the abundance of individuals were when viewing one or two large aquariums exhibits, and how these perceptions influenced well-being outcomes.

1.4.2 Outline of Studies

To achieve the first aim, two photo studies were undertaken. The first, Study 1, built on previous research (White et al., 2010), which asked participants about their preferences for three environments (urban, green space and blue space) using a photograph rating methodology. Study 1 extended earlier research reported in White et al. (2010) by adding a fourth environment category: natural underwater scenes. Participants were asked to rate their aesthetic and behavioural preferences for, their

affective response to, and the perceived restorativeness of, these sub-aquatic images that were compared with participants' ratings of more commonly researched environments (urban, green space and above the waterline blue space). In order to explore whether familiarity with sub-aquatic environments influenced responses, participants were also asked about their previous, and preferred, diving or snorkelling experiences. Study 1 was included with two other studies in a journal article for Landscape Research (White, Cracknell, Corcoran, Jenkinson & Depledge, 2014 – see Chapter 2).

Study 2 extended Study 1 by adding a further sub-aquatic setting to the photo set: aquarium exhibits ('managed' underwater nature). This enabled a comparison of both different types of sub-aquatic environment (natural and human-made), against the other environments used in Study 1.

Study 3 expanded on Study 2 by focusing solely on participants' responses to aquarium exhibits. As anecdotal evidence from aquarium visitors suggests that people have preferences for different exhibit types, so these preferences were explored using a selection of images of exhibits typically found in public aquariums. In order to establish whether any preference trends existed, the exhibits were categorised by geographical region (i.e. temperate/tropical), species richness (high/low) and abundance of individuals (high/low). To maintain consistency, images were again rated on the same four measures used in Studies 1 and 2. A paper based on Studies 2 and 3 has been accepted for publication in Landscape Research (Cracknell, White, Pahl & Depledge).

Study 4 moved the studies from the laboratory to a real public aquarium setting, the National Marine Aquarium, Plymouth, UK. This study aimed to examine people's responses to increasing levels of marine life in a large exhibit, during a period of restocking. Not only did Study 4 expand on Studies 1-3 by taking a more in-depth look at people's psychological responses to aquarium exhibits, but it also extended the previous three photo studies by exploring the participants' behavioural and

physiological responses. Furthermore, in addition to examining participants' responses to different levels of marine life, I also investigated how these responses changed over time, in order explore whether any 'dose-responses' existed. This study was published in Environment & Behavior, in 2015 (see Chapter 3).

Finally, previous research in terrestrial settings (e.g. Dallimer et al., 2012) found that people can experience difficulties when trying to estimate species richness. These difficulties in assessing species richness have implications for the establishment of a link between species richness and well-being outcomes. As perceptions of biodiversity were not investigated in Studies 1-4, Studies 5 and 6 sought to investigate the links between perceptions of marine life and well-being outcomes. Study 5 asked aquarium visitors about their perceptions of species richness and abundance when viewing one of two large aquarium exhibits, whereas Study 6 asked study participants about both exhibits in order to establish whether participants' estimates changed when they were able to make comparative judgements. In both studies participants were also asked how restorative they found the exhibits and how the exhibits made them feel. These well-being outcomes were then compared with perceptions of marine life in order to establish whether any relationships existed.

1.4.3 Discussion and Conclusions

The final chapter of this thesis summarises and discusses the main findings from the above studies, and how they extend the current literature. The limitations in these studies and how they may be addressed are also discussed. Potential real-world applications of this work are considered (e.g. in healthcare and workplace settings, and for aquarium design). Finally, while not the main focus of this body of work, the possible implications for wildlife conservation are also touched upon.

Chapter 2.

Preferences for Natural and Human-made Sub-aquatic (Aquarium) Scenes

An abbreviated version of Study 1 has already been published as part of a paper summarising three photo studies (of which Study 1 was one). An abbreviated version of Studies 2 and 3 are currently under review. Please see below for details:

Study 1: White, M. P., Cracknell, D., Corcoran, A., Jenkinson, G. & Depledge, M. H, (2014). Do preferences for waterscapes persist in inclement weather and extend to sub-aquatic scenes? *Landscape Research, 39,* 339–358.

Studies 2 & 3: Cracknell, D., White, M. P., Pahl, S. & Depledge, M. H. (under review). A preliminary investigation into the restorative potential of public aquaria exhibits: A UK student-based study. Accepted for publication in *Landscape Research*.

2.1 Introduction

2.1.1 Overview

Numerous studies have investigated human landscape preferences and their relationship with human health and well-being. Although many studies exploring restorative effects have not sub-categorised landscapes, often referring to them simply as ‘built’ or ‘natural’ (Velarde et al., 2007), other studies have aimed to investigate people’s preferences for, and the effects of, a specific landscape feature: one such feature is water. Overall, people tend to respond positively to, and express preferences for, natural environments that contain elements of water such as rivers, lakes and sea (Ulrich, 1983). Herzog (1985) examined people’s preferences for four different waterscapes ranging from unattractive ‘swampy areas’ to majestic ‘mountain waterscapes’, using the length of time the images were viewed and the ratings of six predictor variables (e.g. spaciousness and complexity). Overall, there was variation between the different waterscapes with the ‘large bodies of water’ category receiving the highest preferences scores. Han (2007) looked at preferences for six different biome

types (‘desert’, ‘tundra’, ‘grassland’, and three types of forest – ‘coniferous’, ‘deciduous’ and ‘tropical’) and found that, when ignoring biome classification, people responded more positively to landscapes that featured a high level of complexity and a large quantity of water.

Other researchers have looked at one particular type of waterscape. For instance, Gregory and Davis (1993) looked at perceptions of riverscape aesthetics, particularly with regard to the effects of river channels (unmanaged vs. managed, i.e. ‘channelised’ – using a ‘hard’ engineering technique for the purposes of flood control, drainage etc.). They concluded that the colour of water (representative of good water quality), and the percentage of channelised river bank present (with less river bank present receiving more positive ratings), were the two best predictors of scene preference. Nasar and Lin (2003) looked at responses to photographs of five different water features (e.g. fountains) found in urban places. Water movement was categorised as ‘still’, ‘flowing’ and ‘falling’ water, ‘jets’ of water, and ‘combinations’ of moving water features. Following ratings on their three measures (‘preference’, ‘calming’ and ‘excitement’), they found that ‘still’ water was rated more ‘calming’ and less ‘exciting’ by participants than any of the moving water features, whereas ‘falling’ and ‘flowing’ water features were found to be the least ‘calming’. ‘Jet’ and ‘combination’ were rated higher on ‘preference’ than all other water features but, considering that the ‘preference’ scores for all five water features were above the mid-point, the authors suggest that all water features were rated favourably.

People’s non-verbal behaviours also allude to a preference for aquatic settings. Luttik (2000) examined environmental features that influenced housing choices and found that houses with attractive views (e.g. parkland or water), were considerably more expensive than those without. Overall, in Luttik’s study, the most influential environmental factor was the presence of water: houses that overlooked water were, on

average, 8-10% higher in price than properties without a water view. The greater cost associated with a water view will not be lost on anyone who has booked a beach holiday: ‘sea view’ rooms are invariably more expensive than rooms with an inland view (see Lange & Schaeffer, 2001).

As explained in Chapter 1, it is suggested that, from a functional-evolutionary point of view, humans have a predisposition to respond positively to certain natural features (e.g. vegetation and water) and arrangements of these features that aided survival and facilitated well-being during hominid evolution (Ulrich 1983; Ulrich et al., 1991). Early humans settled close to water as it gave them immediate access to drinking water, attracted animals that could be hunted for food and provided valuable safety and protection, and a means of transportation. Some aquatic locations, such as rivers, estuaries and the coast, also provided humans with high quantities of food in the form of fish, shellfish and crustaceans (Ulrich, 1993). Yet, despite these benefits, little research (outside of tourism and conservation-related studies) has centred on people’s responses to underwater environments or the species within them

Although, on a day-to-day basis, sub-aquatic environments are less likely to be encountered than terrestrial landscapes, these settings are still of interest for two main reasons. First, millions of people enjoy viewing underwater environments, whether by engaging in SCUBA diving (PADI, 2015), visiting a public aquarium (Gusset & Dick, 2011), or creating their own aquaria at home (Kidd & Kidd, 1999), yet little is known about how underwater settings compare with more terrestrial environments. Second, studies in terrestrial settings have suggested that human health benefits tend to be greater in more species rich environments (e.g. Fuller et al., 2007 - see Chapter 1). Therefore, as biological species richness can influence well-being, and aquaria (real and simulated) can help alleviate stress and promote calm in the home and in healthcare settings (e.g. Katcher et al., 1984, see Chapter 1), a greater understanding of how the

biological components of aquaria can influence well-being outcomes is important. Additionally, as most people will not encounter sub-aquatic settings and species on a regular basis, it is important to understand what benefits they provide as this could help acknowledge and appreciate their value.

Hence, in order to investigate people's responses to two underwater settings, and the biological species within them, three photo studies were undertaken. These studies had two main aims. First, to investigate people's preferences for, affective responses to, and the restorative potential of, two sub-aquatic environments: natural underwater scenes (Study 1) and human-made underwater scenes (i.e. public aquarium exhibits - Study 2). In both studies, the sub-aquatic environments were compared with other, more commonly researched environments: built/urban, rural/green space and aquatic/blue space. Second, to investigate whether people's responses to public aquarium exhibits were influenced by the biological components of the exhibits, i.e. the number and abundance of biological species present (Study 3).

2.1.2 Measuring Restoration and Perceived Restorativeness

Day-to-day life can deplete our cognitive, physiological and emotional resources in numerous ways. There may be increased mental and physical fatigue, heightened levels of stress, reduced concentration, and a worsening of mood (Ulrich et al., 1991). It is proposed that certain environments, particularly unthreatening natural settings, have the ability to reduce these effects and 'restore' a person to a more positive state. There are two main ways in which the ability of an environment to provide restoration can be measured: *perceived* restoration (i.e. a retrospective report of people's perceptions of how restorative they found an environment) and *actual* restoration (i.e. an actual measure of restoration, e.g. physiological changes or changes in performance on tasks involving directed attention).

Over the years, a number of different scales have been developed to measure perceived restorative potential. Hartig et al. (1997) developed the Perceived Restorativeness Scale (PRS) that aimed to differentiate between environments that differed in restorative potential by measuring people's perceptions of a setting with regards to the four theoretical restorative qualities propose by ART: fascination, being away, extent, compatibility (Hartig, 2004). The PRS was developed using four studies that employed a number of strategies for assessing reliability and validity. Sixteen items were developed that represented the four components of ART (e.g. 'My attention is drawn to many interesting things' - *fascination*). These items were tested in eight environments that differed in theoretically relevant ways: the settings were categorised as being 'natural' or 'built', 'indoor' or 'outdoor', and possessing either 'high' or 'low' anticipated perceived restorativeness (e.g. 'A rock garden in the centre of a large park; exotic plants, shady alcoves, and views out to large trees and buildings' – natural/outdoor/high perceived restorativeness). Participants either visited the real sites and/or viewed video or photographic slide simulations of the sites. Results were consistent across the four studies and, overall, it was concluded that the PRS was a useful means of measuring the perceived restorativeness of an environment. Pasini, Berto, Brondino and Hall (2014) later developed a short form (the PRS-11) of the original 26-item scale with the aim of making the scale more usable in research situations where time was more limited.

Later, Herzog et al. (2003) developed a single-item, direct measure of the perceived restorativeness of a setting (the perceived restorative potential – PRP) that aimed to measure the four components of a restorative setting, as suggested by ART. For the PRP measure, participants were asked to remember an occasion when they had worked hard on a project that had required prolonged and intense effort, to the point where they needed to take a break. Participants were then instructed to rate 70 colour

slides of urban and nature settings (35 urban and 35 field/forest scenes) on how good a place it would be to take a break and restore their ability to work effectively. Participants rated the images on only one of 10 variables, including the PRP item and the above mentioned four components of ART. The other five measures were preference and four exploratory predictor variables ('openness', 'visual access', 'movement ease' and 'setting care'). While Herzog et al. (2003) acknowledged that the PRP was not the same as a measure of actual restorativeness, they suggested that the PRP measure could be used to validate the four predictive components of restorativeness.

Laumann et al. (2001) also produced an instrument that, although not named, is generally referred to as the Restorative Components Scale (RCS), after the title of their published paper (Herzog et al., 2003). The RCS differs from the PRS by splitting one of the ART components, Being Away, into two: Novelty (physically being in a novel place and doing something new), and Escape (psychologically distanced from work routines and other obligations). Using the PRS and RCS as a base, Pals et al. (2009) developed the Perceived Restorative Characteristics Questionnaire (PRCQ); designed to measure the perceptions of five restorative characteristics: Fascination, Novelty, Escape, Compatibility and Coherence of zoo attractions.

The development of the above scales has enabled the restorative potential of a range of natural and built environments to be evaluated, in both field and laboratory settings. For instance, building on work by Staats, Kieviet and Hartig (2003), Hartig and Staats (2006) measured the attitude of college students towards walking in a forest or urban environment; how positively they evaluated a given set of behavioural outcomes; and the likelihood of those outcomes in a given environment. Felsten (2009) also used college students and asked them to rate indoor campus locations on their perceived ability to relieve cognitive fatigue. Felsten used five items, adapted from Herzog et al.

(2003) and Berto (2005), to measure perceived restorativeness. Four of the items measured the four components of ART (fascination, being away, extent and compatibility), whereas the final item assessed the overall perceived restorative potential. The campus locations that were rated by the college students rated differed in their view of nature: no views of nature; window views of nature (leafless trees) plus buildings; wall-sized murals of colourful trees or fields and forests; or wall-sized waterscapes (coastal scene or waterfall – with vegetation). In both of these studies, natural settings were perceived as more restorative than built. Furthermore, in Felsten's study, there were differences between the nature-based locations: students rated murals of waterscapes more restorative than either murals without water or real window views of mundane nature. Tenngart Ivarsson & Hagerhall (2008) took a further step by examining whether it was possible to discriminate between the restorative potential of different examples of the same scene type, rather than just using a simple 'built vs. nature' comparison. Using a modified version of the PRS, they examined the restorative potential of two healing gardens using a photo set containing 24 photos (12 each of two different gardens). They found that both healing gardens were perceived as restorative but, importantly, the PRS was able to differentiate between the two gardens.

The optimum means of assessing 'restoration' would be to monitor an array of physical, cognitive and mental responses, and several studies have aimed for this 'gold standard'. For instance, Ulrich et al. (1991) exposed 120 subjects to a stressful film before they viewed videotape presentations of one of six different natural or urban environments. Physiological assessments of stress recovery were obtained during the environmental presentations using heart period (from an electrocardiogram), pulse transit time (which correlates with systolic blood pressure), spontaneous skin conductance, and frontalis muscle tension (EMG). Changes in psychological reactions were assessed by asking participants to rate their emotions ('positive affect',

‘attentiveness’, ‘fear arousal’, ‘sadness’ and ‘anger/aggression’) using Zuckerman’s (1977) Inventory of Personal Reactions (ZIPERS).

In another study, Hartig et al. (2003) tracked psychophysiological stress recovery and directed attention restoration in field settings. The study crossed an ‘environmental treatment’ condition with a pre-treatment condition (no task or task: Stroop-based and binary classification tasks). Physiological responses of systolic and diastolic blood pressure were measured, as were changes in emotion (using the ZIPERS and the Overall Happiness Scales). Attentional performance was measured using two tasks: the Necker Cube Pattern Control task (NCPCT) and a memory-loaded search task.

Finally, an experiment by Berman et al. (2008) investigated the restorative effects of exposure to natural and urban field settings using a backward digit-span task to measure changes in cognitive functioning, and the Positive and Negative Affect Schedule (PANAS) to assess participants’ mood.

In the studies reported in this thesis, I have, predominately, used perceived restorative potential as a measure of restoration, with the exception of the large field study (Chapter 3) that included the examination of actual physiological changes as a measure of restoration.

2.1.3 Use of Photographic Images

As field experiments can sometimes be logistically challenging, simulated environments are often a more practical option. Previous studies have used a range of materials to simulate an environment, including photographs, video footage, virtual reality (VR), digitally manipulated images and art. The use of photographic images, however, is possibly the most frequently used method and, as noted by Nasar and Lin (2003), has a number of advantages over video recordings or on-site measurements.

First, photographs enable a larger number of participants to experience a variety of different scenes. This is particularly helpful when researchers want to reduce bias, and aid generalizability, by presenting large numbers of landscape type exemplars that can be rated on multiple variables (e.g. 40 each of Urban, Rural and Aquatic settings with four questions per photo; White et al. 2010, Study 1). Second, still images allow factors, such as sound, to be controlled in a way that may not always be possible when using video recordings or in-situ exposure. Third, photographs can capture real scenes that are carefully constructed to test specific content (e.g. Wyles, Pahl, Thomas & Thompson, 2015). Finally, photographic content can be electronically manipulated. For instance, Wilson, Robertson, Daly and Walton (1995) investigated the effect of visual cues on perceptions of water quality. Using pairs of photographs with identical waterscape backgrounds, they manipulated the content of the scene by adding or subtracting key elements: in one image pair they replaced a tyre with a local goose, and in another image pair they presented the photos with and without a large algal bloom.

In view of the above, and in order to assess the perceived restorative potential of a range of settings, my first three studies used the well-established approach of asking people to rate a series of photographic images on a number of variables: aesthetic and behavioural preferences, affect and perceived restorative potential. As mentioned in Chapter 1, the aim of these studies was to compare natural (Study 1) and human-made (Study 2) sub-aquatic settings with more traditionally researched environments (urban, green and above the waterline blue spaces), and to then explore people's responses to different types of aquarium exhibits (Study 3).

2.2 Study 1 and 2: Comparing Natural and Human-made Sub-aquatic Environments with Urban, Green and Blue Space

2.2.1 Introduction

Studies 1 and 2 built on two earlier studies, published by White et al. (2010). I was involved in these studies before my PhD and they have provided the foundation for my current work. The original work with White et al. (2010) had three main aims. First, to systematically investigate whether the presence of water positively affected people's preferences (for example, attractiveness, willingness to visit), affect and perceived restorativeness ratings, for images of both built and natural environments. Second, to examine whether a potential 'dose-response' existed; for instance, do people's responses to the scenes become more positive as the proportion of water in the scene increases? Finally, to re-examine previous work on natural (specifically 'green') and built preferences by excluding water from both of these settings.

In order to achieve these aims, a photo set was developed based on the three core environments: 'Aquatic' (e.g. sandy beach, rocky shore); 'Green' (e.g. woodland, fields and parkland) and 'Built' (e.g. walls, roads). Images were collected that represented these settings alone (e.g. 'Aquatic-Only') or a combination of two environments (e.g. 'Green-Built'). All scenes that featured two environments featured a 1/3rd of one environmental component and 2/3^{rds} of another: for instance 'Green-Aquatic' featured 1/3rd 'green' environment and 2/3^{rds} 'water', and vice versa. Furthermore, in some previous studies, image content (e.g. presence of people or animals) had not always been standardised. For instance, Ulrich et al. (1991) included people in urban but not natural settings. Other studies had excluded animals or people altogether (e.g. Felsten, 2009). Therefore, image content in this study was standardised: images were either 'Scene-Only' or contained 'Objects' (e.g. cars, boats), 'People' or 'Animals'. All photos were of temperate climates (e.g. UK) and were taken in pleasant weather conditions.

The above described photo set was used in two studies. In the first study, there were four questions for each photograph. These questions measured aesthetic ('How attractive do you find this scene?' – see Herzog, 1985) and behavioural preferences ('How willing would you be to visit this scene?' – an approach-avoidance measure, see Ulrich, 1983), and responses were on a scale of 'Not at all' (1) to 'Extremely' (10). The emotion items were designed to reflect the two aspects of the affect circumplex, i.e. valence and arousal (Russell, 1980 – as suggested by de Kort et al., 2006). Participants were asked 'How does this photo make you feel?' with two response scales, 'Very Sad (1) to Very Happy' (10), and 'Calm (1) to Excited' (10). After rating the photos, participants were asked questions that sought to establish their familiarity and preferences for the three core environments.

In order to examine generalisability across measures, the second study used willingness to pay for a hypothetical hotel room with different views as a preference measure ('How much would you be willing to pay for a room with this view?' - see Lange & Schaeffer, 2001). Perceived restorative potential was measured using a short-version of the PRS (see Berto, 2005; Hartig et al., 1997), and included items reflecting Fascination, Being Away, Coherence, Scope and Compatibility.

In both studies only a minority of people either grew up or were currently living in a mostly marine environment. Nevertheless, at least half said that they would prefer to live in such a location. In Study 1, as predicted, both built and natural scenes containing water were associated with greater positive affect, higher preferences, and perceived restorative potential than scenes without water. Also, there was a 'dose-response' relationship between the quantity of Green space in a scene and the positivity of people's preferences and affective responses: the greater the amount of Green space, the more positive the responses. However, for Aquatic scenes, people's preferences were greater, and their emotions were rated more positively, when they viewed images

containing a large amount of water (2/3^{rds}) and smaller quantity (1/3rd) of Green space, compared with images that were 100% Aquatic. In Study 2, people were willing to pay more to stay in a room with a 100% Green vs. 100% Built view, an Aquatic-Green room compared to a fully Green room, and a room with a fully Aquatic view, rather than a fully Built view.

While White et al.'s studies above clearly demonstrate people's preferences for environments that contain aquatic elements, benign sub-aquatic environments may also have the potential to provide restorative experiences. First and foremost, by their very nature, sub-aquatic settings contain water, a dominant characteristic of preferred environments (Ulrich, 1983). Furthermore, taking ART as an example framework, benign underwater settings potentially fulfil the four criteria central to ART. They may contain a variety of different fauna and flora (e.g. coral reef) that capture one's attention effortlessly (Fascination); they are physically located away from a person's everyday setting and routines (Being Away); the setting can be coherently structured and facilitate exploration (Extent), and they may be compatible to a person's goals – people consciously choose to dive, snorkel, build their own aquarium at home or visit a public aquarium, suggesting they are seeking out these particular environments to satisfy some underlying preference (Compatibility). However, individual differences are possible. Some people may find sub-aquatic settings intimidating, for instance, if they cannot swim, the visibility is poor or they are worried about currents or predators. For these people preferences for underwater settings may be low and the environment may not conducive to restoration at all.

My first two photo studies extended the above work by investigating preferences for, affective responses to, and the perceived restorative potential of natural (Study 1) and human-made (aquarium exhibits: Study 2) sub-aquatic waterscapes, and comparing these settings with the more widely researched, and familiar, built and rural landscapes

and waterscapes viewed from above the waterline.

Although most people no longer need to forage underwater for food, a percentage of the population (e.g. SCUBA divers) may be more familiar with this environment than others. Therefore, as familiarity with sub-aquatic environments may be important and could, potentially, influence responses, a secondary question sought to establish whether those with diving experience would show higher preferences for the sub-aquatic scenes.

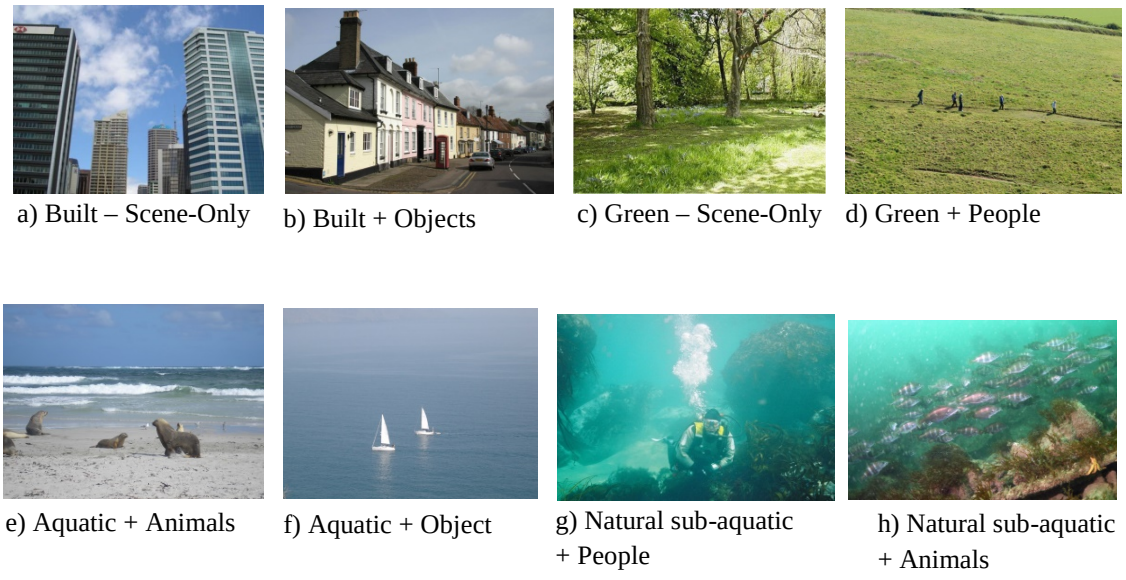
Due to the lack of previous research into sub-aquatic waterscape preferences, no particular outcomes were predicted for Study 1. However, after Study 1 had been completed and the data analysed, it was hypothesised that the images of human-made sub-aquatic environments (aquarium exhibits) in Study 2 would be at least as preferred and potentially restorative as natural underwater scenes and green space, and would be rated more highly than built settings. Furthermore, in light of the inclusion of tropical settings, it was anticipated that the aquarium images would be more preferred than natural underwater images, given that most of the participants in Study 1, who had snorkelling and SCUBA diving experience, expressed an overall preference for tropical seas, rather than temperate.

2.2.2 Methods

2.2.2.1 Development of Photo Sets

Study 1 used a total of 50 colour photographs and included 10 each of three core environment categories featured in White et al. (2010): ‘Built’, ‘Green’ and ‘Aquatic’. In keeping with White et al. (2010), image content was standardised to include images representative of ‘Scene-Only’ (4/10), ‘Scene + Objects’ (2/10), ‘Scene + People’(2/10) and ‘Scene + Animals’ (2/10) (Figure 1). As sub-aquatic settings were of key interest, 20 photographs of ‘Natural sub-aquatic’ scenes were included in the photo set. For these

photographs, image content was standardised as follows: ‘Scene-Only’ (e.g. sandy seabed, 8/10), ‘Scene + Objects’ (e.g. wrecks, 4/10), ‘Scene + People’ (e.g. divers, 4/10) and ‘Scene + Animals’ (e.g. fish, 4/10). All images were representative of flora and fauna found in temperate regions, including many photographs taken around the UK coast. All images had been taken in clement weather conditions. Three practice photographs were also included (one each of sub-aquatic, green and built settings) so that participants could familiarise themselves with the photo rating procedure. Data for these photos were not used again in the main study.



a) Built – Scene-Only
b) Built + Objects
c) Green – Scene-Only
d) Green + People
e) Aquatic + Animals
f) Aquatic + Object
g) Natural sub-aquatic + People
h) Natural sub-aquatic + Animals

Figure 1. Study 1: Example scenes of each environment type

Study 2 used the same 30 original Built/Green/Aquatic photographs and 10 of the natural underwater scenes used in Study 1. Once again, these images were standardised for content. The fifth category, ‘Human-made sub-aquatic’, contained 10 photographs of exhibits typically encountered in public aquariums and, as such, contained mostly tropical exhibits (Figure 2). It was not possible to standardise the images for this category in the same way as the four other categories for several reasons.

All aquarium exhibits tend to contain animals, and rarely contain human-made ‘objects’. Therefore, the ‘Scene-Only’ and ‘Scene + Objects’ categories were not applicable. Aquarium exhibits do sometimes feature divers, who enter the tank for routine husbandry purposes (e.g. feeding fish, cleaning windows), so three of the 10 photographs did include ‘People’. The remaining seven photographs simply featured a variety of aquarium animals (e.g. tropical marine fish) and were therefore most representative of typical aquarium exhibits visitors are most likely to encounter.

a) Human-made sub-aquatic + Animals

b) Human-made sub-aquatic + Animals

c) Human-made sub-aquatic + Animals

d) Human-made sub-aquatic + People

Figure 2. Study 2: Example scenes of human-made sub-aquatic environments (aquarium exhibits)

2.2.2.2 Participants

In both studies, participants were psychology students from Plymouth University, UK, participating for course credit. In Study 1 (N = 77; 61 females; M_{age} = 21.5 years), almost half of the participants (n = 36) said that they had previously snorkelled, free-dived or SCUBA dived. In Study 2 (N = 39; 29 females, M_{age} = 19.5 years), over 40% (n = 16) said they had snorkelled, free-dived or SCUBA dived in the past.

2.2.2.3 Design and Procedure

All participants in Studies 1 and 2 saw all 50 images in a fully repeated measures design. On arrival at the testing laboratory, the participants were briefed about the general nature of the study and informed of the confidentiality of their answers and

their right to withdraw, in accordance with the University's ethical requirements. If they were happy to proceed, they were seated in front of a standard PC, approximately 60 cm away from a flat-screen monitor (42 cm x 27 cm). Participants read an introductory passage that told them that they were going to rate a series of photographs on four variables. The photographs took up roughly 75% of the screen and were shown against a black background. The participants then conducted three practice trials before proceeding with the main study, at their own speed. Four questions were asked about each photograph. The questions appeared below the image in sequence and only after a response was made to the first question (via computer keyboard) was it replaced with the second. Image order was randomised for each participant. After the final photograph rating, participants answered a small number of additional questions (three for Study 1 and two for Study 2), before being debriefed and thanked.

2.2.2.4 Measures

The measures for both studies were the same. Adapted from White et al. (2010; see also Herzog, 1985), the preference questions reflected aesthetic and behavioural preferences: 'How pleasant do you rate this scene?' and 'How willing would you be to hang this picture in your room?', respectively. Responses were on a scale of 'Not at all' (1) to 'Extremely' (10). In White et al. (2010), behavioural preference was measured by asking 'How willing would you be to visit this scene?. However, as some of the photographs were of underwater scenes, that might seem a little unusual to some participants, this item was amended. The affective responses to the photographs were measured by asking 'How does this photo make you feel?' from 'Very Sad (1) to Very Happy' (10) (see de Kort et al., 2006). Perceived restorative potential was measured using a single item adapted from Felsten (2009): 'Overall, to what extent do you think that this scene would be excellent for restoring your ability to concentrate or work

effectively on a demanding project?' with a response scale from 'Not at all (1) to Extremely' (10).

The final questions that followed the final photograph ratings differed slightly between the two studies. At the end of Study 1, participants were asked 'Have you ever snorkelled, free dived or scuba dived?' (Yes/No response). If they answered 'Yes', they were asked 'What best describes the majority of your snorkelling, free diving or SCUBA diving experience?' and 'What sort of snorkelling, free diving or SCUBA diving do you prefer?'. The response options for both questions were: 'Mostly cool water/temperate', 'Mostly warm water/tropical' or 'Mixture of both'. In Study 2, participants were asked 'Have you (either now or in the past) snorkelled, free dived or SCUBA dived?' ('Yes/No' response), and 'To what extent do you find watching fish relaxing?' with responses on a scale from 'Not at all (1) to Extremely' (10).

2.2.3 Results

2.2.3.1 Study 1: Comparing Natural Sub-aquatic Environments with Urban, Green and Blue Space

The responses for each of the four dependent variables were collapsed for all images of land or waterscape environment type, and results were explored using a series of one-way repeated measure Analysis of Variance (ANOVA), with environment type as the within-subjects factor. Based on a pre-screening of means, the environment types were entered, in order from the lowest (built) to the highest (aquatic – above water) means (see Table 1), using repeated contrasts, adjacently ranked environments were compared. The main effect of environment type was significant for all four dependent variables: Aesthetic preference (Attractiveness), $F(3, 228) = 245.72$, $p < .001$; Willingness to display (an image of), $F(3, 228) = 210.85$, $p <. 001$; Positive affect, $F(3, 228) = 205.52$, $p < .001$, and Perceived restorative potential, $F(3, 228) = 198.49$, $p <$

.001 (Table 1). The 'Natural sub-aquatic' images rated significantly higher than 'Built' environments on all four variables: Attractiveness, $F(1, 76) = 161.39$, $p < .001$; Willingness to display, $F(1,76) = 180.20$, $p <. 001$; Positive Affect, $F(1,76) = 129.00$, $p < .001$, and Perceived restorative potential, $F(1, 76) = 151.62$, $p < .001$. Responses to 'Natural sub-aquatic' scenes were, overall, highly comparable to 'Green' environments: there were no significant differences in ratings for Attractiveness, $F(1, 76) = 2.20$, $p =.142$, Willingness to display, $F(1,76) = 3.85$, $p = .053$ or Perceived restorative potential, $F(1, 76) = 0.78$, $p =.379$. However, affective reactions were more positive to 'Green' than 'Natural sub-aquatic' images, $F(1,76) = 6.62$, $p = .012$. Ratings for 'Aquatic' scenes were consistently more positive on all four variables than 'Green' scenes: Attractiveness, $F(1, 76) = 125.09$, $p < .001$; Willingness to display, $F(1,76) = 197.65$, $p <. 001$; Positive Affect, $F(1,76) = 116.42$, $p < .001$, and Perceived restorative potential, $F(1, 76) = 108.96$, $p < .001$).

Responses on all four variables for each environment were collapsed (all Cronbach's alphas[7] > .88) to give an overall preference rating for each environment. In summary, 'Natural sub-aquatic' images ($M = 5.50$, SD 1.28) were rated significantly higher than images of the 'Built' environments ($M = 3.20$, SD .99), significantly lower than the 'Aquatic' (above water line) images ($M = 7.12$, SD 1.13), and not significantly differently from the 'Green' environment images ($M = 5.59$, SD 1.19).

[7] Generally, Cronbach's alpha of ≥ 0.9 Excellent, $0.9 > \alpha \geq 0.8$ Good, $0.8 > \alpha \geq 0.7$ Acceptable, $0.7 > \alpha \geq 0.6$ Questionable, $0.6 > \alpha \geq 0.5$ Poor, $0.5 > \alpha$ Unacceptable.

Table 1. Study 1: Means (*M*) and standard deviations (*SD*) for attractiveness, willingness to display, positive affect and perceived restorative potential for different environments.

Environment Type	Attractiveness		Willingness to display		Positive affect		Perceived restorative potential	
	M	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)
Study 1								
Built	3.50[a]	(1.22)	2.36[a]	(1.03)	3.98[a]	(1.18)	2.95[a]	(1.18)
Natural sub-aquatic	6.15[b]	(1.44)	4.88[b]	(1.60)	5.85[b]	(1.18)	5.10[b]	(1.35)
Green	6.41[b]	(1.33)	4.50[b]	(1.57)	6.22[c]	(1.17)	5.22[b]	(1.37)
Aquatic	7.84[c]	(1.04)	6.68[c]	(1.65)	7.44[d]	(1.03)	6.53[c]	(1.38)

Note: Column means with different superscripts are significantly different, indicating differences between environments ($p < .05$). All scales from 1-10.

In order to examine the relationship between overall 'preferences' and scene content (e.g. Animals, Objects etc.), all four dependent variables were collapsed for each scene content category, for each environment (e.g. All 'Blue Scene + Animals' questions; All 'Green Scene-Only' questions etc.), resulting in 16 variables. These were explored using a 4 (Environment: 'Built', 'Natural sub-aquatic', 'Green', 'Aquatic') x 4 (Scene content: 'Scene-Only', 'Scene + Animals', 'Scene + People', 'Scene + Objects') repeated measures ANOVA (both within-subjects factors, environment and scene content types, were manipulated – see means in Table 2). The scene content types were entered based on a pre-screening of means: 'Scene + Objects' (*M* = 4.54, *SD* .97), 'Scene + People' (*M* = 5.18, *SD* 1.03), 'Scene + Animals' (*M* = 5.71, *SD* .96), 'Scene-Only' (*M* = 5.98, *SD* .97). Repeated contrasts then compared between adjacent scene content types.

Table 2. Study 1: Means (*M*) and standard deviations (*SD*) for different scene contents, for different environment types

Environment Type	**Scene + Objects**		**Scene + People**		**Scene + Animals**		**Scene-Only**	
	M	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)
Study 1								
Built	2.97	(1.06)	2.77	(1.13)	3.70	(1.36)	3.36	(1.12)
Natural sub-aquatic	4.55	(1.66)	5.48	(1.44)	6.04	(1.34)	5.91	(1.51)
Green	4.17	(1.29)	5.81	(1.48)	5.50	(1.50)	6.87	(1.43)
Aquatic	6.47	(1.52)	6.67	(1.63)	7.58	(1.35)	7.78	(1.33)

Note: Scale from 1-10.

As before, there was a main effect of environment, $F(3,228) = 258.81$, $p < .001$, and repeated contrasts revealed a significant difference between Built and Natural sub-aquatic ($p < .001$), no difference between Natural Sub-aquatic and Green ($p = .550$), and a significant difference between Natural sub-aquatic and Aquatic ($p < .001$). There was also a main effect of scene content, $F(3,228) = 106.97$, $p < .001$, with contrasts showing a significant difference between each adjacently ranked scene types: 'Scene + Objects' vs. 'Scene + People', $F(1,76) = 56.58$, $p < .001$; 'Scene + People' vs. 'Scene + Animals', $F(1,76) = 29.79$, $p < .001$; 'Scene + Animals' vs. 'Scene-Only', $F(1,76) = 14.31$, $p < .001$. There was also a significant interaction, $F(9,684) = 24.87$, $p < .001$: means for 'Scene + Animals' dipped in the 'Green' condition, whereas in the other three conditions there was an increase in mean ratings for the 'Scene + Animals', compared to the 'Scene + People' scores (Figure 3). When examining scene content

responses for the environment of concern only (i.e. Natural sub-aquatic images), using a one way ANOVA (with repeated contrasts), and entering the means in increasing order, (Scene + Objects, M = 4.55, SD = 1.66; Scene + People M = 5.48, SD = 1.44; Scene-Only, M = 5.91, SD = 1.51; Scene + Animals, M = 6.04, SD = 1.34), it was noted that 'Scene + Objects' images were significantly less preferred than 'Scene + People', $F(1,76) = 36.83$, $p < .001$, which in turn were significantly less preferred than 'Scene-Only' images, $F(1,76) = 12.15$, $p = .001$. There were, however, no significant differences between mean preference scores for the 'Scene-Only' vs. 'Scene + Animals' images, $F(1,76) = 0.960$, $p = .330$.

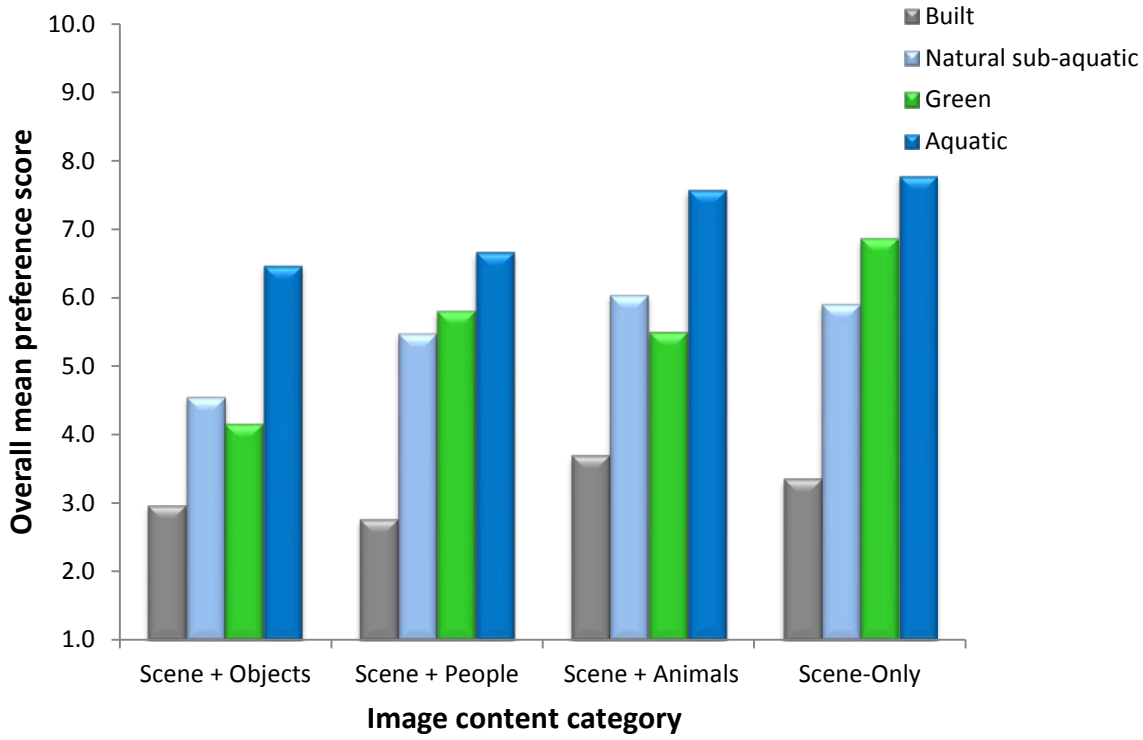


Figure 3. Study 1: Preference ratings for image content categories
Note: Scale from 1-10.

To investigate whether familiarity with sub-aquatic environments influenced responses, a series of independent sample *t*-tests were conducted comparing responses of participants with and without sub-aquatic experience (divers vs. non-divers). This

analysis revealed no differences in responses to any of the three normal landscape types ('Built', 'Green' and 'Aquatic'), on any of the four dependent variables. However, of greater interest was the possibility that responses to sub-aquatic waterscapes might be affected. Although there were no significant differences between the two groups for Attractiveness, Willingness to display, or Perceived restorative potential (all *p*s > .16), divers/snorkellers (M = 6.14) did report more Positive affective responses than non-divers (M = 5.60) to the 'Natural sub-aquatic' images, $t(75) = 2.01$, $p = .048$. A series of one-way ANOVA indicated that preferences for, and familiarity with, different sub-aquatic environments (i.e. temperate vs. tropical) among divers did not affect responses to the four measures. However, of relevance to subsequent studies, it was noted that of those participants who had previous snorkelling or diving experience, 58% said their experiences were in mostly tropical waters, 25% stated mostly temperature waters, and 17% said a mixture of both. In terms of location preferences, 72% preferred to dive in tropical seas, 6% in temperate water and 22% preferred a mixture.

2.2.3.2 Study 2: Comparing Human-made Sub-aquatic Environments with Urban, Green and Blue Space

Analysis for Study 2 followed the same basic pattern as Study 1. The responses for each of the four dependent variables were collapsed for the 10 images of each land/waterscape type and were examined using a series of one-way repeated measures ANOVA. Following a pre-screening of means, environment types were entered in order (lowest to highest), enabling repeated contrasts to compare adjacently ranked environments (Table 3). The main effect of environment type was significant for all four measures: Attractiveness, $F(4, 152) = 142.87$, $p < .001$; Willingness to display, $F(4, 152) = 91.13$, $p < .001$; Positive affect , $F(4, 152) = 94.87$, $p < .001$; and Perceived restorative potential, $F(4, 152) = 86.12$, $p < .001$. As before, the 'Built' environment

was the least preferred environment and scored significantly lower on all four variables (all *p* values < .001) than did images of natural environments ('Natural sub-aquatic', 'Green' and 'Aquatic') and 'Human-made sub-aquatic' (aquarium exhibits/managed nature).

Table 3. Study 2: Means (*M*) and standard deviations (*SD*) for attractiveness, willingness to display, positive affect and perceived restorative potential for different environments.

Environment Type	**Attractiveness**		**Willingness to display**		**Positive affect**		**Perceived restorative potential**	
	M	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)
Built	3.18[a]	(1.37)	2.23[a]	(1.10)	3.58[a]	(1.29)	2.45[a]	(1.06)
Natural sub-aquatic	6.19[b]	(1.80)	4.94[b]	(2.05)	5.78[b]	(1.62)	4.83[b]	(1.98)
Green	6.53[b]	(1.28)	4.67[b]	(1.70)	6.21[b]	(1.32)	5.17[b]	(1.68)
Human-made sub-aquatic (aquarium)	7.64[c]	(1.30)	6.40[c]	(1.92)	7.02[c]	(1.45)	5.88[c]	(1.92)
Aquatic	7.89[c]	(1.27)	6.61[c]	(1.99)	7.35[c]	(1.49)	6.48[d]	(1.85)

Note: Column means with different superscripts are significantly different, indicating differences between environments ($p < .05$). All scales from 1-10.

There were no significant differences between ratings for 'Natural sub-aquatic' and 'Green' environments on any of the four variables (all *p*s > .05) but both of these environments were significantly less preferred than 'Aquatic' and 'Human-made sub-aquatic' scenes (all *p*s < .01). 'Aquatic' and 'Human-made sub-aquatic' images were the most preferred environments, and, although ratings for 'Aquatic' images were consistently higher, there were no significant differences between these waterscapes for Attractiveness $F(1,38) = 1.82$, $p = .185$; Willingness to display, $F(1,38) = 0.986$, $p =$

.327 or Positive affect $F(1,38) = 3.35$, $p = .075$: 'Aquatic' images, however, were perceived as more restorative $F(1,38) = 6.40$, $p = .016$.

As for overall preferences, responses to all four measures for each land/waterscape environment were collapsed (all Cronbach's alphas > .90) to give a rating for each environment. The environment of interest, 'Human-made sub-aquatic' ($M = 6.73$, SD 1.49), was rated significantly higher than images of 'Built' ($M = 2.86$, SD 1.07), 'Natural sub-aquatic' ($M = 5.44$, SD 1.74) and 'Green' environments ($M = 5.65$, SD 1.37) but was rated similarly to 'Aquatic' (above water line) images ($M = 7.08$, SD 1.54).

Due to the inability to standardise scene content, no analysis of the effect of scene content was undertaken in Study 2. However, the effect of familiarity with sub-aquatic environments was again examined by comparing the differences in environment ratings between divers and non-divers on each of the four variables using one-way ANOVA. Despite divers tending to rate all environments higher than non-divers, there were no statistically significant differences between the two groups for any of the environments, on any of the four variables. Therefore, familiarity with sub-aquatic environments appeared to be unimportant in this study.

2.2.4 Brief Summary

Both studies found that ratings for the 'Natural sub-aquatic' waterscape images were comparable to the ratings for the more traditionally researched 'Green' landscapes. The 'Natural sub-aquatic' waterscapes, however, were generally rated less positively than the images 'Aquatic' (above the waterline) scenes. In agreement with many previous studies, both studies rated waterscapes higher on preferences and perceived restorative potential than rural/green and urban/built landscapes without water. In Study 2, as hypothesised, images of aquarium exhibits were rated more highly than built,

green space and natural sub-aquatic images, and similarly to above-water aquatic scenes.

However, although the aquarium images were significantly more preferred than natural sub-aquatic ones, this may be the result of the more 'exotic' nature of many images included in the 'Human-made sub-aquatic' (aquarium) category. As the main aim of Study 2 was to simply gain an overall impression of people's reactions to a range of typical aquarium exhibits, the majority of images used were of tropical species. This reflects the fact that while public aquariums found in temperate locations (e.g. the UK) tend to house tropical species, as well as a mixture of local (temperate) species, there is much less of a tendency for aquariums located in tropical regions (e.g. the Caribbean) to house non-native, temperate species as well as tropical species. Therefore, potentially, if only images of temperate marine animals had been included in the aquarium category there may have been little, if any, difference between ratings for the aquarium images and those of the natural (temperate) underwater scenes. Therefore, in light of high ratings for the aquarium images (compared to the temperate, natural sub-aquatic scenes), and the divers'/snorkellers' overall preferences for tropical diving experiences, the third study sought to focus purely on human-made sub-aquatic environments with the aim of establishing whether the biological characteristics of an exhibit influenced self-reported well-being outcomes. To achieve this, a further photo study was designed that systematically categorised typical aquarium exhibits by region, species richness and abundance.

2.3 Study 3: Comparing Responses to Different Aquarium Exhibit Types

2.3.1 Introduction

Previous studies have found that people's psychological responses to different environments can be affected by the biological components within that setting. Some of

these studies have focused on people's responses to species richness only. For instance, Fuller et al. (2007) and Dallimer et al. (2012) noted that well-being measures, such as opportunities for reflection, tended to be more positive in urban or semi-urban parks that contained greater actual, or perceived, species richness. However, these studies found that people's psychological responses to an environment varied depending on taxon (e.g. birds, butterflies and plants). Furthermore, even within a group of plants or animals, preferences may emerge. In a study exploring aesthetic preferences for plants in a botanical garden, Lindemann-Matthies and Bose (2007) found that visitors to the botanical garden created structurally diverse and species rich assemblages when asked to create their ideal patch of meadow, indicating a spontaneous preference for diversity.

Although more logistically challenging to examine in a field setting, other studies have explored the effects of abundance, as well as species richness. For instance, Luck et al. (2011) measured personal and neighbourhood well-being in 36 residential neighbourhoods in southeastern Australia. To measure personal well-being they used a cross-cultural, self-report subjective well-being index that included eight items that represented different aspects of life satisfaction. For neighbourhood well-being, they developed their own eight item index that represented the level of satisfaction the residents' felt about living in their neighbourhood. Luck et al. found that personal well-being and neighbourhood well-being were positively associated with species richness and abundance of birds, and vegetation cover and density.

Individual groups of animals themselves have also been the focus of some studies. People have clear preferences for different animals and tend to like animals they find 'human-like', attractive, intelligent and/or tame; animals that they think of as unattractive, dangerous or unpleasant in some way are generally unpopular (Kellert, 1993; Woods, 2000).

There are a number of reasons why people may react differently to environments

containing different species. Some species may be more visible or abundant than others (Fuller et al., 2007) or reactions may be driven by personal preferences for particular species (e.g. Woods, 2000). However, studies in which small aquaria have been used to provide stress recovery and relaxation have tended to use one small hobbyist tank, usually of freshwater tropical fish (e.g. Katcher et al., 1984), or a generic videotape of tropical fish (e.g. DeSchriver and Riddick, 1990). There do not appear to have been any attempts to ascertain whether different fish species, and configurations of these species, affect well-being outcomes.

Hence, using the same measures as Studies 1 and 2, Study 3 aimed to investigate people's responses to different types of exhibit typically found in public aquariums. Based on my experience of aquarium exhibits and also findings from Study 1, in which participants who were SCUBA divers frequently expressed a preference for tropical exhibits, images were categorised by climatic region (Temperate/Tropical water). Images were then further sub-categorised by biological taxon, species richness and abundance of individuals. Based on previous studies it was hypothesised that preferences and perceived restorative potential would be greater for tropical exhibits (see Study 1, diver preferences), vertebrates (e.g. Woods, 2000), and exhibits containing a higher abundance of animals, and greater species richness (e.g. Luck et al., 2011).

2.3.2 Methods

2.3.2.1 Development of Photo Set

A set of 40 photographs representing different exhibit types typically found in public aquariums was developed (Figure 4). In order to keep the photo set manageable, the full range of animals that could possibly be found in a public aquarium was not included. Instead, I decided to concentrate on fish, the most common group of animals found in public aquariums (and also the most common in home aquaria). These images

were to be sub-categorised by species richness and abundance. However, while the original intention was to explore responses to temperate and tropical fish species only, there were insufficient images available for the High species richness/Low abundance category. In view of this, I decided to replace this category with another – 'Invertebrates' – that are also commonly found in aquariums, usually in relatively low numbers. This development resulted in a somewhat less 'balanced' photo set but one that was still representative of the majority of species found in public aquariums. This also resulted in two sets of analyses being undertaken (see section 2.3.3): responses to Low species rich/Low abundance of Invertebrates vs. Vertebrates, and responses to all Vertebrate (fish) only categories (High species richness/High abundance; Low species richness/High abundance; Low species richness/Low abundance).

These images were initially categorised by climatic region (Temperate/Tropical water), and further sub-categorised by biological taxon (Invertebrate/Vertebrate), species richness (Low/High) and abundance of individuals (Low/High). Thirty images of vertebrates (all fish species) and ten images of invertebrates (mostly crustaceans) were selected. As far as possible, sub-categories were balanced for animals that appear to be more or less popular ('charismatic' vs. 'less charismatic' species) with aquarium visitors.

Photographs were sourced from my personal collection and those of colleagues. A small number of images were collected from the internet using sites such as Flickr. Permission to use all photographs was obtained. Although an initial search of photographs yielded a vast number of potential images, the large majority of these were discounted due to poor quality or unsuitable content (e.g. blurred fish movement, reflected camera flash or visitors obscuring the view of the tank). A shortlist of images was reviewed and rated by six aquarium biologists at the National Marine Aquarium. The aquarium biologists were instructed to select five images most representative of

each of the eight exhibit sub-categories (example sub-category: Temperate - High abundance/High species richness).

a) Temperate: High nos./ high species richness

b) Temperate: High nos./ low species richness

c) Temperate: Low nos./ low species richness (vertebrates)

d) Temperate: Low nos./ low species richness (invertebrates)

e) Tropical: High nos./ high species richness

f) Tropical: High nos./ low species richness

g) Tropical: Low nos./ low species richness (vertebrates)

h) Tropical: Low nos./ low species richness (invertebrates)

Figure 4. Study 3: Example scenes of different aquarium exhibits

It should be noted from examples of the above images, that it was not possible to ensure that all images were wholly standardised with regard to issues such as proximity and depth of field. This partly, again, represents the availability of images from which to select but also indicates the types of actual views that visitors gain of the animals during a typical visit. For instance, visitors cannot necessarily get close views of individual animals when viewing a very large exhibit (e.g. Fig. 4e). These exhibits may be 10s of meters in length, height and width, and often individual animals are simply too far away to be viewed in any great detail. In contrast, much smaller exhibits often provide a clearer, closer view of the animals on display. Furthermore, often individual or extremely small numbers (e.g. a pair) of animals may be deliberately exhibited in small tanks that visitors can get physically very close to so that the animal's particular aesthetic features or behaviours can be appreciated.

2.3.2.2 Participants

Participants (N = 40) were students at a UK university who participated for course credit (27 females, M age = 20.8 years, age range 18-35 years). Nearly half of the participants (n = 18, 45%) had snorkelling, SCUBA or free diving experience.

2.3.2.3 Design, Procedure and Measures

The procedure and measures were identical to Studies 1 and 2: participants were asked to rate photographs on four variables, and were asked about prior diving experience and how relaxing they found watching fish.

2.3.3 Results

Responses for each exhibit sub-category were collapsed (Table 4) and the results for each dependent variable was examined using a series of repeated measures ANOVA.

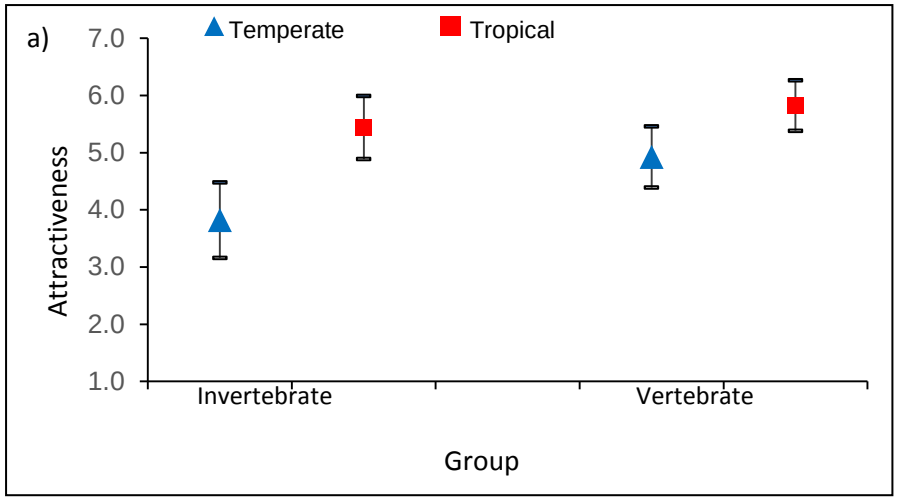
First, a two (region: Temperate; Tropical) by two (biological taxon: Invertebrates; Vertebrates) repeated measures ANOVA was conducted on the Low abundance/Low species richness category (Figure 5a). There was a significant effect of region: images of Tropical species were consistently more preferred than those of Temperate species on all four variables (Attractiveness: $F(1,39) = 80.30$, $p < .001$; Willingness to display: $F(1,39) = 64.24$, $p < .001$; Positive affect: $F(1,39) = 92.93$, $p < .001$; Perceived restorative potential: $F(1,39) = 51.49$, $p < .001$). In addition, Vertebrates were significantly more preferred than Invertebrates (Attractiveness: $F(1,39) = 29.76$, $p < .001$; Willingness to display: $F(1,39) = 13.57$, $p = .001$; Positive affect: $F(1,39) = 30.81$, $p < .001$; Perceived restorative potential: $F(1,39) = 23.47$, $p < .001$). There was also a significant interaction for three of the four variables (Attractiveness: $F(1,39) = 12.02$, $p = .001$; Willingness to display: $F(1,30) = 4.80$, $p =$

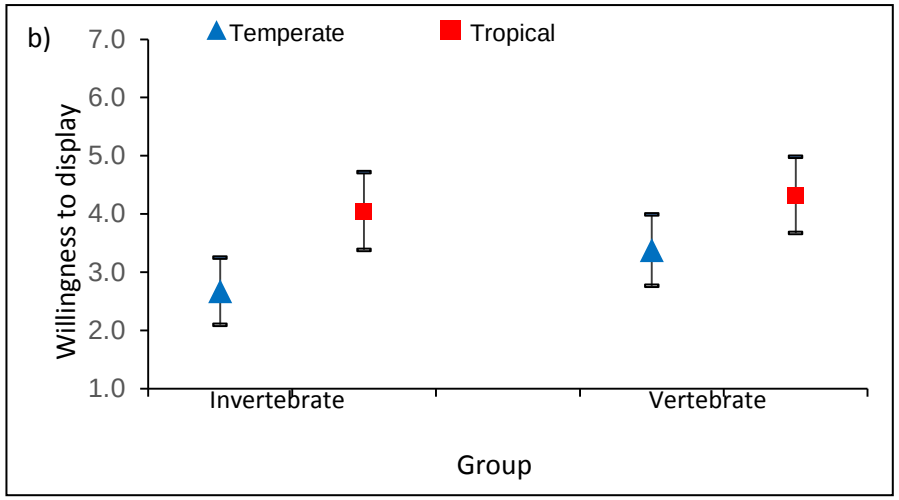
.035; Perceived restorative potential: $F(1,39) = 6.45$, $p = .015$). This suggested that the content of Temperate exhibits (i.e. whether Invertebrates or Vertebrates were present) was more important than for Tropical exhibits (emphasised in Figure 5b).

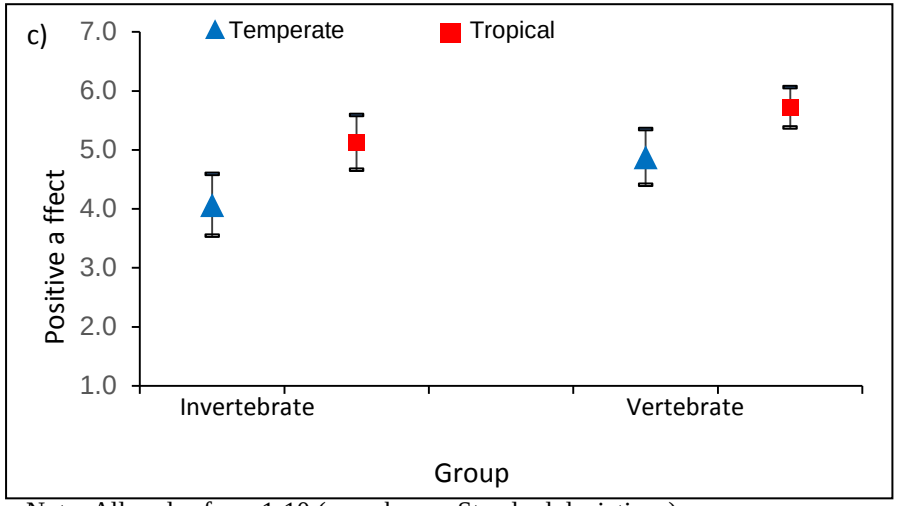
Table 4. Study 3: Means (*M*) and standard deviations (*SD*) for attractiveness, willingness to display, positive affect and perceived restorative potential for different exhibit types.

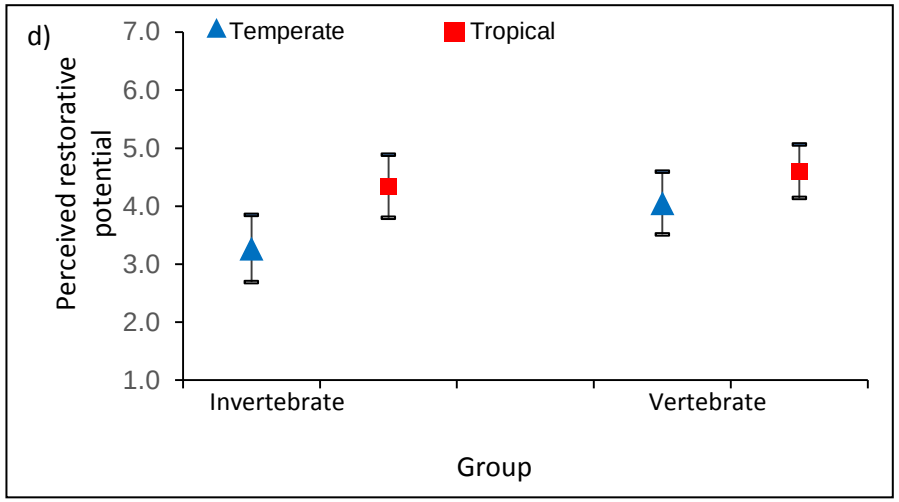
Environment (exhibit) content				**Variables**			
Biological taxon	**Region (no. of images)**	**Species rich-ness**	**Abundance**	**Attractive-ness**	**Willing-ness to display**	**Positive affect**	**Perceived restorative potential**
				M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Invertebrate	Temperate (5)	Low	Low	3.82 (2.06)	2.67 (1.81)	4.06 (1.64)	3.27 (1.81)
Invertebrate	Tropical (5)	Low	Low	5.44 (1.72)	4.05 (2.08)	5.12 (1.45)	4.34 (1.70)
Vertebrate	Temperate (5)	Low	Low	4.93 (1.67)	3.38 (1.93)	4.88 (1.48)	4.05 (1.69)
Vertebrate	Tropical (5)	Low	Low	5.83 (1.38)	4.33 (2.05)	5.72 (1.07)	4.60 (1.44)
Vertebrate	Temperate (5)	Low	High	6.10 (1.34)	4.31 (1.80)	5.58 (0.99)	4.60 (1.56)
Vertebrate	Tropical (5)	Low	High	6.94 (1.07)	5.38 (1.80)	6.29 (1.00)	5.22 (1.64)
Vertebrate	Temperate (5)	High	High	4.80 (1.29)	3.31 (1.47)	4.63 (1.20)	3.90 (1.44)
Vertebrate	Tropical (5)	High	High	7.67 (0.98)	6.05 (1.78)	6.92 (1.21)	5.62 (1.91)

Note: All scales from 1-10.



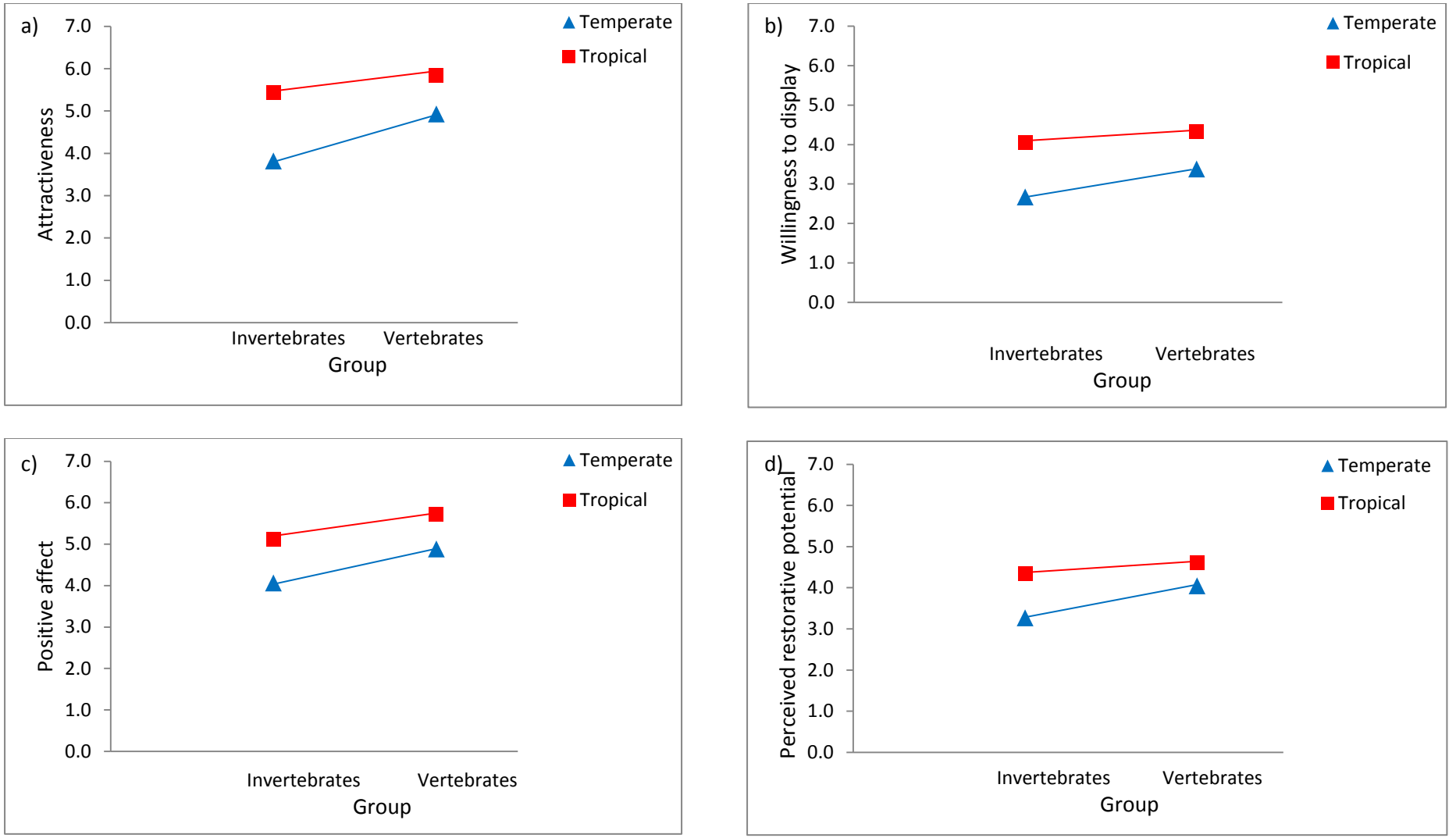






Note: All scales from 1-10 (error bars = Standard deviations).

Figure 5a. Study 3: Mean preference ratings for attractiveness, willingness to display, positive affect and perceived restorative potential as a function of climatic region and biological group (Low abundance/Low richness images only).



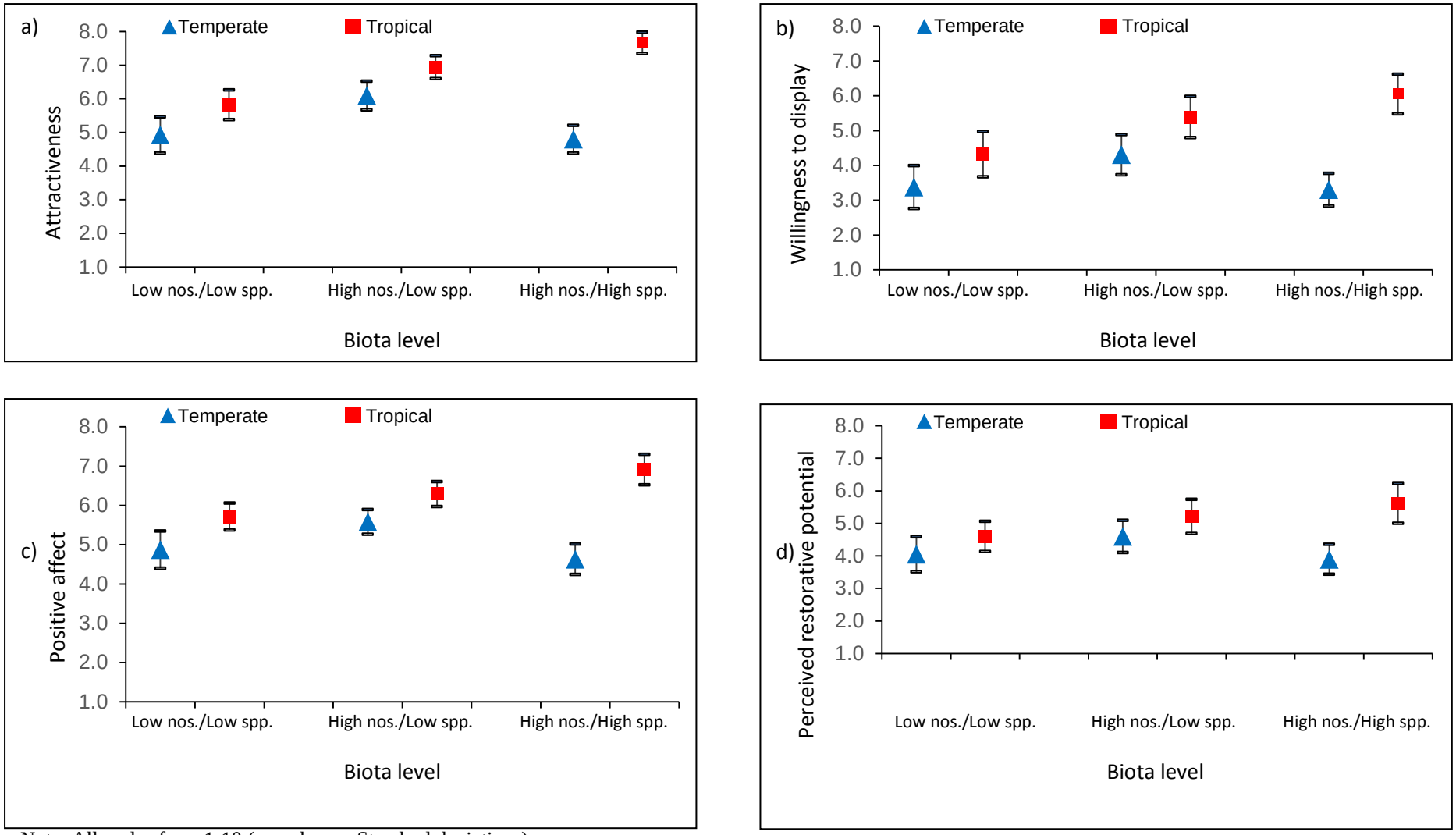
Note: All scales from 1-10 (error bars = Standard deviations).

Figure 5b. Mean preference ratings for attractiveness, willingness to display, positive affect and perceived restorative potential as a function of climatic region and biological group (Low abundance/Low richness images only).

Second, a series of two (region: Temperate; Tropical) by three (biota level: Low species richness/Low abundance; Low species richness/High abundance; High species richness/High abundance) repeated measures ANOVA were carried out on the four dependent variables (Figure 6).

Once again there was a significant effect of region: images of Tropical species were consistently more preferred than those of Temperate species on all four measures: Attractiveness: $F(1,39) = 135.99$, $p < .001$; Willingness to display: $F(1,39) = 141.29$, $p < .001$; Positive affect: $F(1,39) = 174.04$, $p < .001$, and Perceived restorative potential: $F(1,39) = 79.93$, $p < .001$. There was also a significant effect of biota level for all four measures: Attractiveness: $F(1,39) = 135.99$, $p < .001$; Willingness to display: $F(1,39) = 141.29$, $p < .001$; Positive affect: $F(1,39) = 174.04$, $p < .001$, and Perceived restorative potential: $F(1,39) = 79.93$, $p < .001$.

Repeated measures contrasts revealed that the High abundance/Low species richness condition was rated significantly higher than the Low abundance/Low species richness condition: Attractiveness: $F(1,39) = 23.27$, $p < .001$; Willingness to display: $F(1,39) = 15.88$, $p < .001$; Positive affect: $F(1,39) = 11.90$, $p = .001$, and Perceived restorative potential: $F(1,39) = 8.15$, $p = .007$. Comparison of the High abundance/High species richness and High abundance/Low species richness conditions found that there was only a statistically significant difference for Attractiveness, $F(1,39) = 6.49$, $p = .015$.



Note: All scales from 1-10 (error bars = Standard deviations).

Figure 6. Study 3: Mean preference ratings for attractiveness, willingness to display, positive affect and perceived restorative potential as a function of climatic region and biota level.

A series of paired samples *t*-tests revealed that, although ratings for the Tropical High abundance/High species richness exhibits were consistently and significantly greater than the Tropical High abundance/Low species richness ratings (Attractiveness: $t(39) = 6.75$, $p < .001$; Willingness to display: $t(39) = 4.76$, $p < .001$; Positive affect: $t(39) = 5.00$, $p < .001$; Perceived restorative potential: $t(39) = 2.84$, $p = .007$), intriguingly, the opposite was true for the Temperate images: the High abundance/Low species richness images were preferred to the High abundance/High species richness images: Attractiveness: $t(39) = 6.83$, $p < .001$; Willingness to display: $t(39) = 5.85$, $p < .001$; Positive affect: $t(39) = 5.93$, $p < .001$; Perceived restorative potential: $t(39) = 4.25$, $p = .007$). With regard to how relaxing participants found watching fish overall, ratings were comparable to Study 1 ($M = 7.50$, SD 1.47).

Both divers and non-divers rated the high abundance categories similarly and there were no significant differences between the two groups (although participant numbers for analysis were small). Interestingly, there were some significant differences in ratings for the low abundance categories. In this instance, divers consistently rated the Low abundance/Low species richness categories higher than non-divers. Although, overall, low abundance images tended to be rated lower than high abundance images, most of the means from divers' responses were above the mid-point (5.5 on the 1-10 scale) and many were significantly different from non-divers, especially regarding how the image made them feel. For this particular question, divers rated both Temperate and Tropical Vertebrate (Temperate: $F(1,38) = 6.17$, $p = .018$; Tropical: $F(1,38) = 7.77$, $p = .008$) and Invertebrate (Temperate: $F(1,38) = 8.09$, $p = .007$; Tropical: $F(1,38) = 5.67$, $p = .022$) images significantly higher than non-divers. There was no significant difference between diver and non-diver ratings for how relaxing they found watching fish (overall $M = 7.50$, SD 1.47).

Finally, as mentioned, I ensured that images in the Low abundance/Low species

richness categories were ‘balanced’ by including images that represented both ‘charismatic’ and ‘ less charismatic’ species. Although not of primary interest in this study, I explored whether participants’ responses did reflect visitors’ preferences for more charismatic species. A paired sample *t*-test was carried on collapsed responses (i.e. the mean of all four dependent variable means) for ‘charismatic’ vs. ‘less charismatic’ images. I found that there was a significant difference in responses to these sub-categories (charismatic: $M = 4.88$, $SD = 1.40$; less charismatic: $M = 3.93$ $SD = 1.460$, $t(39) = 9.14$, $p < .001$). A further two paired *t*-tests (comparing Tropical charismatic/less charismatic vs. Temperate charismatic/less charismatic), highlighted that there were also differences between responses for the different regional categories. In keeping with other findings for this study, the Tropical images were significantly preferred to the Temperate equivalents: Tropical charismatic ($M = 5.65$, $SD = 1.34$), Temperate charismatic ($M = 4.12$, $SD = 1.62$), $t(39) = 9.49$, $p < .001$; Tropical less charismatic ($M = 4.21$, $SD = 1.49$), Temperate less charismatic ($M = 3.65$, $SD = 1.49$), $t(39) = 6.44$, $p < .001$.

2.3.4 Brief Summary

Generally, there was support for the hypotheses and previous, related studies. Participants preferred tropical exhibits to temperate versions of the same exhibit type, higher numbers rather than lower numbers of individuals, and vertebrates to invertebrates. The significant preference for images of vertebrates (all fish in this study), rather than invertebrates, is in keeping with other studies, such as Kellert (1993). However, intriguingly, and contrary to the original hypothesis, high species richness was only rated more highly for the tropical exhibits: the temperate exhibit images scored more highly when species richness was low. As a supplementary thought, there were significant preferences for charismatic, rather than less charismatic, species.

2.4 Discussion

2.4.1 Summary of Main Findings

Photo studies 1 and 2 were the first to place sub-aquatic settings in the context with other, more traditionally researched landscape types. In both studies, sub-aquatic settings were at least as preferred and potentially restorative as green space. In Study 1, it was possible to explore the relationship between preferences and scene content. Interestingly, it was noted that while 'Scene + Objects' was the least preferred scene category, in agreement with White et al. (2010), the highest rated scene category in Study 1 was 'Scene-Only': in White et al. (2010) 'Scene + People' tended to be the most preferred scene category.

In Study 2, images of aquarium exhibits were significantly more preferred than those of natural sub-aquatic images and green space scenes, and were rated similarly to the most highly rated environment (aquatic – above water). However, as mentioned, this is likely to be a reflection of the more exotic nature of many images used in this study as they were predominately of tropical exhibits, rather than temperate ones. In order to reflect natural habitats, tropical exhibits in aquariums tend to be more brightly lit than temperate exhibits and, in general (although there are exceptions, e.g. male Cuckoo wrasse, *Labrus mixtus*), temperate species tend to be less colourful than tropical species. Photographs in the other environment categories were all of temperate locations (e.g. locations around the coast of the UK). Initially, it was tempting to only use temperate aquarium exhibits in Study 2 to maintain consistency, however, this would not have been representative of a 'typical' aquarium visit. Although, there are examples of public aquariums that house only temperate or cold water species (e.g. MacDuff Aquarium, North East Scotland http://www.macduff-aquarium.org.uk/), this is relatively uncommon. The majority of aquariums around the world (even in temperate locations) house either a mixture of tropical and temperate species (e.g. Deep Sea World,

Edinburgh, http://www.deepseaworld.com; Loch Lomond, Scottish Highlands, http://www.visitsealife.com/loch-lomond/; and Aquaria Vattenmuseum, Sweden, http://www.aquaria.se) or just house tropical species (e.g. Marine Habitat at Atlantis, Bahamas http://www.atlantisbahamas.com/thingstodo/marinehabitat), that are native to the region. If the aquarium images in Study 2 had been of temperate species only then there may have been fewer, if any, differences between the natural and human-made sub-aquatic categories.

With regard to Study 3, on the whole, the hypotheses were supported. When viewing a range of different exhibit types, participants usually preferred tropical exhibits to temperate exhibits, exhibits containing a higher number of animals to lower numbers, and vertebrate species to invertebrates. Nevertheless, one finding in this study was contrary to predictions. Although, as hypothesised, the Tropical High abundance/High species richness category was scored significantly higher than both of the Low species richness categories (High abundance/Low species richness; Low abundance/Low species richness), the same pattern was not evident for the temperate equivalents. The Temperate High abundance/High species richness category was rated surprisingly low by participants.

There are a number of potential explanations for these results. It is possible, for instance, that the relatively poor ratings for this category partly reflect the lack of good quality images available to enable this category to be represented at its best. Although there were many good quality images of large, tropical mixed species exhibits (indicative of the High abundance/High species richness category), equivalent images of temperate exhibits were rare. As mentioned, this is likely to be the result of aquarium theming. Aquarium exhibits are designed to simulate a natural habitat and, in tropical regions, species are usually brightly coloured and well illuminated in clear water, creating visually pleasing displays. In contrast, however, light intensity in temperate

regions is often lower, and species are frequently less colourful and can be more difficult to see. In keeping with natural settings, temperate exhibits, particularly deeper displays, are often dimly lit. This alone will make taking photographs more challenging. Taking photographs without flash, and compensating by using a slower shutter speed or faster film, will result in moving objects being blurred. The alternative, using flash, will result in a crisper image but, undesirably, the camera flash will be reflected in the exhibit window. Therefore, despite an apparently endless supply of aquarium images, the vast majority of photographs obtained were unusable: blurred fish movement, camera flash reflection, and also too many visitors blocking the view of the animals, all contributed to photographs being unsuitable for inclusion in the study. Additionally, photographs of some exhibit sub-categories featured more heavily than others. For instance, images of colourful coral reef exhibits, 'charismatic' species (e.g. clownfish and jellyfish), dynamic schooling fish and exhibits housing large and impressive animals, such as whale sharks (*Rhincodon typus*), were especially well represented. Potentially, the overall lack of available images was also an indication of people's behavioural preferences. It is possible that people simply take fewer photographs of exhibits they do not find interesting or pleasing in some way. Alternatively, perhaps they do take images of temperate exhibits but these are rarely of sufficient quality to keep in a personal collection or upload to a website.

It is also possible that the actual content of the exhibit categories influenced preferences. The presence of a number of images of schooling fish in the Temperate High abundance/Low species richness may have contributed to this category being more preferred than the High abundance/High species richness category. These 'bait ball' images (e.g. Figure 7) were extremely striking, and it is possible that the participants found the inferred movement fascinating, despite the uniform appearance of the fish. On this subject, although a comparison of charismatic and less-charismatic species was not

of central interest in this study, the findings suggest that more charismatic species may significantly impact on preferences, affect and perceived restorativeness, and should perhaps be investigated further. Interestingly, Dallimer et al. (2012) stated that "it is equally possible that the abundance of a given taxonomic group is more important or noticeable than the number of different species" (p. 51).

Although these findings suggest that people clearly find some exhibit characteristics preferable and potentially more restorative than others, I am certainly not suggesting that public aquariums are only filled with animals that people 'like best'. Less aesthetically pleasing animals are still ecologically important and demonstrate the diversity of the marine environment. Whilst many people do visit aquariums for 'entertainment', this is not their sole (or even main) purpose: aquariums aim to foster a greater understanding of their animals, and the threats that they face, in an effort to promote conservation and encourage visitors to establish more pro-environmental behaviours. Instead, I believe that finding variability in preferences and perceived restorative potential between different exhibit types, (especially as greater species richness may not always be the preferred over less species richness) is significant as, potentially, it suggests that different fish assemblages may provide different health and well-being outcomes. If certain animals or behaviours are found to be particularly relaxing, uplifting or stimulating to watch, then these assemblages could be 'tailored' depending on purpose and circumstance (e.g. calming vs. energising experiences).

Figure 7. Example of schooling fish in Temperate High abundance/Low species richness category.

2.4.2 Limitations

The three photo studies provided an effective method of exploring people's preferences for different human-made and natural settings, and aquarium exhibit types. Nevertheless, the use of photos can have some limitations, especially if the photo sets are quite sizeable. For instance, due to the number of photographs being evaluated in each study, it was decided to use one item per construct. Although this is a common approach when there are numerous settings to evaluate (e.g. Felsten, 2009; White et al., 2010), it can reduce the sensitivity to underlying constructs. Thus, in future work that uses smaller stimuli sets, and therefore places fewer burdens on participants, it may be preferable to use established multi-item scales (e.g. Perceived Restorativeness Scale - Hartig et al., 1997) to ensure greater robustness in concept measurement.

Furthermore, it is likely that some of the images or image categories were

confounded. This could be especially true of the stimuli material used in Study 3. There was a noticeable difference between scenes containing large numbers of species and those featuring only a few animals, particularly with regard to considerations such as proximity, depth of field and clarity of image. For instance, visitors usually only gain a distant view of animals contained in large, mixed exhibits, whereas they are likely to obtain clearer views of fish and invertebrates housed in smaller tanks as the animals are physically closer to the visitors viewing them. Indeed, some animals are deliberately housed in small 'specimen' tanks in order that visitors can get a close-up view of a particularly feature (e.g. the delicate patterning of a Harlequin shrimp, *Hymenocera picta*) or behaviour (e.g. 'sand sifting' feeding behaviour of the Blue cheek goby, *Valenciennea strigata*). Therefore, as images were selected based on a 'visitor's view' of the exhibits, which naturally varies throughout the course of an aquarium visit (e.g. distant vs. close-up views), it is difficult to determine exactly how these confounds could be addressed and also how they could affect preferences and, ultimately, data interpretation.

Furthermore, even within the same sub-category images were often confounded: sizes of aquarium exhibit area and theming differed, as did quality and quantity of lighting and, most pertinently, the number of species and individuals. Although aquarium exhibits are not 'standard', every effort was made to try and standardise the images used in the sub-categories as far as possible from the images available. Unfortunately, however, despite best efforts confounds remained that may, ultimately have affected, findings.

Also, although photo sets are a practical means of assessing a large number of exemplars of a range of different settings, it is possible that they may not adequately represent responses to real environments, particularly those containing water. Studies that have examined whether simulated settings can sufficiently represent real settings

(e.g. Kjellgren and Buhrkall, 2010), often find that while simulated natural settings may provide psychological and physiological health benefits, real natural environments tend to enhance health benefits further. On this point, Huang (2009) actively sought to investigate how the use of visual surrogates to represent waterscapes compared to in-situ experiences. Specifically, Huang compared participants' responses (e.g. behavioural, emotional) to slides and video footage, to their responses in the real environment, and found that slides were only able to sufficiently represent the still physical features in the waterscape (e.g. built objects). Although Huang found that video footage was better than slides for conveying the dynamic aspects of a scene, such as water flow, participants' on-site preferences and emotional responses were significantly stronger than those of either visual substitute.

In view of this, although static images are commonly employed in landscape research, photographs may not necessarily the best way to represent environments containing water (see also Nasar & Lin, 2003), or highly mobile species, such as fish. Where practical, a greater use of video footage and field studies may be beneficial.

2.4.3 Conclusions

Overall, findings from the three photo studies contribute to a greater understanding of the preferences for, and the restorative potential of, natural and human-made underwater settings, both areas of research that have received relatively little attention. Findings from Study 1 and 2 suggested that both natural and human-made sub-aquatic environments were preferred to urban settings, and were rated at least as highly as green space environments. Study 3 found that participants', in general, displayed markedly different reactions to different examples from one setting type. In this study, participants' responses were influenced by the biological content of the aquarium exhibits: tropical exhibits and exhibits containing vertebrates (fish) were

rated significantly higher than temperate exhibits and those containing invertebrates. Participants also tended to prefer exhibits containing a higher abundance of fish and/or species. This study highlights how important it may be to sub-categorise components in a particular environment, in order to establish which components of that setting contribute most to perceived well-being outcomes.

Although the photo studies provided extremely valuable data, there are limitations associated with using static images in a laboratory setting. In view of this, my next study took place in the field: a public aquarium.

Chapter 3.

Psychological, physiological and behavioural responses to different levels of the same type of aquarium exhibit

Chapter 3 is based on the publication: Cracknell. D., White, M. P., Pahl, S., Nichols, W. J. & Depledge, M. H. (2015). Marine biota and psychological well-being: A preliminary examination of dose-response effects in an aquarium setting. *Environment & Behavior, DOI: 10.1177/0013916515597512*, 1-29.

3.1 Introduction

3.1.1 Overview

Psychological research suggests that individuals tend to prefer natural environments to urban/built settings (e.g. see review by Bowler et al., 2010). Moreover, these environmental preferences appear to be associated with the perception that nature can deliver a variety of psychological benefits such as reduced stress, positive emotions, and fascination (Ulrich, 1984; van den Berg et al., 2003; also see reviews – Bowler et al., 2010; Velarde et al., 2007). Many studies looking at the effects of contact with nature have used simulations of nature in a laboratory setting, rather than exposure to the actual environment. The use of simulated settings is understandable: laboratory simulations can have a number of advantages over field studies, including better control of external variables such as the weather and ambient noise, plus providing an opportunity for easier manipulation of test stimuli. Furthermore, as nature simulations can act as effective substitutes for 'real nature' (e.g. see Felsten, 2009), the option of using these simulated environments in research is clearly appealing, and may have important implications for people who, for whatever reason, are unable to access natural settings (McMahan & Estes, 2015).

That said, other studies maintain that, although simulated nature can provide health benefits, these benefits tend to be greater in real nature settings. For instance,

Kjellgren and Buhrkall (2010) compared the restorative effects of 30 minutes of relaxation in a natural environment, Karlstad Nature Park, with a simulation (a slideshow of 97 photographs) of the same park. They found that both the real and simulated natural environments facilitated stress reduction but noted that the real environment also increased energy and resulted in significantly higher ratings for 'altered states of consciousness' (a factor that appeared to be important for relaxation in their previous research). In a meta-analysis of 32 studies, McMahan and Estes (2015) examined a range of potential moderator variables that may influence the effect of nature on emotional well-being, including the type of exposure (real nature vs. laboratory-simulated nature). They found that, although exposure to simulated nature resulted in significant increases in positive affect, people gained additional benefits from exposure to real nature. In view of this, the current study moved away from laboratory simulations of aquarium exhibits to a real aquarium exhibit.

3.1.2 Moving from Lab to Field: Photo Study to Real Aquarium

This study took advantage of the need to completely refurbish and restock a large exhibit in the UK's National Marine Aquarium in Plymouth. As restocking of such a large exhibit needed to be conducted in three stages, it provided a rare opportunity for a 'natural experiment' (Medical Research Council, 2011) to compare people's responses to different levels of biota[8] in exactly the same location. This study also used this opportunity expand on previous studies to include physiological, as well as psychological, measures. By investigating how psychological and physiological measures were influenced by exposure to different levels of sub-aquatic biota, this study aimed to contribute to the body of work attempting to understand potential 'dose-

[8] Biota is defined here as 'the plant and animal life of a particular region' - biota (n.d.): in *Collins English Dictionary*. Retrieved April 3 2015 from http://www.thefreedictionary.com/biota

response' relationships between natural ecosystems and human well-being (Millennium Ecosystem Assessment, 2005; UK National Ecosystem Assessment, 2011).

In the context of health sciences, 'dose' is the amount of a substance (e.g. medication) or activity that can affect health. 'Dose' can be measured in a number of ways that reflect the various pathways thorough which the substance or activity can influence health (Shanahan, Fuller, Bush, Lin & Gaston, 2015). A 'dose response relationship' can be defined as the "relationship in which a change in the amount, intensity, or duration of exposure is associated with a change in risk of a specified outcome" [9].

The term 'dose' is often now used when discussing nature and health but should be distinguished from the technical meaning referred to above. According to Shanahan et al. (2015), Barton and Pretty (2010) were the first to explicitly label 'nature dose' when they sought to determine the best 'doses' of green exercise (i.e. intensity and duration) that would be required to improve self-esteem and mood, two indicators of mental health. Other researchers have sought to determine other types of 'dose', such as the type and amount of nature that people require in order to receive physical, social, or psychological health benefits (Shanahan et al., 2015).

Dose-response modelling, commonly used in health sciences, involves modelling the effect of a dose of a substance or activity on an individual's (or population's) causally linked health response. Shanahan et al. (2015) suggest that this qualitative approach is appealing as it could inform nature-based health interventions by recommending minimum 'doses' of nature exposure for individuals which could provide considerable public health benefits. However, 'dose-response modelling' can be present analytical challenges as an individual's or population's health responses can be affected by a number of factors including age, gender, preferences, experience or

[9] Dose-response relationship. (n.d.) *Farlex Partner Medical Dictionary*. (2012). Retrieved August 4 2016 from http://medical-dictionary.thefreedictionary.com/dose-response+relationship

culture (Hartig et al., 2014; Shanahan et al. 2015). Furthermore, Hartig et al. (2014) cautions that using the 'dose' metaphor could cause a number of problems, such as neglecting or underestimating the importance of especially powerful nature encounters, such as wilderness experiences which have the capacity to be life-transforming.

There were two parts to the study that, between them, sought to answer three main questions: was there a relationship between the length of time that aquarium visitors spent in front of the exhibit and changes in the stocking level; would physiological markers of stress (e.g. heart rate) respond to different levels of biota, and what emotional states would participants report during the three stages of restocking? The first question required the use of incidental visitor observations to establish changes in viewing time throughout the restocking period, whereas closer monitoring of the experimental study participants was required in order to answer the second and third questions.

Previous research carried out in urban and semi-urban parks suggests that greater actual, and perceived, species richness is associated with greater psychological well-being (Dallimer et al., 2012; Fuller et al., 2007). This two-part study extended these findings in three important ways. First, it appears to be the first study that considers people's reactions to different levels of sub-aquatic, rather than terrestrial, biota by examining responses to increases in marine life during a restocking event. In view of the paucity of research on the health and well-being benefits of aquatic environments (Sandifer et al., 2015), this is an important step, and seems especially relevant considering how many people enjoy SCUBA diving, visiting public aquaria, or keeping their own fish tank at home. Second, as the seawater in the exhibit needed to 'mature' before any marine life was introduced to the exhibit, it provided a 'control' condition (i.e. water, but no living animals) that enabled the relative importance of the physical environment to be separated from the animals present within it. This is

particularly important in the context of aquatic environments as previous studies have found that they may be particularly good at providing psychological benefits, such as feelings of calm and mental well-being, irrespective of the presence of wildlife (White, Alcock, Wheeler & Depledge, 2013a; White et al., 2014; White, Pahl, Ashbullby, Herbert & Depledge, 2013b; White et al., 2010). Even studies that have not specifically explored preferences for aquatic settings but, for instance, have investigated scenic preferences for different environment types, have found that water features strongly as a preferred environmental variable (e.g. Han, 2007; Kweon et al., 2008; Purcell et al., 2001). Third, by examining people's responses to different levels of biota, after both 5 and 10 minutes of exposure, it was possible to explore potential duration 'dose-response' effects. Recent field studies suggest that longer self-selected visits to natural environments may result in additional psychological gains (e.g. White et al., 2013b). Earlier work by Herzog (1985) found that length of viewing time was one of the determinants of preference for waterscapes. Hence, this quasi-experimental study is the first to examine people's psychophysiological responses to different 'doses' of underwater marine life over different 'doses' of time.

3.1.3 Current Research

This study extended earlier aquarium-based studies in a number of ways. For instance, as far as is known, this study was the first to explore the additional effects that adding marine life to an aquatic environment could have on positive well-being outcomes. Furthermore, the experimental design was not simply 'with' and 'without' marine life, but investigated people's reactions to three different stocking levels, over two different time points, enabling dose response comparisons to be undertaken. Also, the 'tank' used was markedly larger than in previous studies which generally employed small, hobbyist tanks (e.g. 30 cm x 20 cm inch viewing area – see Edwards & Beck,

2002). Several previous studies have also tended to use small sample sizes, often less than 10 participants per condition (e.g. DeSchriver & Riddick, 1990: Katcher et al., 1984), whereas this study was completed using between 26 and 29 participants per condition. Finally, this study was conducted in a public aquarium, rather than a laboratory (e.g. Well, 2005) or clinical/healthcare setting (e.g. Katcher et al., 1984). Considering that public aquariums have the potential to provide the general public with restorative experiences, a greater understanding of how this may be achieved is important.

The study had two parts. Part A consisted of observing the amount of time a sub-sample of aquarium visitors spent looking at the exhibit during each of the three stages of restocking. Previous studies have found that there are positive relationships between psychological well-being and (i) level of species richness, and (ii) length of time of self-selected visits to natural environments. Therefore, Part A investigated whether there was a relationship between stocking level and voluntary exposure time to the exhibit across the three conditions.

Part B consisted of monitoring the physiological and psychological reactions of experimental participants seated in front of the exhibit after 5 and 10 minutes during the three stages of restocking. Again, based on earlier research, the relationship between indicators of psychophysiological well-being (e.g. positive mood, heart rate) and the stocking level in the exhibit were examined. Furthermore, by monitoring these indicators at 5 and 10 minutes it was possible to establish whether longer exposure times conferred more benefits. The exposure duration times of 5 and 10 minutes were selected partly due to experimental time constraints, but mainly to keep consistency with timings used in previous studies. For instance, Wells (2005) noted significant changes in physiological measures when using a 10 minute video intervention. Katcher et al. (1983, 1984) used longer interventions (≥20 minutes) but felt that maximal

relaxation could be obtained in less time, after noting that participants watching just water and plants in a previous study became bored and restless within 20 minutes. Other studies exploring reactions to restorative environments have found that physiological responses can occur within a few minutes (e.g. < 4 minutes - Ulrich et al., 1991) and psychological changes can be immediate (e.g. Pretty et al., 2005). McMahon and Estes (2015) noted that each study in their review only used a short exposure to natural environments, suggesting that even brief doses of nature provide emotional well-being benefits. From an adaptive evolutionary viewpoint, it would be expected that restoration should occur swiftly (in minutes, instead of hours), depending on the stress response (Ulrich et al., 1991). These swift changes in psychological and physiological indices also highlight the importance of employing a repeated measures strategy (Hartig et al., 2003).

A small number of studies have explored psychological reactions to species richness in terrestrial settings (e.g. Dallimer et al., 2012; Fuller et al., 2007), yet species abundance has less frequently been taken into consideration. However, although this study was able to extend previous research by obtaining an exact measure of species abundance (as well as species richness), it was conducted in a working public aquarium and, as such, there was little control over restocking events. In view of this, species richness and abundance were still confounded.

Based on this previous research, it was hypothesised that the voluntary exposure time would reflect intrinsic fascination and would be positively correlated with the level of biota present within the exhibit (Hypothesis 1: Part A). As previous studies suggest that psychological and physiological benefits may be gained from viewing aquaria, it was hypothesised that psychophysiological responses would be indicative of higher benefit the more marine life it contained (Hypothesis 2: Part B). More specifically, a decrease in heart rate and blood pressure (e.g. as per Katcher et al., 1983; Wells, 2005),

an improvement in mood, and a decrease in arousal (e.g. as per Katcher et al. 1984) were anticipated with more marine life, indicative of relaxation and induced stress. Positive responses to the evaluation statements (e.g. I enjoyed watching this exhibit) were also anticipated. Moreover, it was hypothesised that these benefits would be greater in the 'Fully stocked' condition, as previous work (e.g. Dallimer et al., 2012) has associated greater psychological well-being with higher species richness. As field studies have found a relationship between psychological benefits and length of self-selected visits to natural environments, it was also hypothesised that a longer exposure to the exhibit would result in improved psychophysiological responses (Hypothesis 3: Part B).

3.2 Study 4: Psychological, Physiological and Behavioural Responses to Different Levels of the Same Type of Aquarium Exhibit

3.2.1 Methods

3.2.1.1 Experimental Site

The exhibit at the National Marine Aquarium undergoing refurbishment was a 550,000 litre aquarium exhibit (14.3 m length x 6.2 m width x 6 m height). The exhibit is predominately viewed through a single, huge acrylic window (14 m length x 4.25 m height). While drained of water, the exhibit was decorated with artificial seaweed (e.g. kelp – *Laminaria* spp.) and temperate corals (e.g. pink sea fans – *Eunicella verrucosa*) in order to recreate a local UK underwater habitat. The exhibit was then filled with seawater and left to mature for three weeks before the first fish and invertebrates were introduced. After this time marine life was introduced to the exhibit as and when a sufficient quarantine period had been completed. Skylights above the tank allowed some natural light to penetrate the exhibit, and the sheer size of the exhibit, together with the subtle changes in natural light and the gentle movement of the artificial

seaweed (generated by hidden pumps), created a natural looking underwater scene that was intended to be pleasant, soothing and immersive.

Each stage of the study was conducted on week days, during normal aquarium opening hours. However, particularly busy times of the year, such as Christmas and school holiday periods, were avoided. In order to minimise the effects of husbandry activities on fish behaviour, the studies were conducted mid-afternoon, following the main feed of the day. (Fish behaviour has been shown to alter with food anticipation, with heightened swimming activity as the fish increasingly orientate themselves toward a known food source (i.e. 'time-place learning' - see e.g. Barreto, Rodrigues, Luchiari & Delicio, 2006).

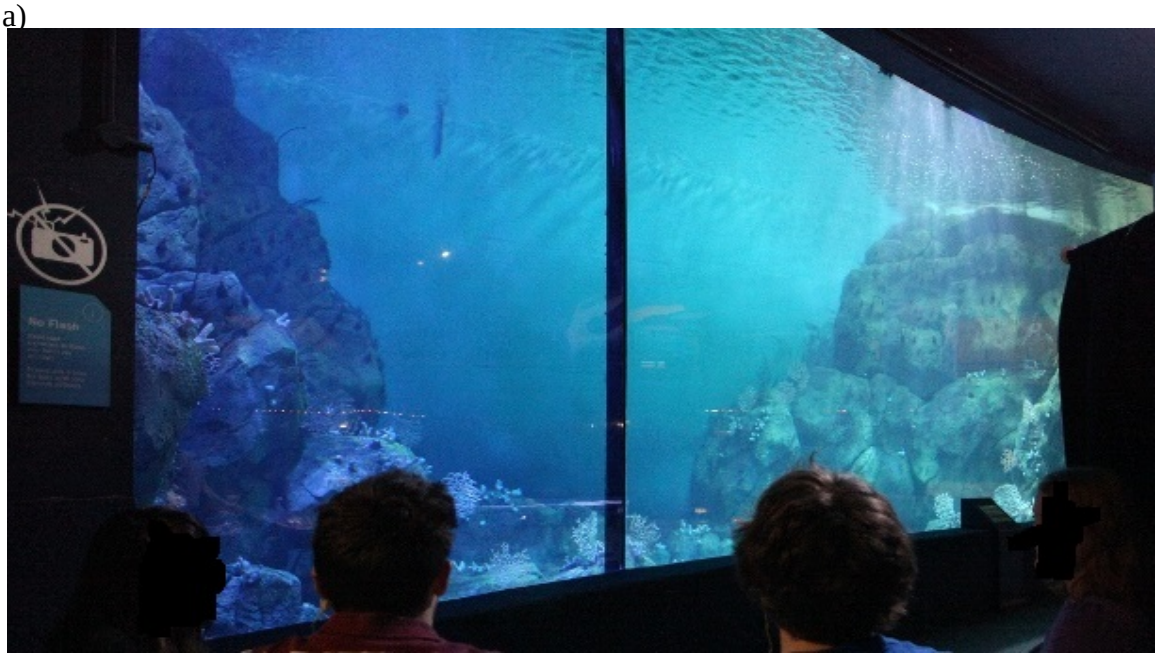
In Condition 1 (Unstocked – Figure 8a), normal visitors and participants in the experiment viewed the exhibit when it contained only seawater and artificial decoration. After Condition 1 was completed, the first fish and invertebrates were introduced to the exhibit. While every effort was made to ensure that all visitors and study participants in Condition 2 (Partially stocked – Figure 8b) were presented with the same biota, this was not possible. The practicalities of coordinating a field study in a busy working aquarium resulted in a number of fish being introduced to the exhibit throughout the time taken to collect all visitor observations and experimental participant data in Condition 2, although not while visitors or participants were actually present.

In order to attribute a more rigorous measure to the stocking levels and determine the differences between them, Simpson's Index of Diversity (D – 1) was calculated for the Partially and Fully stocked conditions. The decision to use this diversity measure was based on conversations with Dr Paul Somerfield, at Plymouth Marine Laboratory, who specialises in the distribution and functioning of biodiversity. However, as mentioned in Chapter 1, there is considerable confusion surrounding the use of diversity indices and, as other biodiversity-based studies (e.g. Dallimer et al.,

2012) have used the Shannon Wiener Index, this diversity index was also used to establish the differences between the two stocking levels. The Simpson's Index of Diversity (1 – D) for the exhibit, therefore, increased from 0.615 to 0.808 as the number of fish species increased to 10 over a three day period (80 individual fish – see Appendix A for full species list). Nevertheless, the majority of participants (>88%) viewed the exhibit when it contained 5 or 7 species of fish (50 - 71 individuals) and 2 species of crustaceans (14 individuals). For these participants Simpson's Index of Diversity averaged 0.730. Before the start of Condition 3 (Fully stocked - Figure 8c) a further period of restocking was undertaken resulting in a total of 22 species: 19 fish species (138 individual fish) and 3 invertebrate species (13 individual crustaceans). All visitors and participants in Condition 3 were exposed to the same level of biota (1 - D = 0.881).

Ethical approval for the study was provided by the University of Plymouth's Faculty of Science Ethics Committee. In total, restocking took approximately 9 months. Study periods were February (Unstocked), March (Partially stocked) and November Fully stocked).

a)



b)

c)

Figure 8. Study 4: (a) Condition 1 – Unstocked; (b) Condition 2 – Partially stocked; (c) Condition 3 - Fully stocked exhibit

3.2.1.2 Part A – Behavioural Observations

3.2.1.2.1 Participants

Participants (aquarium visitors) were 112 members of the public who were observed during their visit to the National Marine Aquarium. Observations were carried out during each of the three stages of refurbishment: Unstocked (n = 41), Partially stocked (n = 31) and Fully stocked (n = 40). Visitors were informed at the aquarium entrance that the exhibit was being refurbished.

3.2.1.2.2 Procedure and Measures

A rectangular area of 84 m^2 (14 m x 6 m) in front of the exhibit was defined as the 'target area'. Observations were made by two trained researchers who were positioned unobtrusively at the back of the exhibit area. On commencement of a data collection session, the first adult visitor to enter the target area (either a lone visitor or one individual from a couple or group) was timed (in seconds) from the moment they entered the target area to the time they left it. The researchers then waited one minute before selecting the next adult that entered the target area. Observations were carried out on a time schedule to reduce potential bias. Measurements were taken twice weekly, at varying times of the day. Numbers of observations differed across conditions due to the varied volume of visitors experienced on sampling days.

3.2.1.3 Part B – Psychological and Physiological Measures

3.2.1.3.1 Participants

Eighty four students from Plymouth University, UK, elected to take part in the study for course credit (M_{age} = 24 years; 64 females). Due to some 'no shows' participant numbers differed slightly across conditions: Condition 1: n = 29; Condition 2: n = 26; Condition 3: n = 29. As this study was a 'natural experiment' it was not

possible to randomly allocate participants to condition. Restocking took place over a 10 month period and, since participants were recruited for each condition at different time points, it is only quasi-experimental.

3.2.1.3.2 Procedure and Measures

Participants made their own way to the aquarium and were collected from the entrance, in pairs, at an agreed time. As equipment and paperwork needed to be monitored and administered throughout the study, one researcher was allocated per participant (see Figure 9 for procedure). Participants were taken directly to the study area (without stopping to view any other exhibits on the way) and were seated in a curtained booth located in front of the exhibit but which obstructed the view of the exhibit. Participants were seated and briefed at the start of the study. They were informed that the study aimed to explore how their psychological and physiological measures changed in response to watching an aquarium exhibit: they were not informed about the different stocking levels at this point. The participants were informed that measures of mood, heart rate and blood pressure would be taken before, during and after watching the aquarium exhibit. Finally, participants were informed of the confidentiality of their responses and their right to withdraw. If happy to proceed, participants signed a consent form. A heart rate monitor (Cateye PL-6000 with ear clip) and blood pressure monitor (Omron HEM705C) were attached to each participant and were tested to ensure that they worked correctly (that is, operationally and returning reliable readings).

Approx. time (25 mins)	Stage	Physio		Mood			Evaluation
		HR	BP	AD ACL	FS	FAS	
0-5	Brief + rest	√	√				
5-10	Baseline pre-anagrams (**T1**)	√	√				
	Anagrams for 3 mins						
	Baseline post-anagrams (**T2**)	√	√	√	√	√	
10-20	Watching tank:						
	@+5 (**T3**)	√			√	√	
	Watch tank for another 5 mins						
20-25	Post- tank (**T4**) *(i.e. after 10 mins of watching)*	√	√	√	√	√	√

Figure 9. Study 4: Procedure

Participants then sat quietly behind the curtain for 5 minutes, and blood pressure and heart rate were measured twice: after 2 minutes and after 5 minutes. Heart rate readings could be recorded by simply glancing and recording the heart rate reading, whereas blood pressure had to be manually initiated by the researcher. In the 3 minute interval, participants were asked to complete a series of anagrams. Although some anagrams were simple and solvable (see Appendix B for example of anagram task), the majority of the anagrams were impossible to complete. The aim of this task was to increase participants' stress arousal, as participants were informed that 'most people' successfully completed at least 10 anagrams when undertaking this task. This target was, of course, impossible. Although stress induction could be achieved using other tasks, such as the Trier Stress Test, a test that has been found to be the most appropriate and useful standardized protocol for studies of stress hormone (Birkett, 2011), the anagram task was the only task approved by the University's ethics Committee that was

suitable for use in the Aquarium study setting. Unfortunately, however, subsequent data analysis revealed no significant effects on either blood pressure or heart rate between the two time periods. In view of this, both measures were collapsed to provide a more robust estimate of baseline physiological states.

Just after the second set of physiological measurements was taken, and before the curtain was withdrawn, three measures of psychological mood were taken: the Feeling Scale (Hardy & Rejeski, 1989), the Felt Arousal Scale (adapted from Svebak & Murgatroyd, 1985) and the Activation-Deactivation Adjective Check List (AD ACL: Thayer, 1989). The Feeling Scale is a single-item 11-point bipolar scale (Very bad – Very good, -5 to +5), designed to measure affective valence. The Felt Arousal Scale uses a single-item 7-point scale (Low – High arousal, 0 to +6). The Feeling Scale and Felt Arousal Scale were selected because, together, these measures recognise the fact that mood is related to two orthogonal dimensions (valence and arousal). For instance, one can be in a positive mood with high arousal (excited) or low arousal (calm), or a negative mood with high arousal (angry) or low arousal (depressed). Combined, these scales have been validated in many studies examining the impact of exercise on mood at multiple time points and show reliable patterns of change over time (e.g. Ekkekakis, Hall, Van Landuyt & Petruzzello, 2000). The AD ACL is a 20 item multi-dimensional self-report instrument, also commonly used to assess mood in physical activity studies (Ekkekakis, Hall & Petruzzello, 2005). The AD ACL has two dimensions, with each dimension having opposite poles, reflecting positive and negative (pleasure/displeasure) tones: Dimension A (Energetic Arousal) – Energy (positive) and Tiredness (negative), and Dimension B (Tense Arousal) – Calm (positive) and Tension (negative). There are five items for each of the four states. The AD ACL uses a 1-4 scale: Definitely do not feel (1) – Definitely feel (4). The measures used in Studies 1-3 (e.g. ‘How pleasant do you rate this scene?) would not have been appropriate for this study as the aim of Study

4 was to determine changes in measures, such as mood, following one intervention, rather than asking participants to rate multiple different scenes.

A number of earlier studies have also incorporated an element of self-reporting to measure psychological responses. For instance, DeSchriver and Riddick (1990) used a revised version of the shortened Leisure Satisfaction Scale developed by Beard and Ragheb (1980), to measure relaxation in their study on elders' stress. Similarly, Katcher et al. (1984) used the Patient's Treatment Comfort Index as a subjective measure of comfort and relaxation during their dental surgery study. Whilst both studies suggested that aquaria were perceived as more restorative than other conditions (e.g. viewing a poster of a waterfall), neither of these studies uses identical measures to the current study and therefore direct comparisons were not possible. Nevertheless, it was anticipated that the combination of mood scales, together with the responses to the Evaluation Statements, would provide data on people's psychological responses whilst watching an aquarium exhibit.

Once the three psychological measures were also completed, the curtain was then drawn to reveal the exhibit in one of the three experimental conditions (Unstocked, Partially stocked or Fully stocked: i.e. Time 1: 'Baseline'). Participants were instructed to watch the exhibit until the curtain was drawn again. After a period of 5 minutes, researchers discretely noted the participants' heart rate before asking them to complete the Feeling Scale and the Felt Arousal Scale again (Time 2: '+5 min'). Blood pressure readings were not taken at this point so as not to disturb participants and mitigate any effects of 'white coat syndrome' (see Pickering et al., 2005).

Participants then watched the exhibit for a further 5 minutes after which the final heart rate and blood pressure readings were recorded. All three mood scales were also completed again at this time (Time: '+ 10 min'). Finally, participants were asked to complete five evaluation statements: 'I enjoyed watching the exhibit'; 'I feel better after

watching this exhibit'; 'I would be happy to watch this exhibit again' (on 7-point scales: 'Not at all - Very much, 0 to +6'); 'I found watching this exhibit…Very boring/Very interesting' (0 to +6), and 'I would be happy to watch this exhibit for another (5, 10, 15 or 20) minutes'. At the end of the study the participants were debriefed and thanked for their time (see Appendices C-E for study paperwork - C: Explanation of AD ACL for participants; D: Paperwork recording participants' response; E: Field notes - Observations of background noise levels and/visitor numbers).

3.2.1.4 Statistical Analysis

3.2.1.4.1 Part A – Behavioural Observations

Preliminary analysis of visit duration found a large positive skew (1.89), reflecting the fact that while the majority (66%) of visitors spent less than 4 minutes at the exhibit, a few visitors spent much longer, some up to 20 minutes. Nevertheless, time was approximately lognormal, so was transformed to log base 10 to enable greater confidence in the outputs of the subsequent ANOVA analysis. Planned repeated contrasts were also used to compare each subsequent stage of restocking.

3.2.1.4.2 Part B – Psychological and Physiological Measures

For the psychophysiological part of the study, participants' evaluations of their own experiences after watching the exhibit for 10 minutes were examined first, using one-sample *t*-tests to compare responses to zero. The effects of watching the exhibit on individuals' blood pressure, heart rate and mood were examined next. To investigate the relative effects of the different stocking levels, the change in blood pressure scores over time (from Baseline to +10 minutes) was calculated for each participant. These change scores were then analysed using a one-way ANOVA, with level of stocking as the between-participant factor, and planned contrasts if the main effect was significant. As

blood pressure was only taken twice, paired-samples *t*-tests for each condition were used separately to establish any changes associated with watching the Unstocked, Partially or Fully stocked exhibits for a period of 10 minutes.

In order to explore the relative effects of the different conditions, the difference scores were again derived by subtracting the baseline scores from those at 5 and 10 minutes. These change scores were then analysed using a series of 2 (Time: +5 min/+10 min) by 3 (Condition: Unstocked/Partially/Fully stocked) mixed factorial ANOVA, with repeated measures on 'Time' and 'planned repeated contrasts' (reflecting the predicted order of Stocking and Time). As heart rate and mood (valence and arousal) were measured at three time points, one-way repeated measures ANOVA, with planned repeated contrasts, were used to explore the effects of each condition, separately, over time.

Change scores were used for several analyses because there was a pattern of non-equivalence across the different conditions at Baseline. In particular, participants who arrived at the aquarium for the Fully Stocked condition had, by chance, higher average levels of (diastolic) blood pressure, significantly higher heart rate, and a less positive mood. Potential reasons for these differences are presented in the discussion, and possibly reflect the studies status as a 'natural experiment'.

The five items representing each of the four affective states (Energy, Calm, Tiredness and Tension) were collapsed to give four overall state scores. Changes over time (Baseline/+10 mins) for the four AD ACL affective states was measured by conducting a separate one way repeated measures ANOVA for each of the four states (Energy/Calm/Tiredness/Tension), with level of stocking (Unstocked/Partially/Fully stocked) as the 'between-subject' factor and 'planned contrasts' if the main effect was significant.

3.2.2 Results

3.2.2.1 Part A – Behavioural Observations

The time spent by the participants in front of the exhibit increased as the stocking level increased (Unstocked *M* = 3.01 min, *SD* = 3.57; Partially stocked *M* = 4.08 min, *SD* = 3.66; Fully stocked *M* = 5.94 min, *SD* = 4.16). Using the log base 10 transformation, it was noted, as predicted, that the duration was greatest in the Fully stocked condition (log10 *M* = .66, *SD* = .35), followed by the Partially stocked condition (log 10 *M* = .48, *SD* = .35), and lastly the Unstocked condition (log10 = .26; *SD* = .47), ANOVA found a main effect of condition $F(2,109) = 10.15$, $p < .001$, $\eta_p^2 = .157$. Planned contrasts revealed that the time spent in front of the Fully and Partially stocked conditions was significantly greater than the Unstocked condition ($p < .001$ and $p = .022$, respectively). There was, however, no significant difference between the Partially and Fully stocked conditions ($p = .065$). In summary, and in support of Hypothesis 1, visitors stayed significantly longer in front of the exhibit with the highest stocking level suggesting that they found it more interesting.

3.2.2.2 Part B – Psychological and Physiological Measures

3.2.2.2.1 Evaluation Statements

Participants in all three conditions found 10 minutes in front of the exhibit was an enjoyable and interesting experience that made them ‘feel better’. Furthermore, when answering Evaluation statement 5, participants stated that they were happy to continue watching the exhibit for another 7 ½ (Unstocked) or 11 ½ minutes (Partially and Fully-stocked). When comparing the participants’ evaluations across the three conditions using one-way ANOVA on each of the five statements (see Figure 10 for evaluation statements 1-4; the time estimates for statement 5 are reported separately below), there

was a significant increase in all five ratings, as predicted (Hypothesis 2). The planned repeated contrasts revealed that responses to all five evaluation statements were significantly more positive in the Partially vs. Unstocked condition ('enjoyed watching', $p < .001$; 'found interesting', $p < .001$; 'feel better', $p = .023$; 'happy to watch again', $p = .001$; and 'watch for an additional 3.94 mins [i.e. 7.41 mins Unstocked; 11.35 minutes Partially stocked], $p = .005$). The means for the Fully stocked condition were also all higher than in the Partially stocked condition, but were only significantly higher for level of interest ($p = .041$) and willingness to watch the exhibit again ($p = .043$). In other words, people rated watching an Unstocked exhibit positively, Partial restocking significantly improved these ratings and, when Fully stocked, two of the ratings improved further.

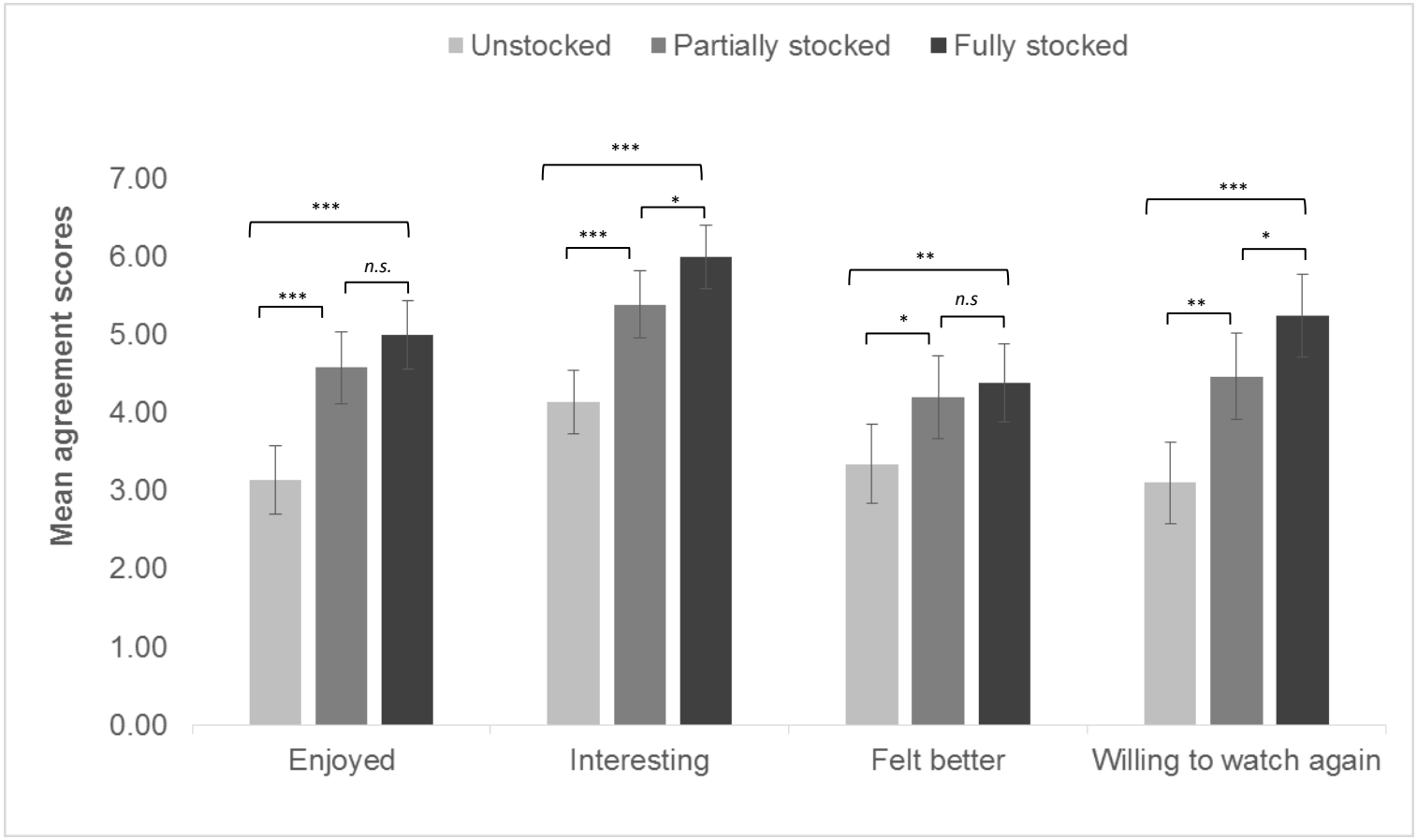


Figure 10. Study 4: Mean agreement scores for evaluation statements (Scale 1-7).
Note: *** p = < .001; ** p = < .01; * p = < .05; *n.s.* p = not significant. Error bars: 95% confidence intervals.

3.2.2.2.2 Blood Pressure

Two participants, one in the Unstocked and one in the Partially Stocked condition, were excluded from the blood pressure analysis due to erratic readings suggesting measurement error (changes > 3 *SD*s from the mean). ANOVA of the remaining participants found no significant interaction between Time x Condition, $F(2,76) = 0.77$, $p = .467$, or main effect of condition, $F(2,76) = 0.436$, $p = .648$ for SBP. There was, however, a significant main effect of time $F(1,76) = 16.24$, $p < .001$. The same pattern of results was observed for DBP: no significant interaction, $F(2,76) = 0.542$, $p = .584$, or main effect of condition $F(2,76) = 2.18$, $p = .120$ but there was a significant main effect of time $F(1,76) = 7.38$, $p = .008$. Although there was a lowering of both systolic (SBP) and diastolic blood pressure (DBP) over time in all three conditions (Table 5 and Figure 11), only some of these decreases were statistically significant. Specifically, systolic blood pressure dropped significantly for the Partially, $t(23) = 2.96$, $p = .007$, and Fully stocked, $t(26) = 2.59$, $p = .016$, conditions but diastolic blood pressure dropped significantly only in the Partially stocked condition, $t(23) = 2.27$, $p = .033$. In short, there was only partial support for Hypothesis 2 by this measure. Watching the exhibit (after a rest period), irrespective of condition, generally decreased blood pressure, but the role of stocking level was unclear.

3.2.2.2.3 Heart Rate

Data from one participant, in the Fully Stocked condition, was excluded due to erratic readings (changes > 3 *SD*s from the mean). The mixed factorial ANOVA found no significant effect of Time x Condition interaction, $F(2,79) = 0.91$, $p = .405$, $\eta_p^2 = .023$ or Time, $F(1,79) = 0.50$, $p = .482$, $\eta_p^2 = .006$, but there was a significant effect of condition, $F(2,79) = 3.38$, $p = .039$, $\eta_p^2 = .053$. The planned contrasts revealed that

both the Partially (p = .032) and Fully (p = .024) stocked conditions resulted in significantly greater drops in heart rate than the Unstocked (control) condition. Nevertheless, the significant Intercept for Time, $F(1,79) = 62.23$, $p < .001$, $\eta_p^2 = .441$ reflects the overall drop in heart rate compared to baseline (using change scores). The ANOVA for each condition separately revealed a similar basic pattern over time, with heart rate dropping substantially during the first five minutes, followed by more modest changes over the next five minutes (Table 5). Specifically, there was a main effect of time in all three conditions. In each case the planned repeated contrasts showed significant drops in heart rate over the first five minutes but no further significant change from 5 to 10 minutes, although the drop in the Fully stocked condition was somewhat greater than the other two conditions (Figure 12). In short, heart rate dropped in all three conditions but drops were significantly greater in the two conditions containing marine life, supporting Hypothesis 2. Despite some indication of a duration 'dose-response' effect, most of the effects took place in the first 5 minutes with only marginal gains subsequently, thus only partially supporting Hypothesis 3.

It was noted that the mean baseline heart rate was, by chance, higher in the Fully stocked condition than the other two. This may partly have been due to generally poorer weather during the testing period which (as well as potentially worsening the mood of participants) tends to make the aquarium more crowded and noisy. Given this possibility, analyses were re-run, controlling for visitor numbers on test days ($Mean_N$ = 421, min_N = 288, max_N = 656). However, no significant main effect of attendance numbers or any interactions with attendance were found on any of the physiological or psychological variables. Nevertheless, attendance figures are per day and therefore it was not possible to be sure how participants were affected by ambient visitor numbers at the exact time of testing.

Table 5. Study 4: Means (*M*) and standard deviations (*SD*) for blood pressure and heart rate readings.

	Unstocked (*n* = 26)		**Partially stocked (*n* = 29)**		**Fully stocked (*n* = 26)**	
	M	**(*SD*)**	***M***	**(*SD*)**	***M***	**(*SD*)**
Blood Pressure (mm HG)[a]						
Systolic						
T1: Pre-exposure (Baseline)	115.71	(10.51)	114.21	(12.39)	114.50	(9.47)
T3: @10 min exposure	113.54	(9.73)	109.67	(15.20)	111.67	(8.06)
Diastolic						
T1: Pre-exposure (Baseline)	68.98	(6.28)	68.31	(9.05)	71.85	(8.30)
T3: @10 min exposure	67.50	(7.18)	65.79	(10.71)	70.89	(7.22)
Heart Rate (bpm)[b]						
T1: Pre-exposure (Baseline)	74.61	(11.89)	76.62	(11.86)	81.59	(13.69)
T2: @5 min exposure	72.04	(10.93)	71.38	(10.56)	76.57	(11.79)
T3: @10 min exposure	72.43	(12.02)	71.08	(10.76)	75.61	(11.29)

Note: [a]: Excludes two outliers with changes >3 SDs from the mean; [b]: Excludes one outlier with changes >3 SDs from the mean.

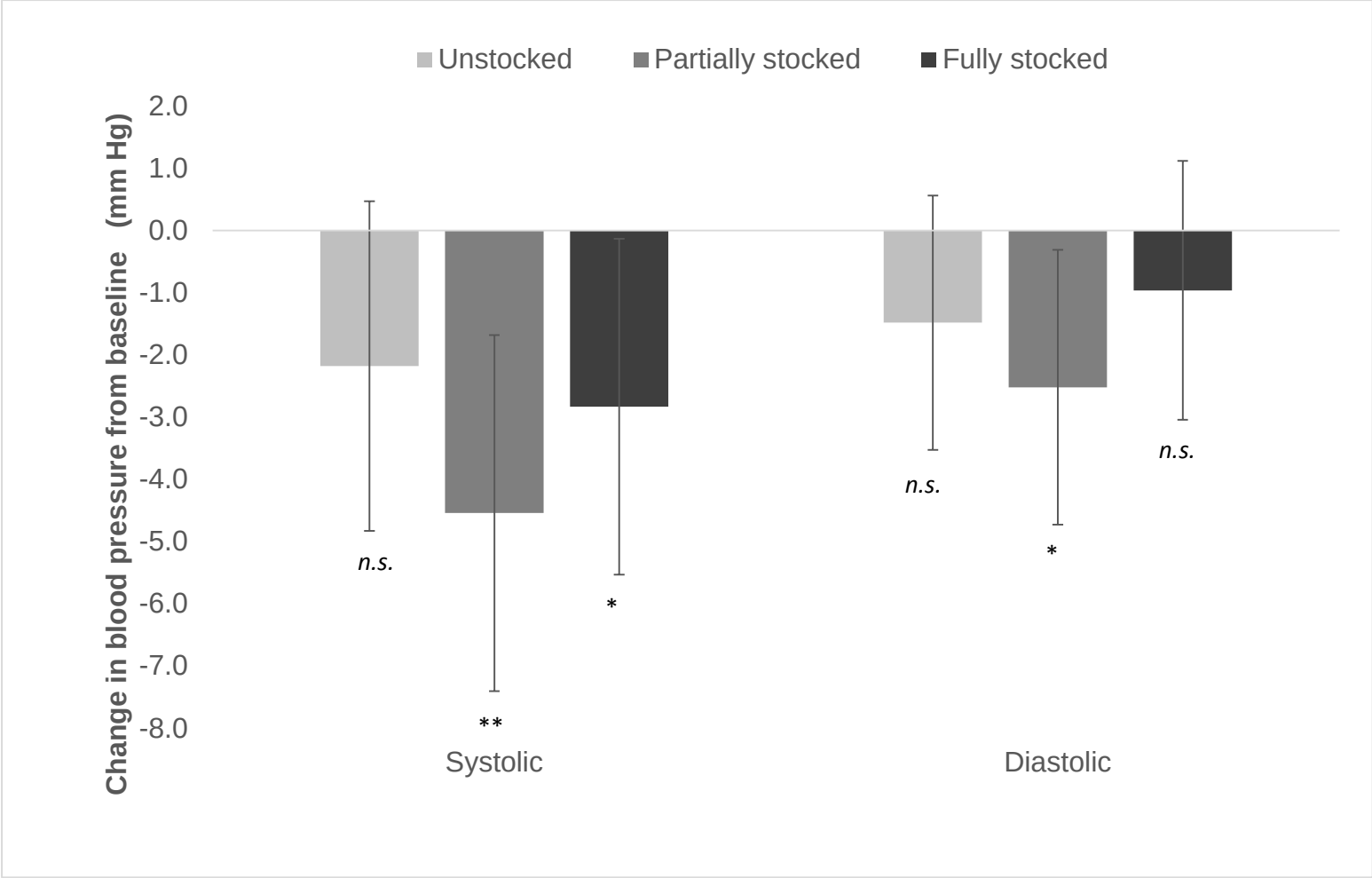


Figure 11. Study 4: Mean change in systolic and diastolic blood pressure (mm Hg) from baseline at 10 minutes as a function of exhibit stocking level

Note: *** p = < .001; ** p = < .01; * p = < .05; *n.s.* p = not significant. Error bars: 95% confidence intervals.

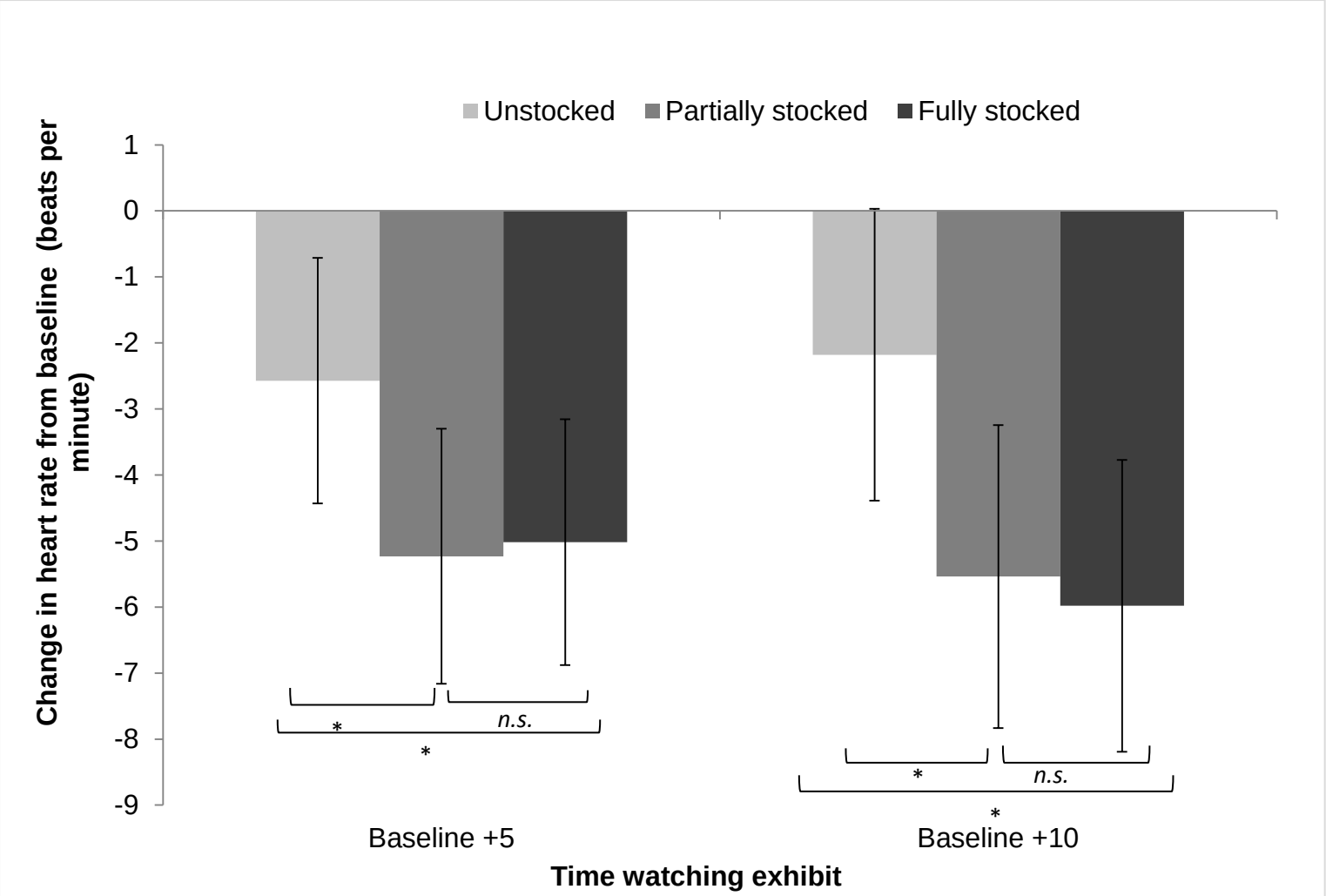


Figure 12. Study 4: Mean change in heart rate (beats per minute) from baseline at 5 and 10 minutes as a function of exhibit stocking level
Note: *** p = < .001, ** p = < .01, * p = < .05, *n.s.* p = not significant

3.2.2.2.4 Mood

Two mixed factorial ANOVA (one each for valence and arousal) found no statistically significant Time x Condition interaction for either Valence: $F(2,80) = 0.803$, $p = .451$, $\eta_p^2 = .020$ or Arousal: $F(2,80) = 0.383$, $p = .683$, $\eta_p^2 = .009$. There were, however, significant main effects of time: Valence: $F(1,80) = 10.33$, $p = .002$, $\eta_p^2 = .114$; Arousal: $F(1,80) = 19.75$, $p < .001$, $\eta_p^2 = .198$. In general, valence increased over time (people felt more positive), and arousal fell (people became more relaxed) – see Table 6 and Figure 13. There was only a marginally significant effect of condition for Valence, $F(2,80) = 2.66$, $p = .076$, $\eta_p^2 = .062$, and no effect for Arousal, $F(2,80) = 1.65$, $p = .198$, $\eta_p^2 = .040$. Planned contrasts found that the only reliable difference for valence was between the Unstocked and Fully stocked conditions ($p = .025$), and there was no significant difference between conditions for arousal although there was a marginal effect between the Unstocked and Fully stocked conditions ($p = .075$). As observed previously there seemed to be some effect of biota, with higher levels of restocking 'tipping the balance' compared to the Unstocked exhibit.

The one-way repeated measures ANOVA for each condition revealed that while valence improved considerably in both the Fully, $F(2,56) = 24.80$, $p < .001$, $\eta_p^2 = .470$, and Partially, $F(2,50) = 8.97$, $p < .001$, $\eta_p^2 = .264$, stocked conditions, the improvement in the Unstocked condition was not significant, $F(2,54) = 1.52$, $p = .228$, $\eta_p^2 = .053$. Importantly, in relation to the duration-related 'dose-response' discussion, the planned repeated contrasts revealed that while valence became significantly more positive after 5 minutes in the Partially stocked condition, $F(1,25) = 9.88$, $p = .004$, $\eta_p^2 = .283$, it did not further improve after 10 minutes, $F(1,25) = 1.35$, $p = .256$, $\eta_p^2 = .051$. In contrast, valence increased both from baseline to 5 minutes, $F(1,28) = 17.31$, $p < .001$, $\eta_p^2 = .382$, and from 5 to 10 minutes, $F(1,28) = 10.67$, $p = .003$, $\eta_p^2 = .276$, in the Fully

stocked condition. Given the non-significant main effect of time in the Unstocked condition, neither of the planned contrasts was significant. In other words, and in support of Hypothesis 2 and 3, there appeared to be a double 'dose-response' effect: longer exposure to a greater stocking level produced the greatest improvement in valence.

Arousal decreased significantly in all three conditions: Fully stocked, $F(2,56) = 5.40$, $p = .007$, $\eta_p^2 = .162$; Partially stocked, $F(2,50) = 9.27$, $p < .001$, $\eta_p^2 = .270$, and Unstocked, $F(2,54) = 17.44$, $p < .001$, $\eta_p^2 = .393$. However, the planned contrasts found that while the drops from baseline to 5 minutes and from 5 to 10 minutes were significant in the Unstocked (Baseline to 5 min: $F(1,27) = 12.72$, $p = .001$, $\eta_p^2 = .320$; 5 to 10 min: $F(1,27) = 9.45$, $p = .005$, $\eta_p^2 = .259$) and Partially stocked (Baseline to 5 min: $F(1,25) = 7.70$, $p = .010$, $\eta_p^2 = .236$; 5 to 10 min: $F(1,25) = 5.95$, $p = .022$, $\eta_p^2 = .192$) conditions, the drop in arousal in the Fully stocked condition was only significant from 5 to 10 minutes exposure, $F(1,28) = 4.70$, $p = .039$, $\eta_p^2 = .144$, but not in the first 5 minutes, $F(1,28) = 2.38$, $p = .134$, $\eta_p^2 = .078$. Referring to Figure 13 (differences from baseline) it seems that while watching the Fully stocked exhibit resulted in a greater increase in positive emotions than watching the Partially stocked exhibit, arousal was less affected. Contrary to the original Hypotheses (2 and 3), these findings suggest that watching the Fully stocked condition created a less calming but more energising effect.

When investigating the AD ACL findings, there was no significant interaction between Time and Condition, for any of the four affective states: Energy: $F(1,81) = .610$, $p = .546$; Calm: $F(1,81) = .979$, $p = .380$; Tiredness: $F(1,81) = 1.15$, $p = .323$; Tension: $F(1,81) = .975$, $p = .381$ (Figure 14). There were no significant effects of stocking condition for any of the four emotional states (Energy: $F(1,81) = 1.22$, $p = .302$; Calm: $F(1,81) = .809$, $p = .449$; Tiredness: $F(1,81) = 2.29$, $p = .108$; Tension:

$F(1,81) = .380$, $p = .685$) but there was a significant change over time for all four emotional states: Energy: $F(1,81) = 32.44$, $p < .001$; Calm: $F(1,81) = 90.03$, $p < .001$; Tiredness: $F(1,81) = 41.61$, $p < .001$; Tension: $F(1,81) = 39.70$, $p < .001$. Specifically, participants' ratings for Calm and Tiredness increased, whereas those for Energy and Tension decreased. These findings would appear to indicate that participants felt calmer and less tense, and were more tired and had less energy, after viewing the exhibit for 10 minutes. Taken as a whole, this would suggest that viewing the exhibit for 10 minutes had a relaxing effect on participants.

Table 6. Study 4: Means (*M*) and standard deviations (*SD*) for valence (Feeling Scale), arousal (Felt Arousal Scale) and emotions (Activation-Deactivation Adjective Checklist).

	Unstocked (n = 26)		**Partially stocked (n = 29)**		**Fully stocked (n = 26)**	
	M	***(SD)***	***M***	***(SD)***	***M***	***(SD)***
Valence						
T1: Pre-exposure (Baseline)	2.11	(1.77)	2.27	(1.64)	1.41	(1.88)
T2: @5 min exposure	2.29	(1.56)	2.96	(1.40)	2.24	(1.57)
T3: @10 min exposure	2.54	(1.53)	3.12	(1.21)	2.66	(1.72)
Arousal						
T1: Pre-exposure (Baseline)	2.86	(1.38)	2.77	(1.28)	2.66	(1.40)
T2: @5 min exposure	2.04	(1.37)	2.23	(1.31)	2.31	(1.39)
T3: @10 min exposure	1.50	(1.14)	1.85	(1.41)	1.97	(1.32)
AD ACL: Energy						
T1: Pre-exposure (Baseline)	1.08	(0.60)	1.25	(0.76)	0.92	(0.70)
T3: @10 min exposure	0.70	(0.56)	0.79	(0.63)	0.64	(0.59)
AD ACL: Calm						
T1: Pre-exposure (Baseline)	1.73	(0.75)	1.65	(0.67)	1.64	(0.55)
T3: @10 min exposure	2.41	(0.42)	2.41	(0.56)	2.18	(0.56)
AD ACL: Tiredness						
T1: Pre-exposure (Baseline)	1.26	(0.88)	0.95	(0.78)	1.50	(0.94)
T3: @10 min exposure	1.90	(0.81)	1.57	(0.82)	1.86	(0.81)
AD ACL: Tension						
T1: Pre-exposure (Baseline)	0.70	(0.78)	0.54	(0.48)	0.60	(0.62)
T3: @10 min exposure	0.25	(0.45)	0.21	(0.33)	0.33	(0.41)

Note: Valence values are the mean of reported scores on a single-item 11-point scale (-5 = Very bad, +5 = Very good). Arousal values are the mean of reported scores on a single-item 7-point scale (0 = Low arousal, 6 = High arousal). AD ACL values are the means of ratings for each of the four states (energy, calm, tiredness, tension: 5 items per state) on a 4-point scale (1 = *Definitely feel*, 4 = *Definitely do not feel*)

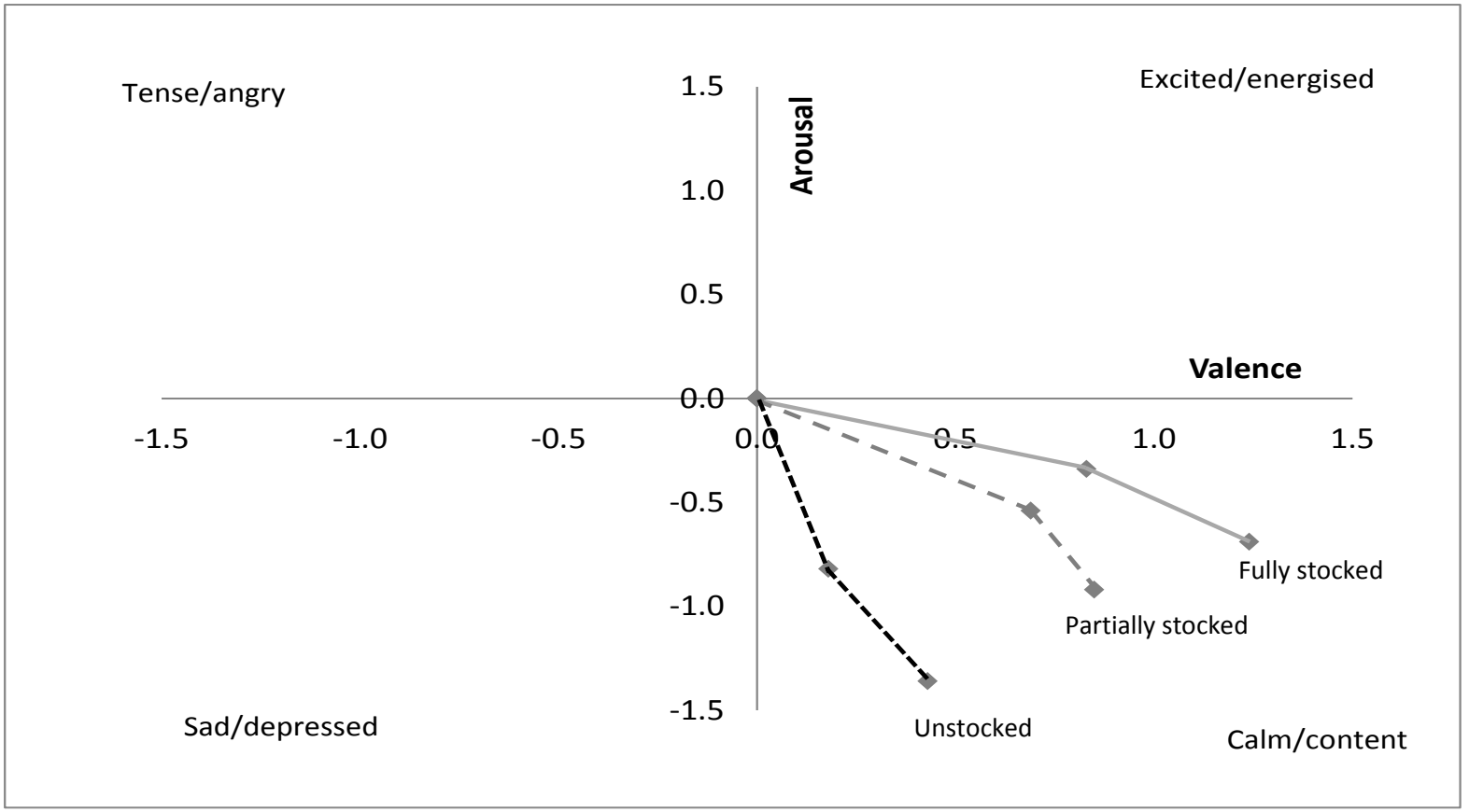


Figure 13. Study 4: Mean psychological reactions to the three different levels of stocking presented in two-dimensional affective space
Note: Change scores used.

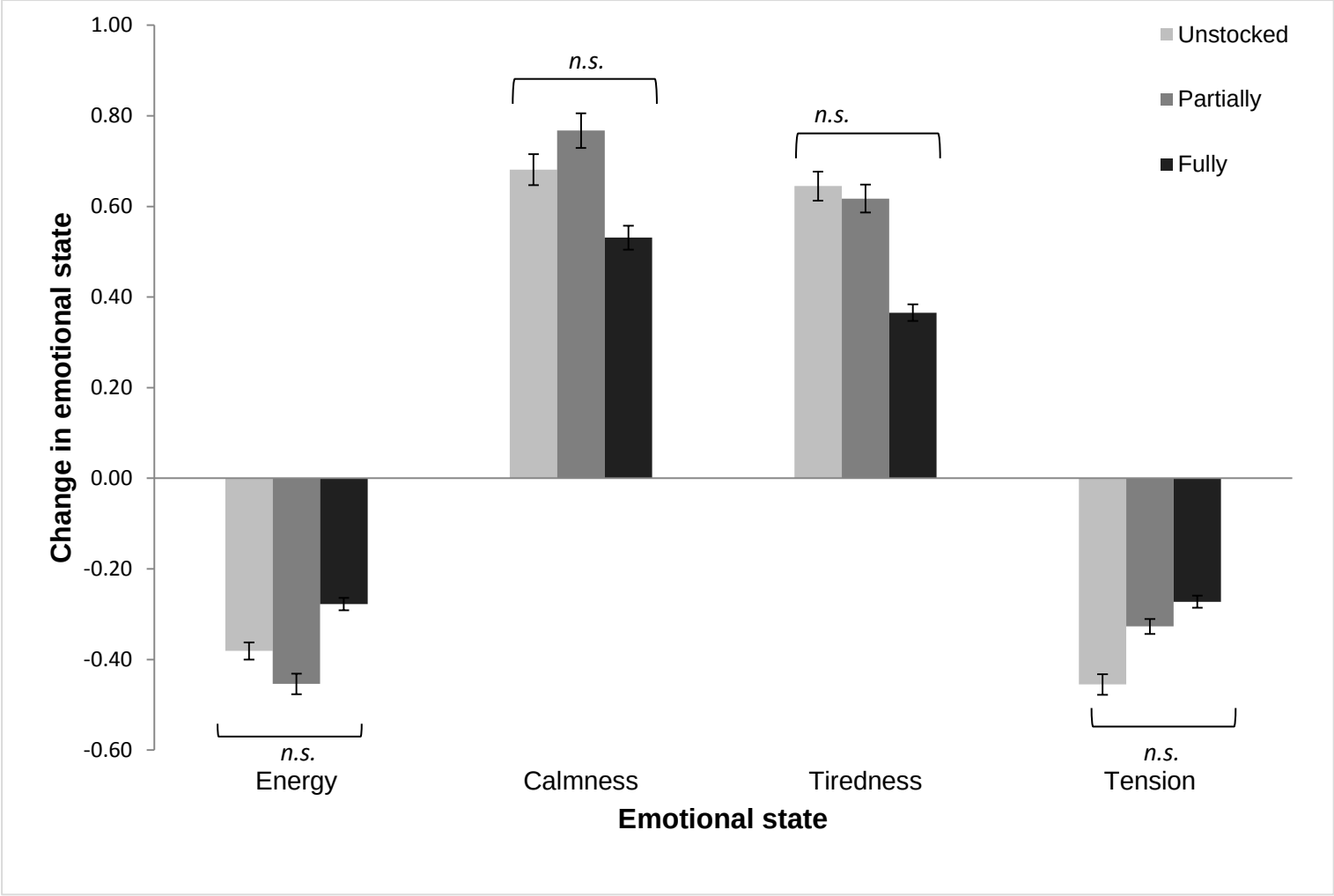


Figure 14. Study 4: Mean change in the four emotional states (Activation-Deactivation Adjective Checklist: energy, calmness, tiredness and tension) from baseline at 10 minutes as a function of exhibit stocking level

Note: *** p = < .001; ** p = < .01; * p = < .05; *n.s.* p = not significant. Error bars: 95% confidence intervals.

3.3 Discussion

3.3.1 Summary of Main Findings

This study presented a unique opportunity to test a range of psychological and physiological responses to different levels of marine biota in a very large aquarium exhibit. Also, importantly, this study allowed me to examine the relative importance of the physical setting, separate from the marine life contained within it. Finally, examining people's reactions to the exhibit, after both 5 and 10 minutes of exposure, enabled the potential duration 'dose-response' to be explored.

Visitor observations conducted in Part A confirmed that the visitors tended to spend longer in front of the exhibit when it contained the greatest level of marine life, thus supporting Hypothesis 1. If it is assumed that people's behaviour reflects their preferences, then this suggests that people gained more benefit from the exhibit when it was fully stocked. From a psychological perspective it might be that the greater levels of biota provided greater levels of interest and fascination, and also the opportunity to disengage from the mundane, all elements which have previously been shown to aid psychological restoration.

Evaluations from experimental participants that were closely monitored during their exposure to the exhibit in Part B, supported these perspectives. Specifically, as stocking levels in the exhibit increased, participants' interest in the exhibit and their willingness to watch it again significantly increased. This would appear indicative of a 'dose-response' relationship (supporting Hypothesis 2). Furthermore, it was also evident in both the observation and evaluation data that the exhibit alone, although unstocked and containing only seawater and artificial decoration, appeared to be sufficiently interesting to confer some benefits. This appears in line with previous studies that have shown the psychologically restorative effects of aquatic environments in general (e.g. White et al. 2013a) but extended here to different sub-aquatic environments.

The physiological evidence in support of the 'dose-response' effects of stocking level (Hypothesis 2) and exposure time (Hypothesis 3) was weaker. All stages of exhibit restocking were associated with significant drops in blood pressure and heart rate, indicating that exposure in all conditions was calming and physiologically restorative. It should be noted that these decreases were observed after a rest period, so cannot be attributed simply to the participants sitting quietly. However, most of these positive benefits occurred within the first five minutes, with only diminishing returns following a further five minutes of exposure. Nonetheless, the greatest drop in heart rate occurred in the Fully stocked condition and this drop was significantly different from the Unstocked condition.

The mixed blood pressure results may result from the relative responses of SBP and DBP to a given situation: an increase in SBP characterises a beta-adrenergic response linked to stressors involving active coping or defence, whereas an increase in DBP represents an alpha-adrenergic response linked to stressors involving vigilance or passive coping (Hartig et al., 2003). Hence, while there was no effect of condition, potentially the decreases in SBP and DSP (some of which were significant) may reflect the overall benign and non-threatening setting encountered by participants.

It could be suggested that the increased time spent in front of the exhibit by visitors in the Fully stocked condition, coupled with the recorded decreases in heart rate observed in experimental participants, could be attributed to a physiological 'freeze' response (Schmidt, Richey, Zvolensky & Maner, 2008), where the visitors or participants felt threatened or overwhelmed by the presence of the exhibit animals. However, given the large size of the exhibit, the stocking densities, even in the Fully stocked condition, were relatively modest, and were unlikely to have been overwhelming for study participants. Furthermore, the self-reported mood data showed a drop in positive arousal (Table 6) in all three conditions, suggesting a calming, rather

than alarming, experience. Although the drop in positive arousal was less in the Fully stocked exhibit, this is likely to reflect the greater attention and interest when viewing the higher numbers of animals on display, rather than greater anxiety. Finally, during study debriefs, participants frequently mentioned that they found the experience relaxing and enjoyable: none of the participants reported feeling fearful or overwhelmed.

Potential 'dose-response' relationships were more evident in the mood data where people reported how they were currently feeling in terms of valence and arousal. In general, as the duration of exposure increased people became both more positive and calmer, but as biota levels increased people became more positive but relatively less calm. This latter finding is concordant with the notion that the greater levels of biota are associated with more interest and fascination. In fact, when viewed from this perspective there might not be any reason to expect greater drops in blood pressure and heart rate from watching more vs. less marine life as the former is more stimulating (e.g. see Katcher et al., 1983) and is likely to hold one's attention for longer thus providing greater opportunity for cognitive restoration. This would support Kaplan and Kaplan's (1989) theory that preferences and restorative influences are cognitively-based and that humans have evolved to respond to general environmental contents (e.g. vegetation), and natural objects and content configurations that hold one's attention or are fascinating (as well coherent properties of nature that facilitate understanding and encourage exploration) (Ulrich et al., 1991). Indeed, Pilotti, Klein, Golem, Piepenbrink and Kaplan (2012) found a significant increase in participants' SBP following exposure to a nature video (but not an urban video), and suggest that changes in blood pressure can be expected to be related to pre-intervention (baseline) levels and participants' expectations. Furthermore, Ulrich et al. (1991) found that while SDP increased in response to their stressor (a video showing scenes of work accidents), heart rate

decreased, as they predicted. This was interpreted as indicating higher intake/attention resulting from viewing scenes showing blood and mutilation: Ulrich's (1983) theory "explicitly predicts that attention/interest will be a prominent component of *both* restorative responses to unthreatening natural scenes as well as stress responses to natural settings containing risk or threat" (Ulrich et al., 1991, p.208).

This study contributed to the small body of literature which suggests that individuals may gain psychological well-being from exposure to environments that contain relatively high levels of biota. Furthermore, these findings provide some support for all three previously mentioned hypotheses. The aquarium provided contact with nature (Biophilia) and fulfilled the criteria of ART, either fully for visitors who had chosen to visit the aquarium, or partially for participants for whom the aquarium still provided fascination and an escape from their daily routine. Overall, although participants tended to leave feeling happier and more relaxed (psychologically and physiologically) after viewing the exhibit, the unsuccessful stressor task (and the resultant inability to demonstrate a measurable effect on 'elevated stress') would appear to lessen the relevance of this work to PSRT, compared to the two other theoretical models, Biophilia and ART. However, self-rating data from a study using unstressed university students found that everyday natural scenes (particularly those containing water) held the participants' attention and produced more positive emotional states than urban scenes lacking nature (Ulrich, 1981). Furthermore, the self-ratings in Ulrich (1981) were largely convergent with results of brain electrical activity (EEG) recordings in the alpha frequency range, suggesting that participants were more relaxed and wakeful when viewing natural scenes. Similar consistency between psychological and physiological measures in this study likewise justifies greater confidence in the findings and also suggests that findings are not a result of social desirability effects.

Although the results of this study pertained to a very large, and thus presumably

immersive, exhibit, the findings could still have relevance for smaller aquaria. Although, due to size limitations, less scope exists to manipulate the biota levels, optimisation of smaller tanks may still be possible. This could be important for locations where reducing psychophysiological stress is a key objective; not only in traditional healthcare settings (e.g. dental waiting rooms), but in everyday places of stress such as office buildings. Furthermore, these results suggest that an individual does not need to spend much time in front of an exhibit (just 5 minutes) in order to derive benefits. This is an important point as short exposures to nature in managed settings, such as public aquariums, may provide a relatively easy and accessible means of improving health and well-being, and may be especially valuable for people who have little access to natural environments.

3.3.2 Limitations and Future Work

Key advantages of this study are that it included a 'control' condition (identical setting but with no biota present), and also precise knowledge about the actual level of marine life at both stages (unlike most field studies). This made it possible to investigate the added advantage the presence of fauna had, over and above the background aquatic environment. However, whether participants were able to discern the differences in biodiversity levels is unclear. As previous studies in terrestrial environments have highlighted, people's ability to accurately gauge species richness may depend on factors such as prior knowledge of wildlife (see Dallimer et al., 2012; Lindemann-Matthies & Bose, 2007, 2008). Therefore, it is possible that people's responses in this study were moderated by knowledge about underwater species, such that people possessing greater knowledge of temperate marine life gained more benefits. In view of this, one limitation of the current work was that participants were not asked to state their perceived levels of stocking or their familiarity with marine species. As actual and perceived levels of

stocking are not always highly correlated, and prior wildlife knowledge can influence biodiversity perceptions and preferences, it is suggested that these questions should be included in future studies in order that this possible moderating effect can be tested. As highlighted by Dallimer et al. (2012), it is conceivable that perceptions of species richness may be more important for well-being than the actual species richness.

In order to assess whether the Partially and Fully stocked conditions were sufficiently 'different', Simpson's Index of Diversity was recalculated at less detailed taxonomic levels. This was thought to be necessary as the addition of a different species of the same genus to the exhibit may be less detectable to someone with lesser marine life knowledge than the addition of a species from a more taxonomically distant genus. To emphasis the point, a keen diver may be able to differentiate between two species of ray (e.g. *Raja microocellata* – Small eyed ray, and *Raja undulata* – Undulate ray) but a non-diver may only see the addition of 'another ray' to the exhibit. On recalculation at two other taxonomic levels (genus and order), the Fully stocked condition was still found to be more diverse than the Partially stocked condition. Further, another diversity index, Shannon Weiner's Diversity Index, was also used, which again showed that the Fully stocked condition (H' = 2.51) was more diverse that the Partially stocked condition (H' = 1.93).

This study also benefited from taking place in a working aquarium during normal opening hours. Although it may have been possible to conduct the research 'out-of-hours', when peace and quiet could be assured, it was important to examine the potential of the exhibit to promote well-being under 'normal' conditions (i.e. usual opening hours) to ensure wider relevance. However, this also presented challenges. For instance, participants in the Fully stocked condition had, at baseline, generally higher heart rates and more negative moods than those in the other two conditions. Given these baseline differences, potentially due to poor weather and/or higher ambient visitor

numbers, regression to the mean effects cannot be ruled out as a possible explanation for the particularly strong gains (e.g. in heart rate and valence) in the Fully stocked group. Furthermore, if possible, future research should use experimental designs, rather than quasi-experimental, as the present study did.

Also, it was noted that the stressor task (anagrams) did not sufficiently stress participants: there was no significant increase in heart rate or either blood pressure measure following the stressor task, and averaged readings (see Table 5 for means) fell within typically accepted 'normal' rates for adults (i.e. resting heart rate: 60-100 bpm; blood pressure: <120/80 mm Hg - www.heart.org). The lack of stressor means that this study is therefore unlike other studies investigating stress reduction. Had the task been more effective at increasing stress arousal it is possible that some of the findings may have been stronger.

Furthermore, as psychological self-report measures appeared to be more reliable than physiological measures in this study, possibly the inclusion of the mood scales before the stressor task, as well as just after the task, could have been a useful addition to the experimental procedure and may have highlighted any changes in emotional state resulting from the stressor. That said, while the Feeling Scale and Felt Arousal Scales were particularly useful in establishing changes in mood, the AD ACL was less helpful. Although, the AD ACL revealed clear patterns of change over time (e.g. increased feelings of calm after viewing the exhibit for 10 minutes), this instrument did not appear to be sufficiently able to differentiate between participants' responses to the different stocking levels. In contrast to the Feeling Scale (an 11-point scale) and the Felt Arousal Scale (7-point scale), the AD ACL only contained four levels of response, i.e. Definitely do not feel (1) – Definitely feel (4). In view of this, it potentially lacked sufficient sensitivity to enable more subtle emotional state changes to be detected.

A further limitation of this study was that, due to its opportunistic nature, species

richness was naturally confounded with species abundance, which therefore limits the ability to be able to understand the relative impact of species richness vs. abundance. However, such studies would be almost impossible to investigate in situ, and would probably require more controlled laboratory studies. At best, I could at least demonstrate that participants were responding to current, known measures of species richness and abundance, rather than estimates obtained during past surveys.

Finally, although no data collection was carried out during feeding times (when many species are particularly active), it is possible that the behaviour of certain species may influence the exhibit's restorative potential. Some species are relatively 'shy' or have a limited behaviour repertoire whereas others are more gregarious or exhibit intriguing behaviours which may enhance the experience. Hence, future work could consider exploring whether there might be different levels of well-being associated with different types and/or combinations of underwater species exhibiting different characteristic behaviours.

3.3.3 Conclusions

In summary, this study added experimental evidence to the limited research showing that there are psychological and physiological benefits associated with watching aquaria. It extends earlier studies by exploring the potential influence of increasing biota levels on well-being measures recorded at different time points. The evidence that greater levels of stocking had a positive effect on experience evaluations and mood extends the findings taken from terrestrial studies that suggest 'dose-response' relationships between biota levels and immediate psychological well-being. The next step would be to investigate the potential benefits across a range of different aquarium exhibit types. Just as research on plant array preferences may improve the design of green spaces for well-being (e.g. healing gardens), thus a greater

understanding of aquarium biota and exhibit composition may maximise the restorative potential of aquaria in healthcare environments and other stressful settings such as the workplace. Additionally, future work should also seek to establish a greater understanding of the relationship between actual and perceived biota levels, and how certain animals, or animal behaviours, may influence human well-being outcomes.

Chapter 4.

Biodiversity, perceived biodiversity and human well-being: The importance of context and comparative judgements.

Chapter 4 is based on a journal article in preparation:

Cracknell, D., White, M. P., Pahl, S., Humphrey, L. & Depledge, M. H. (2015). Biodiversity, perceived biodiversity and human well-being: The importance of context and comparative judgements. Target journal *Human Ecology*.

4.1 Introduction

4.1.1 Overview

A number of studies investigating the relationship between natural environments and human health and well-being have explored the impact that biodiversity can have on positive health outcomes (see review by Lovell et al., 2014). Some studies suggest that psychological well-being benefits may to be greater in environments that are, or are perceived to be, more species rich (e.g. Dallimer et al., 2012; Fuller et al., 2007). In general, however, few studies actively determine people's perception of biodiversity and the factors that may influence these perceptions. Dallimer et al. (2012) did conduct these investigations and found that well-being outcomes were positively correlated with perceived species richness and that wildlife identification skills predicted a person's ability to estimate biodiversity levels: as wildlife knowledge increased, so did the accuracy of biodiversity perceptions. Interestingly, however, these findings were at odds with earlier work by Fuller et al. (2007) who found that well-being outcomes were associated with actual species richness. These mixed findings are particularly intriguing considering that both studies explored perceptions of the same three taxa (plants, birds and butterflies) and suggest that the relationships between actual, and perceived, biodiversity and well-being outcomes has complexities. Other fields of research have also revealed the difficulties that people can experience when trying to estimate

numbers of stimuli, such as crowds at a sporting event (Kemp, 1984) or flocks of birds (Erwin, 1982).

While Study 4 examined people's psychological and physiological responses to different levels of marine life in the same setting, how well people were able to distinguish the different components of the marine life present (i.e. the species richness and abundance of individuals) was not investigated. Furthermore, although Study 4 examined different *levels* of marine life, the 'type' of marine life viewed was similar, i.e. all animal species were temperate species, found around the coast of the UK. In view of this, two studies were undertaken that had the following aims: (i) to investigate how well people perceived the 'biodiversity' (note: for participants of these studies biodiversity was defined as 'species richness and abundance') of two large mixed species aquarium exhibits (one temperate, one tropical exhibit); (ii) to explore the relationship between these perceptions and people's self-reported well-being; (iii) to examine how these perceptions altered depending on context, that is, whether perceptions differed when viewing two exhibits consecutively, rather than a single exhibit; and (iv) to investigate whether prior marine life knowledge influenced biodiversity perceptions. Further, I wished to build on previous studies by investigating whether people preferred the temperate exhibit or the tropical exhibit (*cf.* Study 3), and whether the two different stocking levels of one of the exhibits (the tropical exhibit), elicited different well-being outcomes (*cf.* Study 4).

The first study (Study 5), sought to investigate people's perceptions of, and their psychological reactions to, the species richness and abundance in a single location, either a temperate or tropical exhibit. As the stocking levels in one of the exhibits (tropical) varied over time, Study 5 was repeated in order to explore whether reactions to the tropical exhibit differed depending on stocking level ('low' vs. 'high'). This additional aspect of Study 5, therefore partially replicated Study 4 (i.e. different

stocking levels of the same exhibit) but with an exhibit from another geographical region. The second study (Study 6) also aimed to investigate people's perceptions of species richness and abundance but differed from Study 5 by asking participants to view and rate both exhibits, rather than just one. Study 6 also enabled me to explore preferences for an example of a temperate exhibit when compared with a tropical exhibit, which also, therefore, expanded on Study 3.

In both Studies 5 and 6, participants were asked to complete a marine animal identification task that aimed to assess their ability to correctly identify marine species commonly displayed in public aquariums. Finally, for Study 6 only, a number of additional questions were also asked, such as how interconnected with nature participants felt (see Schultz, 2001), with the aim of establishing whether their connectedness to nature, for instance, influenced any well-being outcomes when viewing marine life.

4.1.2 Perceptions of Biodiversity

A number of studies have sought to examine the relationship between biodiversity and aesthetic preferences and/or human health and well-being outcomes. Some studies have highlighted a preference for greater levels of biodiversity in terrestrial settings. For instance, in Lindemann-Matthies and Bose's (2007) study, visitors to a botanical garden created species-rich, structurally diverse arrays, when asked to design their ideal patch of 'meadow', using either live plants or their own mental imagery. Visitors in the study stated that diversity was their main assemblage criterion. In order to examine whether the diversity and composition of the meadow arrays were influenced by the visitors' botanical knowledge or professional background, the questionnaire administered to participants asked them to self-estimate their level of taxonomic knowledge compared to that of the general public and write down their

profession. Analysis revealed that only participants' self-estimated botanical knowledge (and not profession) influenced the composition of their meadows: those who possessed a higher level of botanical knowledge created meadows that were more species-rich, than visitors with poor botanical knowledge.

Later work by Lindemann-Matthies, Junge and Matthies (2010) used a series of studies to investigate how accurately lay people were able to perceive the species richness of grassland arrays, whether aesthetic appreciation increased with true species richness, and whether perceptions and aesthetic appreciation were influenced by the dominance structure (evenness) of an array and the spatial distribution of the grassland species. They found that as true species richness increased so did perceived species richness and aesthetic appreciation of experimental grassland arrays (and natural meadows). Further, they point out that scenes that are visually more complex are often preferred aesthetically to less complex scenes. They also noted that both perceived species richness and aesthetic appreciation was greater when experimental arrays displayed more evenness (i.e. the species present were more even in abundance). Nevertheless, they found that people's estimates of species richness were generally unreliable. This was especially true with greater species richness: people consistently underestimated plant species richness when it was high (note: maximum species richness in their experiments = 64 species) and slightly overestimated species richness when it was low (they suggest that this could be related to 'Weber[-Fecher]'s Law' whereby "the discriminability of two numbers decreases as the magnitude of the numbers increase", p. 200).

The difficulties people experience in estimating numbers of stimuli (note: when a stimulus number is greater than six it is deemed 'an estimate' – Miller & Baker, 1968) has been highlighted in several studies. These studies have examined a range of stimuli, including different sized and shaped objects (Miller & Baker, 1968), crowds at sporting

events (Kemp, 1984), and, more closely aligned to the current work, aggregations of waterfowl (Erwin, 1982) and nesting birds (Frederick, Hylton, Heath & Ruane, 2003). In each of these studies, although some overestimation occurred, there was a tendency for the majority of participants to underestimate stimuli. For instance, Erwin (1982) found that over 80% of counts were underestimates, and Frederick et al. (2003) found that participants, even experienced ones, often miscounted by around 50%. Often, prior experience of estimating numbers for surveys did not improve accuracy (Erwin, 1982; Frederick et al., 2003) and, even between participants with a similar level of experience, the variation in estimates could be substantial (Erwin, 1982). As for whether the size of stimuli aggregation affected estimates, Frederick et al. (2003) found no effect of size of aggregation, whereas Erwin (1982) found that dense aggregations of birds were more likely to be underestimated than more sparse aggregations.

Birds were one of three taxa that participants were asked to estimate in Fuller et al.'s (2007) study. These researchers conducted semi-structured interviews, in situ, with 312 users of 15 green spaces in and around the city of Sheffield (UK). Before the interviews were carried out (July – October), ecological surveys were conducted during the summer (plants were sampled in 'summer'; birds and butterflies were sampled between June and August). These surveys aimed to identify the species most likely to be seen during a summer visit (note: abundance of each species was not measured). During the interviews, closed-ended questions examined psychological well-being by exploring green space as a source of cognitive restoration, positive emotional attachment and a sense of identity. Using a five-point Likert scale (Strongly disagree to Strongly agree), respondents were asked to respond to 23 statements. Five statements, based on ART, measured the likelihood of recovery from mental fatigue and the opportunity for reflection; 18 statements, based on theory and research on 'place', examined emotional attachment to, and personal identity associated with, green space. In order to explore

perceptions of green space species richness, respondents were asked how many different types of plants, butterflies and birds they thought were in the park.

The ecological surveys revealed that species richness varied markedly across the 15 green space sites. Plant species richness varied by an order of magnitude, while bird and butterfly richness varied five- and threefold, respectively. Measures of psychological well-being varied across sites and by taxon. For instance, plant richness was positively related to 'reflection' and 'distinct identity' whereas bird richness was positively associated with 'continuity with the past and attachment'. In contrast, butterfly richness was not related to any of the well-being measures. Respondents' perceptions of plant richness increased strongly with surveyed plant richness but, for birds, there was only a marginally, non-significant positive relationship between perceived and sampled richness. There was no relationship at all for butterflies. Fuller et al. (2007) concluded that psychological benefits were positively related to the species richness of plants and to a lesser extent of birds. Furthermore, for both plants and birds, perceived species richness was related to the species richness estimates obtained from the ecological surveys.

In a similar study, Dallimer et al. (2012) collected 21 psychological well-being measures from in situ visitors to 34 riparian green spaces that had been ecologically surveyed for species richness of plants, birds and butterflies (but, again, not abundance). Once more, psychological measures were based on ART and the sense-of-place frameworks. A number of measures were modifications of Fuller et al.'s, (2007) original statements. Participants were again asked to estimate the number of different types of plants, birds and butterflies. Additionally, participants undertook a species identification task in order to assess their ability to identify elements of the local flora and fauna. Although extremely similar in design and execution to Fuller et al.'s (2007) study, Dallimer et al.'s (2012) findings were not in agreement. Dallimer et al. (2012)

found no relationship between actual and perceived species richness for any of the three taxonomic groups. Furthermore, there was no consistent pattern of relationships between actual species richness and any of their psychological well-being measures. Although, in line with Fuller et al. (2007), they found no relationship between well-being measures and butterflies, they found that well-being increased with greater levels of bird species diversity and declined with greater plant species richness. Intriguingly, however, Dallimer et al. (2012) did note that there were positive associations between respondents' well-being measures and their *perceptions* of species richness for all three taxonomic groups. In view of this, Dallimer et al. (2012) suggested that, as people experience difficulties when trying to accurately estimate species richness, then possibly *perceptions* of species richness are equally, if not more, important than *actual* species richness when considering psychological well-being.

Dallimer et al. (2012) suggested a number of factors that may have influenced their findings. For instance, people may have been responding to other environmental cues, such as tree cover, rather than just species richness. Additionally, some species may be more charismatic than others or be present in a greater abundance, both factors that could make their presence more noticeable or important. This point was also raised by others. Lindemann et al. (2010) noted that certain plants in their grassland arrays, particularly herbs with brightly coloured flowers, tended to increase aesthetic appreciation of their arrays, whereas some grass species tended to decrease aesthetic appreciation. Uyarra et al. (2009) asked divers visiting the Caribbean island of Bonaire to list the attributes that contributed most (and least) to their enjoyment of a dive site. Divers selected from 20 attributes that covered biological (e.g. fish abundance – including fish species richness, coral condition), environmental (e.g. underwater current, visibility) and other external factors (e.g. number of divers at the site). They found that high fish abundance contributed most to divers' enjoyment of the dive sites. They noted,

however, that although fish were present in greater numbers at the most preferred dive sites, the difference in numbers between most and least preferred sites was not statistically significant. Uyarra et al. (2009) therefore suggest that perceived fish abundance may depend on more than just numbers of fish and, more specifically, that certain fish species contribute to divers' perceptions of greater fish abundance. As well-being benefits, or aesthetic values, appear to fluctuate depending on taxonomic group (e.g. birds vs. butterflies), specific species (e.g. colourful specimens) or people's ability to assess species richness, it is perhaps not surprising that the links between biodiversity and health and well-being outcomes are not always clear.

As mentioned, Lovell et al. (2014) undertook a review of studies investigating the relationships between biodiverse environments and human health and well-being. They noted that, although there was evidence of the *negative* impacts that the disruption of biodiversity can have on human well-being (e.g. the possible increases in the spread of zoonotic diseases or loss of potential pharmaceuticals), the evidence for the *positive* benefits of biodiverse environments in promoting 'good' human health and well-being was less conclusive. Related reviews (e.g. Bowler et al., 2010), indicate that being close to natural environments may aid the management of, and reduce the prevalence and risk factors of, some non-communicable diseases such as type 2 diabetes, heart disease and mental health disorders as, potentially, an 'attractive' biodiverse natural setting may encourage greater physical activity or facilitate social activities. Nevertheless, Lovell and colleagues noted that, although there appeared to be theoretical, and partially evidenced, relationships between biodiverse natural environments and good human health and well-being, these links were not necessarily confirmed. They identified at least one positive connection between biodiverse environments and positive health benefits in 10 out of the 16 studies that fitted their review criteria (and that included Dallimer et al., 2012), but reported that the direction of the relationships were often

unclear or inconclusive. They proposed that a number of factors (e.g. the small body of evidence, and the varied research design, methodologies and measures) may contribute to a lack of definitive conclusion as to whether greater biodiversity is associated with more positive human health and well-being.

4.1.3 Current Research

Only one study in Lovell et al.'s review featured aquatic animals (Curtin, 2009 - mentioned in Chapter 1). To date, research exploring people's preferences for aquatic and sub-aquatic biodiversity generally focuses on the implications for tourism and conservation (e.g. Polak & Shashar, 2013; Uyarra et al., 2009), rather than human health and well-being. This stems from an increasing interest in connecting people with nature, and the biodiversity around them, in order to foster greater pro-environmental behaviours (Dearborn & Kark 2009; Hughes et al. 2013; Mlambo 2012). As conservation efforts are often motivated by aesthetic appeal (e.g. whales, dolphins), human preferences for different species may determine the likelihood that a particular species is valued and, ultimately, protected (Stokes, 2007). Furthermore, health considerations aside, there also appears to be a lack of information on how good people are at estimating the biodiversity in sub-aquatic scenes and how these estimates may influence well-being outcomes.

So far, Studies 1-4 of this thesis have provided some evidence of people's preferences for, and the perceived restorative potential of, sub-aquatic environments (natural – Study 1, and human-made/aquarium – Study 2), compared to other environment types; peoples' reactions to different types of sub-aquatic scenes (aquarium exhibits – Study 3); and how people's behavioural, psychological and physiological responses differ between different stages of an exhibit restocking event (Study 4). However, as yet, no measures how well people in the aquarium perceive biodiversity

have been established.

As mentioned, previous ecological studies have found differences between expert and lay estimates of biodiversity, making it unclear whether actual (see Fuller et al. 2007) or perceived (see Dallimer et al. 2012) levels of biodiversity are better linked to well-being outcomes. As well as the issue of lay people's difficulty, in line with other visual and auditory stimuli, in recognising growing diversity as species richness increases (Lindemann-Matthies et al., 2010), it should also be recognised that in these earlier studies people were asked to make a single, isolated judgment about biodiversity for a single environmental setting. Psychologically speaking people find such isolated judgments hard and instead tend to be more accurate when they are able to compare across two or more contexts (Helson, 1964; Parducci, 1995). What is needed, therefore, are studies which allow people to make estimates of species richness across more than one context. Given prior psychological research, it would be expected that the accuracy of estimates increases, if only in relative terms (i.e. which of two locations has 'greater' biodiversity), at least for the second location assessed.

The current research thus extended previous work in three key ways. First, species data for the 'expert' surveys and the 'lay' estimates of species richness and abundance were collected within days of each other. This is likely to have provided a greater degree of accuracy, as estimates of species richness, using standard ecological protocols, are often collected over a period of several weeks or months. Potentially, this delay between establishing species richness estimates from surveys and in situ data collection from study participants may have resulted in a degree of disparity between the survey numbers and participants' estimates collected some months later. Second, due to understandable practicalities, previous in situ work has tended to focus on species richness, and associated well-being outcomes, in one setting, at one time point. In the current studies, participants viewed either one (Study 5) or two (Study 6) large,

live aquarium exhibits. Furthermore, in order to facilitate a comparison of the perceived biodiversity between exhibits, a simple 1-10 relative 'biodiversity scale' was used which enabled a perceived 'biodiversity score' to be calculated and a direct comparison between the two exhibits to be made in terms of their relative stocking level. Finally, I built on previous work by asking participants for estimates of *abundance*, as well as species richness; again this may be important where people are unable to tell the difference between two or more species, but are able to more accurately assess how many individuals are present.

In the current chapter, Study 5 used a 'between-subjects' design to explore perceptions and responses to marine life in two different settings (Temperate vs. Tropical exhibits). This study ran twice, at two different levels of marine life ('Low' vs. 'High'). Study 6 looked at the role of 'context' on judgements of stocking level, that is, participants were asked to view, and make comparative judgements of, both exhibits. This 'within-subjects' design ran at the 'High' level of stocking only. Study 5 enabled me to see how sensitive people were to levels of stocking in different settings and how this affected well-being. Study 6 enabled me to see whether estimates of stocking levels were influenced by context and the contextual factors credited with well-being. Finally, these studies explored the well-being responses to sub-aquatic biota levels, rather than the more traditionally researched greenspace.

In summary, the two studies set out to answer the following research questions:

1) Do people underestimate fish species richness and abundance, in the same way as they do bird species?

2) If underestimation occurs, is it modified by exhibit type, that is, is underestimation similar with temperate and tropical marine life exhibits, or does the region that the marine life originates from make a difference? Tropical marine life is usually more colourful than temperate marine and this, potentially, makes differentiating the different

species more likely.

3) Is there a positive relationship between *actual* species richness/abundance and experienced well-being (e.g. changes in mood and arousal), perceived restorativeness, restorative potential of the exhibit, and/or people's preferences?

4) Is there a positive relationship between *perceived* species richness/abundance (measured using both species/abundance accuracy scores and a generic perceived 'biodiversity score') and experienced well-being, restorative characteristics, restorative potential of the exhibit, and/or people's preferences?

5) Do estimates of species richness/abundance improve when viewing a second tank, as there is now a comparator to base one's judgments on?

6) What impact does viewing a second tank have on experienced well-being, perceptions of how restorative an exhibit is, restorative potential and preferences, and is this moderated by exhibit type?

4.2 Study 5: Perceptions of Species Richness and Abundance, and Associated Well-being Outcomes, When Viewing a Single Exhibit

4.2.1 Methods

4.2.1.1 Preparatory Work

4.2.1.1.1 Questionnaire Development

A questionnaire was developed that aimed to explore participants' psychological responses to viewing one aquarium exhibit for 5 minutes; assess their perceptions of exhibit stocking levels (e.g. numbers of fish species and individuals) and allocate a generic 'biodiversity score' based on these perceptions. The questionnaire also sought to quantify participants' ratings of the exhibits in terms of the exhibits' perceived restorativeness and restorative potential, their experienced well-being, (and, of secondary interest, their preferences - e.g. I like this exhibit); and assess their level of

marine wildlife knowledge. The initial questionnaire was piloted on a small sub-sample of aquarium (n = 3) visitors (my target audience) and was subsequently amended to address any issues including questionnaire length and clarity (Appendix F).

4.2.1.1.2 Estimates of Species Richness and Abundance

Estimates of species richness and abundance for two exhibits (one temperate, one tropical – Figure 15a & b) at the National Marine Aquarium (UK) were obtained using multiple visual counts, from more than one observer, and husbandry stock records. Study 5 ran twice using two different stocking levels for both exhibits. At the lower stocking level, the Tropical exhibit contained approximately 215 individual animals and 45 species (all fish); the Temperate exhibit contained 140 animals (133 fish; seven crabs/lobsters) and 28 species (25 fish species; three invertebrate species – all crustacean). At the higher stocking level, the Temperate exhibit contained approximately 226 individuals (194 fish; 32 crabs/lobsters) and 35 species (28 fish species; seven crustaceans); the Tropical exhibit contained approximately 634 individual animals (633 fish; one turtle) and 68 species (67 fish species; one species of reptile). The Shannon Wiener index for the Temperate exhibit averaged 2.81 and the Tropical exhibit averaged 3.15.

a) b)

Figure 15. Example images: a) Temperate exhibit; b) Tropical exhibit (Note: These images do not represent the fish species and abundance present at the time of either study)

4.2.1.2 Participants

In order to understand the experiences of real visitors to the Aquarium, all Study 5 participants were National Marine Aquarium visitors (Low stocking level: N = 49, 25 females, Mean age 37.9 years; High stocking level: N = 49, 30 females, Mean age 41.8 years). As mentioned, Study 5 ran in two phases to take advantage of the natural variability that can occur in exhibit stocking levels in a real aquarium environment.

4.2.1.3 Procedure

Visitors were approached at the Aquarium entrance and asked if they would be willing to participate in a short questionnaire in return for a free hot drink at the Aquarium's café. Following a pilot study in which random sampling yielded too few participants, visitors were approached on a 'continuous ask' basis. Visitors were informed that their responses would be confidential and that they were free to withdraw from the study at any point. If there was more than one visitor in the party (e.g. a couple) both were asked if they would be willing to participate but were informed that they should not confer. Those willing to participate were asked to complete two mood scales (Time 1) before being led to either the Tropical or Temperate exhibit (alternated for each participant). Once seated in front of the exhibit, the participant was instructed to watch the exhibit for a period of 5 minutes after which time mood scales were completed again (Time 2), followed by the rest of the questionnaire. When the study was finished, participants were thanked for their time and handed their drink voucher (Figure 16).

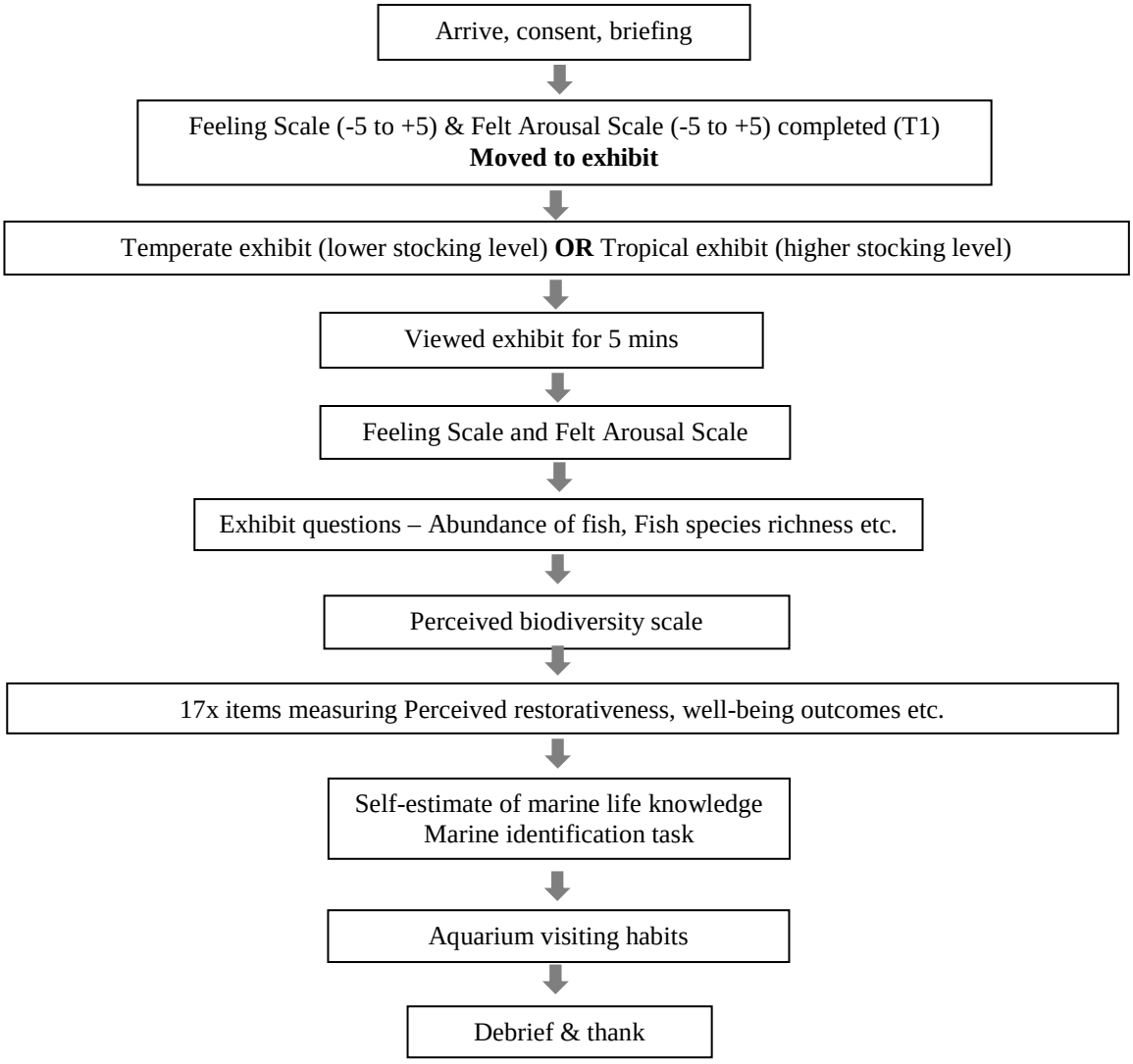


Figure 16. Study 5: Flowchart of procedure

Note: Study 5 ran twice, with two levels of exhibit stocking for each exhibit (with a greater difference between high and low stocking levels for the Tropical exhibit).

4.2.1.4 Measures

4.2.1.4.1 Perceptions of Stocking Levels

Perceived biota levels were measured in two ways. First, participants were asked to estimate how many different fish species (species richness) and individual fish (abundance) they thought they saw and, second, allocate a generic perceived 'biodiversity score' for the exhibit, using a 1-10 scale (1 = Extremely low, 10 = Extremely high). In order to gain some additional information on how participants felt about the animals they were viewing, a number of additional questions were asked, such

as which species of fish they liked best. These data are not explored further here but some interesting trends were observed, such as some general preferences for certain species, such as rays (*Raja spp.*) and the Loggerhead turtle (*Caretta caretta*), and certain behaviours, such as shoaling (see Appendix G for measures and results).

4.2.1.4.2 Perceived Restorativeness, Restorative Potential and Well-being Outcomes

Building on Study 4, two mood scales were used to assess participants' affective states before (Time 1: T1) and after (Time 2: T2) viewing the exhibit for 5 minutes. Affective valence was again based on Hardy and Rejeski's Feeling Scale (1989) and level of excitement was adapted from Svebak and Murgatroyd's Felt Arousal Scale (1985). For these studies, both scales were 11-point bipolar scales, ranging from -5 to +5. It was decided to alter the scales slightly to reflect that fact that they were to be used on members of the public. In view of this, two changes were made. First, the anchor words were altered slightly. For instance, instead of using 'Low' and 'High arousal', the Felt Arousal scale was anchored by 'Very calm' and 'Very Excited' as I felt that trying to explain the meaning of 'arousal' in the psychological context to members of the public might be quite challenging and lengthy. Second, the Felt Arousal Scale was altered to an 11-point scale in order that the layout and wording of the questionnaire would be simplified for visitors.

The key area of interest was how restorative participants perceived the exhibit(s) to be. In view of this, participants were asked about the perceived restorativeness and restorative potential of the exhibit, restorative outcomes and exhibit preferences. Eight items measuring perceived restorativeness were adapted from Pals et al.'s (2009) Perceived Restorative Characteristics Questionnaire (PRCQ). Pals et al. (2009) cite the PRS (Hartig et al., 1997) and the RCS (Laumann et al., 2001) as the inspiration for the

PRCQ. Items from the PRCQ were selected as they were deemed the most appropriately worded items for translation into a public aquarium context, having been used before to measure the perceived restorativeness of zoo exhibits (although, arguably, items from the PRS could also have been adapted for this study). The PRCQ was originally designed and used to measure the five restorative characteristics (Fascination, Novelty, Escape, Compatibility, and Coherence - a narrowed down definition of Extent) of zoo attractions but, as Pals et al.'s (2009) analysis failed to distinguish Compatibility as a separate factor, only items (two of each) measuring Fascination, Novelty and Escape (two aspects of 'Being Away') and Coherence (a limited definition of 'Extent') were used in Studies 5 and 6. When referred to collectively in this thesis, the eight items measuring perceived restorativeness will be referred to as the "Perceived Restorativeness".

Four items measuring 'reflection and restoration' outcomes (reflection: the ability to think and gain perspective) were adapted from Dallimer et al. (2012). Dallimer et al.'s items were developed from previous studies that focused on "cognitive restoration and reflection, emotional attachments and identity" (p.50) and included items grounded in ART (Kaplan and Kaplan, 1989). When referred to collectively, these outcome items will be labelled as "Reflection and Restoration".

Finally, I incorporated four items adapted from Dallimer et al. (2012) that measured 'Attachment' (the degree of emotional attachment with the exhibit). These four items were also used by Pals et al. (2009), although Pals et al. coded these items as measuring 'pleasure' or 'preference', rather than 'attachment' (see Table 7). One additional 'preference' item ('This exhibit is a good place to relax') from Pals et al. (2009) was included as a measure of the' Restorative potential' of the exhibit. Participants expressed their level of agreement with each item using a 5-point Likert scale: 1 = Strongly Disagree to 5 = Strongly Agree. Four items were reverse coded.

Table 7. Items measuring perceived restorativeness, reflection and restoration, restorative potential and attachment

Statement	Measure*	Overall item label
There is much to discover in this exhibit	Fascination[†]	
There are many things in this exhibit that attract my attention effortlessly	Fascination[†]	
This exhibit is unique	Novelty[†]	
This exhibit is not novel[r]	Novelty[†]	
When I am at this exhibit I feel free from my daily routine	Escape[†]	"Perceived restorativeness"
At this exhibit I can forget about my obligations	Escape[†]	
Everything I see in this exhibit goes well together	Coherence[†]	
Everything I see in this exhibit fits here	Coherence[†]	
Watching this exhibit clears my head	Reflection/restoration[‡]	
I feel peaceful when I am in front of this exhibit	Reflection/restoration[‡]	"Reflection and restoration"
I do not feel calm when I watch this exhibit[r]	Reflection/restoration[‡]	
Watching this exhibit makes me feel more connected to nature	Reflection/restoration[‡]	
This exhibit is a good place to relax	Preference[†]	"Restorative potential"
I do not gain pleasure from this exhibit[r]	Attachment[‡]/Pleasure[†]	
I feel happy when I am watching this exhibit	Attachment[‡]/Pleasure[†]	"Attachment"
I am not satisfied with this exhibit[r]	Attachment[‡]/Pleasure[†]	
I like this exhibit	Attachment[‡]/Preference[†]	

* Note: [†] denotes items adapted from Pals et al. (2009); [‡] denotes items adapted from Dallimer et al. (2012); [r] denotes reverse coded.

4.2.1.4.3 Estimates of and Actual Marine Life Knowledge, and Frequency of Aquarium Visits

Participants were asked to self-estimate their knowledge of marine animals compared to the average person of their age and gender (5-point Likert scale: '1 = Well below average' to '5 = Well above average', adapted from Lindemann & Bose 2008). Then, to assess participants' taxonomic knowledge, participants were asked to identify 10 photographs of marine animals regularly encountered in public aquariums. I selected the images based on my previous experience of animal husbandry and asked two colleagues, who interact with aquarium visitors on a daily basis, to rate the images on level of difficulty (i.e. the likelihood that visitors would be able to correctly identify the animals in the images). The majority of images were of relatively common, easy to identify species (e.g. Edible crab, *Cancer pagurus*; Common clownfish, *Amphirion ocellaris*) but a small number of more challenging species were also included (e.g. Pollack, *Pollachius pollachius*, as this species can be difficult to distinguish from other gadoids - members of the cod family - such as Whiting, *Merlangius merlangus*) to enable differentiation between levels of marine wildlife knowledge (Appendix H). Finally, participants were asked about their aquarium visiting habits (e.g. monthly, annually. Note: frequency of aquarium visit was scored as 1 = most frequent, i.e. 'weekly', and 9 = least frequent, i.e. 'first visit') and basic demographics (e.g. gender, age).

4.2.1.5 Data Preparation

Outlier analysis was conducted on participants' estimates of fish numbers and species, changes in mood and arousal, and perceived 'biodiversity score'. Participants with extreme scores that could substantially affect within group means (i.e. >3x *SD*s from the Mean) were excluded from further analysis for the measure for which they

scored excessively high or low. Following outlier analysis, four participants were removed: two participants from fish abundance analysis, one from species richness analysis and one from mood analysis.

To calculate how accurate estimates of fish abundance and fish species were, the actual numbers of fish and fish species were subtracted from the participants' estimates. Therefore, the closer to zero the participants' 'accuracy' scores were, the more accurate were their estimates. Negative 'accuracy' scores indicated that numbers were underestimated, and vice versa. The 'accuracy' scores calculated were used in subsequent analyses (see Section 2.2.3).

4.2.1.6 Statistical Analysis

Using the 'accuracy' scores, the effects of stocking level (Low/High) and exhibit (that is, marine life 'type' - Temperate/Tropical) were explored using two 2 x 2 fully independent univariate ANOVA, once for abundance and once for species richness. This test was also used to examine differences in the Perceived 'biodiversity score'. One sample *t*-tests were conducted to compare actual known numbers with estimates of abundance and species richness.

Changes in mood (positive affect and arousal) over time were examined using 2 (Time: T1/T2) x 2 (Stocking level: Low/High) x 2 (Exhibit: Temperate/Tropical) mixed factorial ANOVA with repeated measures on Time. In order to investigate how the two exhibits and two stocking levels compared on the four Perceived restorativeness (Fascination, Novelty, Escape and Coherence), Reflection and Restoration outcomes, Restorative Potential and Attachment (preferences), a series of 2 x 2 univariate analyses were undertaken. Paired sample *t*-tests were also used to explore any differences between the four mean perceived characteristics scores. Finally, the associations between biota estimates and well-being measures (e .g changes in mood, established by

computing the difference between before and after scores) were examined using bivariate correlations.

4.2.2 Results

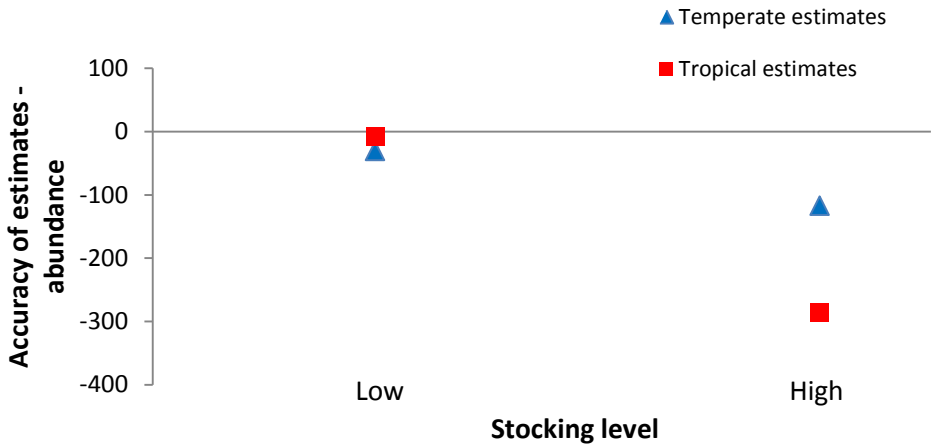
4.2.2.1 Perceptions of Stocking Levels

Examination of the effects of stocking level (Low vs. High) and exhibit (marine life 'type: Temperate vs. Tropical), using the accuracy scores, found a significant interaction between stocking level and exhibit for fish abundance, $F(1,90) = 10.72$, $p = .002$ (Figure 17a). There was a significant main effect of stocking level, $F(1,90) = 38.81$, $p < .001$ and also exhibit, $F(1,90) = 6.13$, $p = .015$. In contrast, there was no interaction between exhibit and stocking level for species richness, $F(1,92) = 0.286$, $p = .594$ (Figure 17b) There was no significant effect of stocking level, $F(1,92) = 3.41$, $p = .068$, although there was a significant effect of exhibit for species richness, $F(1,92) = 19.52$, $p < .001$. In short, in this study, it appeared that participants were more likely to distinguish between differences in fish abundance than they were fish species richness.

Consistent with previous work on birds (e.g. Erwin, 1982), comparing participants' estimates of fish abundance and species richness with actual numbers established in the biological surveys found that participants generally underestimated the number of individual fish and fish species. In the Low stocking condition, the number of fish species was significantly underestimated for both exhibit types (Temperate: $t(23) = 7.03$, $p < .001$; Tropical: $t(23) = 7.73$, $p < .001$). This was also the case in the High stocking condition: there was a statistically significant difference between perceived and actual numbers for fish species (Temperate: $t(23) = 5.84$, $p < .001$; Tropical: $t(24) = 6.48$, $p < .001$). However, in the Low stocking, there was only a statistically significant difference between actual and perceived numbers of individual fish for the Temperate exhibit $t(23) = 2.38$, $p = .026$; not the Tropical exhibit, $t(23) =$

0.41, p = .688. In contrast, in the High stocking conditions, the number of individual fish was significantly underestimated in both exhibits, and by a greater degree: Temperate: $t(22) = 13.69$; $p < .001$; Tropical: $t(22) = 5.27$, $p < .001$.

a)



b)

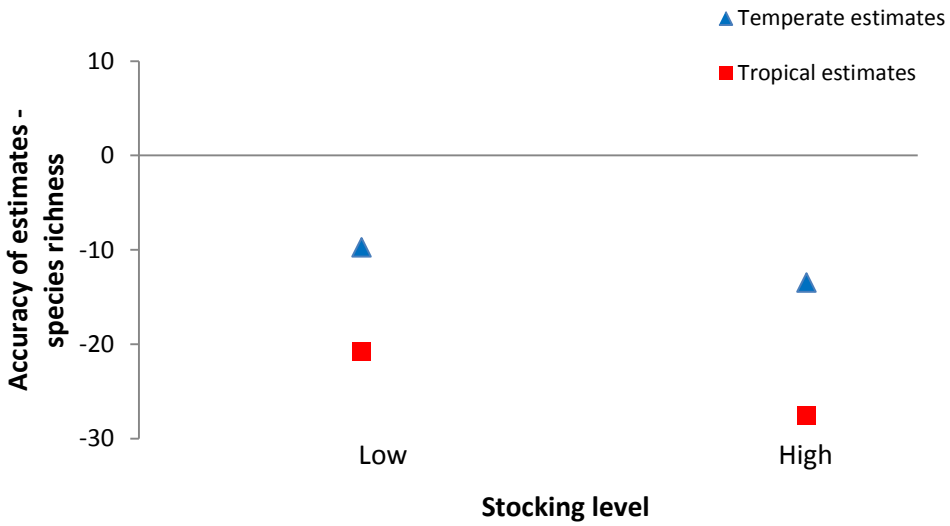


Figure 17. Study 5: Mean accuracy of estimates as a function of stocking level: a) Fish abundance; b) Fish species richness

Overall, although estimates for both fish abundance and species richness were poor, participants were better able to distinguish between higher and lower levels of fish abundance than they were able to distinguish between fish species richness. Perceived

(generic) 'biodiversity scores' across Study 5 were comparable, irrespective of the stocking level or exhibit type (Figure 18). The 2 x 2 univariate ANOVA found no significant effect of stocking level, $F(1,93) = 0.868$, $p = .354$, exhibit, $F(1,93) = 0.178$, $p = .674$, or interaction, $F(1,93) = 1.00$, $p = .319$, suggesting that participants did not distinguish between the stocking level or exhibit when using the Perceived 'biodiversity score'.

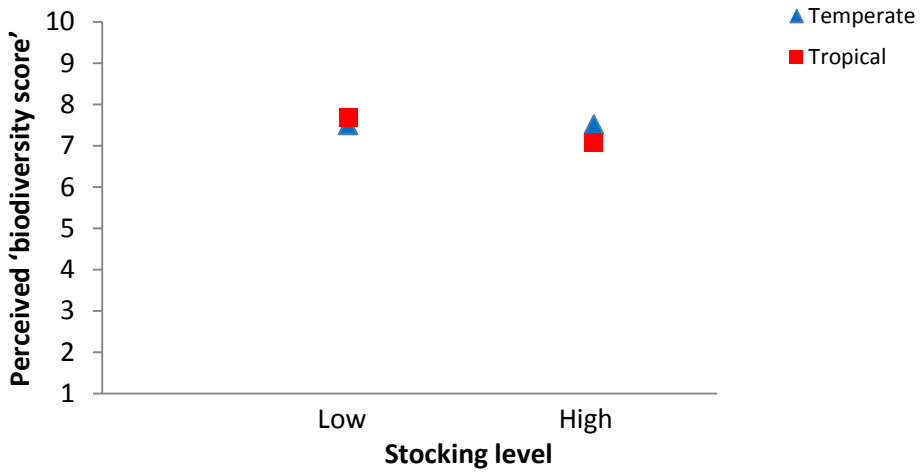


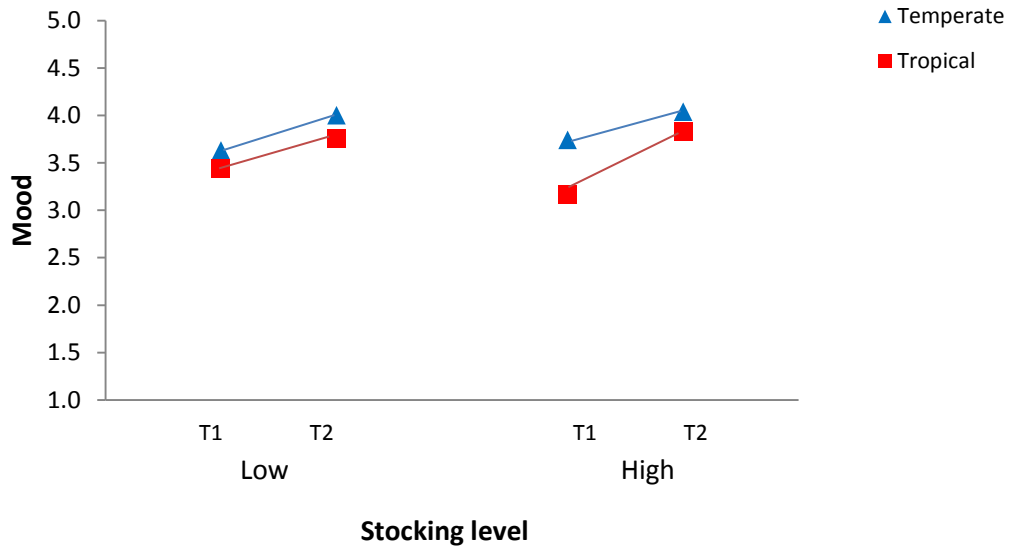
Figure 18. Study 5: Mean perceived 'biodiversity score' as a function of stocking level
Note: Scale 1-10 (1 = Extremely low; 10 = Extremely high)

4.2.2.2 Psychological Well-being

4.2.2.2.1 Mood and Arousal

Outlier analysis revealed that one visitor arrived in a particularly poor mood. This participant was removed from the mood analyses. Overall, however, participants arrived in a relatively good mood ($M = 3.49$, $SD = 1.36$) and a state of mild arousal ($M = 1.76$, $SD = 2.68$). Analysis revealed that there were no significant interactions or main effects between stocking level, exhibit type, and changes in mood or arousal. There was a significant main effect of time for both measures: viewing an exhibit for 5 minutes resulted in a significant improvement in mood, $F(1,92) = 16.41$, $p = < .001$, (Figure 19a) and decrease in arousal, $F(1,92) = 5.07$, $p = .027$ (Figure 19b).

a)



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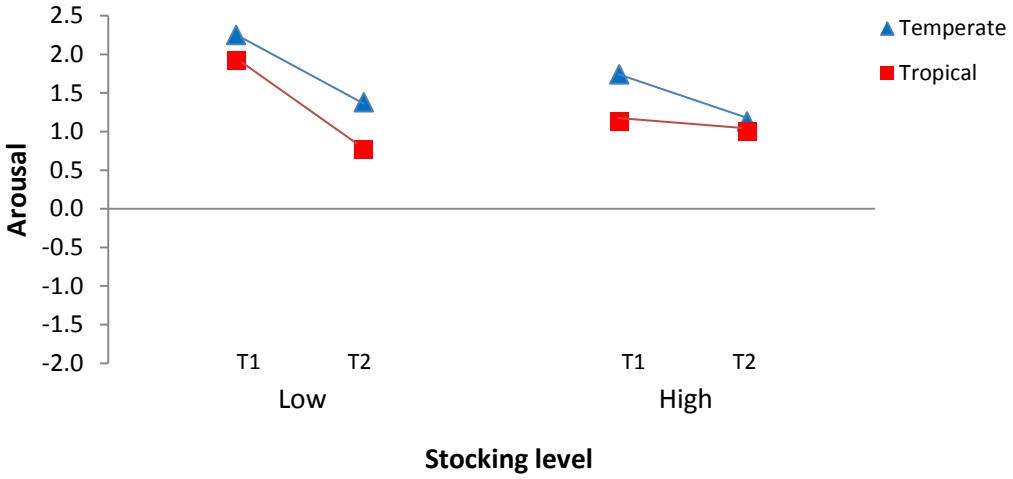


Figure 19. Study 5: a) Mean changes in mood over time as a function of stocking level: Feeling Scale; b) Mean changes in arousal over time as a function of stocking level: Felt Arousal Scale.
Note: 11-point scales (-5 to +5)

4.2.2.2.2 Perceived Restorativeness, Reflection and Restoration, Restorative Potential and Attachment

Comparison of the Perceived restorativeness scores of the two exhibit types revealed that both exhibits were scored 3.50 or more on the 5-point scale for all four characteristics (Fascination, Novelty, Escape and Coherence), with Fascination and Coherence scores consistently greater than 4 out of 5. There were no significant

interactions between stocking level and exhibit type for Fascination, $F(1,94) = 1.16$, $p = .284$; Novelty, $F(1,94) = 0.50$, $p = .481$ or Coherence, $F(1,94) = 2.07$, $p = .153$ (see Figure 20a, b and d). There was, however, a significant interaction between stocking level and exhibit for Escape, $F(1,94) = 5.63$, $p = .020$ (see Figure 20c). Specifically, while there was no difference between exhibits in the High stocking conditions, under conditions of Low stocking, the Perceived restorativeness for the Tropical exhibit were rated lower than those of the Temperate exhibit. There were no significant main effects of stocking level or exhibit type for any of the four Perceived restorativeness measures.

Fascination was the highest scoring Perceived Restorative Characteristic ($M = 4.31$, $SD = .46$), followed by Coherence, ($M = 4.25$, $SD = .60$), Escape ($M = 4.03$, $SD = .68$) and Novelty ($M = 3.69$, $SD = .81$). There was a statistically significant difference ($p < .010$) between all characteristics except between Fascination and Coherence ($p = .312$).

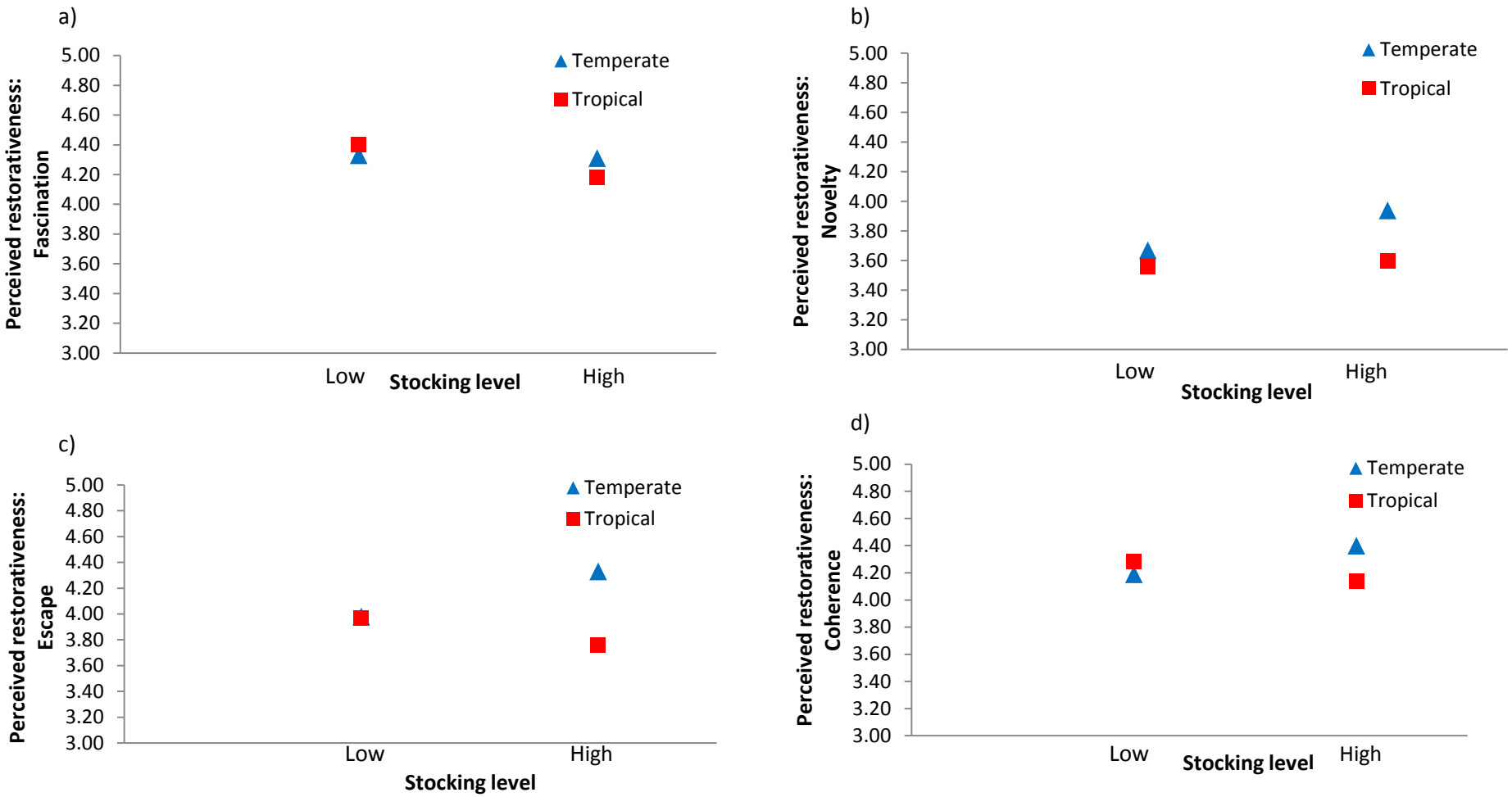


Figure 20. Study 5: Mean perceived restorativeness scores as a function of stocking level (a) Fascination, (b) Novelty, (c) Escape and (d) Coherence.
Note: Scales 1-5 (1 = Strongly disagree; 5 = Strongly agree)

There was no interaction, $F(1,94) = 1.03$, $p = .312$ (Figure 21), or any significant main effects (Exhibit: $F(1,94) = 0.645$, $p = .424$; Stocking level: $F(1,94) = 3.89$, $p = .052$) for the restorative potential item, suggesting that both exhibits were similarly potentially restorative.

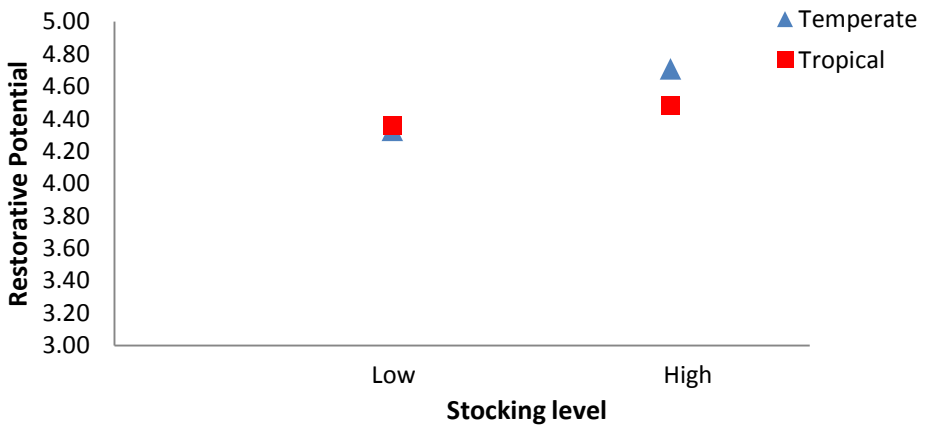


Figure 21. Study 5: Mean restorative potential score as a function of stocking level
Note: 1-5 scale (1 = Strongly disagree; 5 = Strongly agree)

Reflection and Restoration outcomes (Figure 22) and Attachment (preferences) scores (Figure 23), revealed similar patterns: means score were all > 4 on a 5-point scale. There were no significant interactions (Reflection and Restoration: $F(1,94) = 1.60$, $p = .209$; Attachment: $F(1,94) = 0449$, $p = .504$) or main effects of stocking level (Reflection and Restoration: $F(1,94) = 0.425$, $p = .516$; Attachment: $F(1,94) = 0.05$, $p = .823$) for either measure. There was, however, a significant effect of exhibit type for the Reflection and Restoration outcomes measure, with the Temperate exhibit scoring significantly higher than the Tropical exhibit, $F(1,94) = 5.24$, $p = .024$. This significant effect was not shown for the Attachment item: $F(1,94) = 0.39$, $p = .533$.

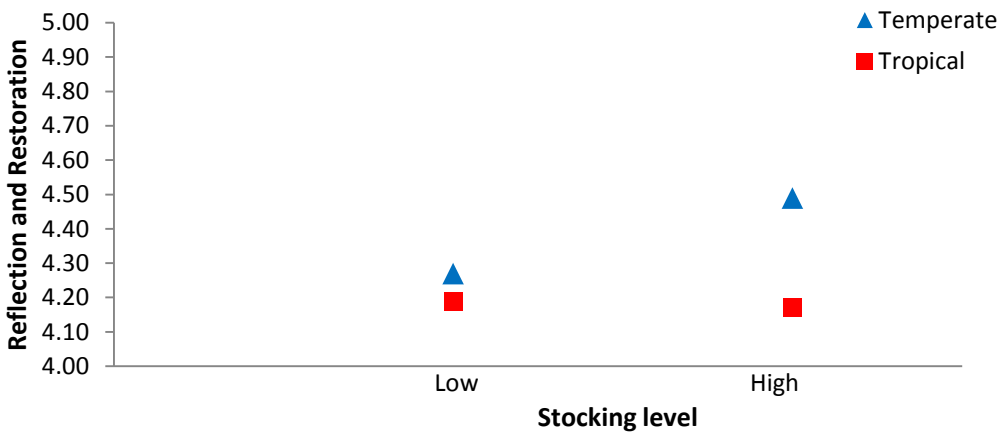


Figure 22. Study 5: Mean reflection and restoration score as a function of stocking level
Note: 1-5 scale (1 = Strongly disagree; 5 = Strongly agree)

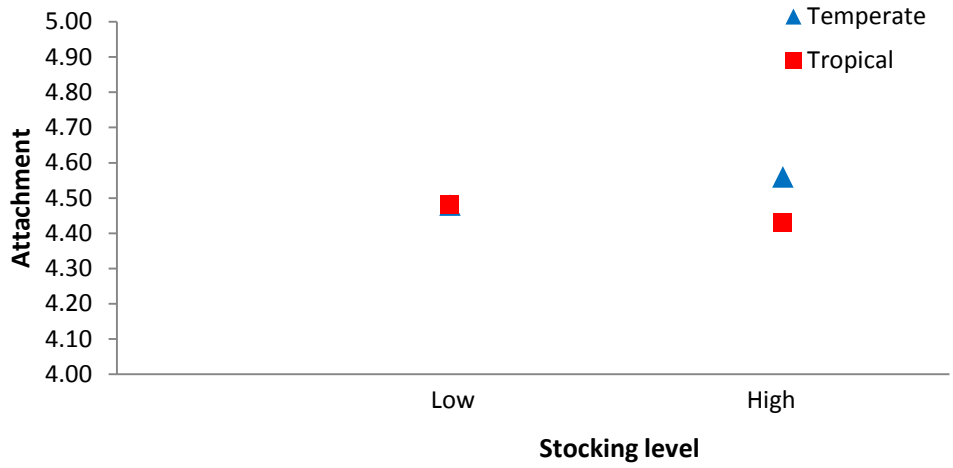


Figure 23. Study 5: Mean attachment score as a function of stocking level
Note: 1-5 scale (1 = Strongly disagree; 5 = Strongly agree)

4.2.2.3 Relationships Between Well-being Outcomes and Perceptions of Stocking Level, and Other Exploratory Analyses

Changes in positive affect and arousal were not correlated with actual fish abundance or species richness, or any of the subjective measures of fish abundance or species richness (i.e. the 'accuracy' scores or the Perceived 'biodiversity score'). There were a small number of correlations between the subjective estimates of exhibit stocking (that is, perceived fish abundance and species richness estimates, and the perceived 'biodiversity score') and Perceived restorativeness or well-being variables.

Perceived fish abundance was positively associated with Novelty, $r(94)= .271$, $p = .008$, and perceived species richness was positively correlated with Reflection and Restoration outcomes, $r(94)= .219$, $p = .034$. The Perceived 'biodiversity score' was positively associated with two Perceived restorativeness: Fascination, $r(94)= .239$, $p = .020$, and Novelty, $r(94)= .320$, $p = .002$ (see Table 8).

An improvement in mood was positively associated Reflection and Restoration outcomes, $r(94)= .271$, $p = .008$, and Attachment (preferences), $r(94)= .298$, $p = .003$. Interestingly, whereas Reflection and Restoration scores increased as arousal decreased, $r(94)= -.223$, $p = .030$, increased Fascination was correlated with an increase in arousal, $r(94)= .211$, $p = .041$.

Aquarium visitors participating in this study generally visited public aquariums every two to five years. Visitors' self-estimates of marine wildlife knowledge were below the mid-point ($M = 2.63$, $SD = .92$) and visitors were usually able to identify six out of 10 species ($M = 6.10$, $SD = 1.85$). There were no correlations between the participants' ability to identify marine life and accuracy scores for species richness or abundance (although there was a marginal, negative association with actual fish species richness). The ability to identify marine life was positively associated with the Perceived 'biodiversity score', $r(94) = .241$, $p = .019$, and an improvement in mood, $r(94) = .210$, $p = .042$, but not with a decrease in arousal or the items measuring Perceived restorativeness or Attachment.

The number of species participants were able to correctly identify was strongly and positively correlated with self-estimates of wildlife knowledge compared to others, $r(95) = .357$, $p < .001$, and frequency of aquarium visit, $r(95) = -.363$, $p < .001$. Analysis revealed that the more frequently participants visited aquariums, the greater their score on the marine life identification task. Interestingly, there was also a positive association with an improvement in mood $r(94) = -.263$, $p = .011$.

Table 8. Study 5: Correlations between actual and perceived stocking levels, perceived restorativeness and well-being outcomes

Measure			Abund-ance accuracy	Species richness accuracy	Perceived 'biodiversity score'	Change in mood	Change in arousal	Perceived restorativeness				Reflection and restoration	Attachment	Restorative potential
								Fascination	Novelty	Escape	Coherence			
Abundance accuracy		Pearson's (*r*) Sig. (2-tailed) N	1	.437 .000 93	.224 .032 92	-.124 .238 92	-.036 .732 92	.040 .701 93	.271 .008 93	-.042 .687 93	.092 .379 93	.142 .175 93	.033 .755 93	.153 .144 93
Species richness accuracy		Pearson's (*r*) Sig. (2-tailed) N		1	.204 .050 93	-.045 .668 93	-.097 .353 93	-.071 .498 94	.130 .211 94	.149 .153 94	.076 .464 94	.219 .034 94	.138 .184 94	.254 .014 94
Perceived 'biodiversity score'		Pearson's (*r*) Sig. (2-tailed) N			1	-.022 .834 93	.190 .068 93	.239 .020 94	.320 .002 94	.080 .446 94	.162 .119 94	.112 .283 94	.175 .091 94	.112 .282 94
Change in mood		Pearson's (*r*) Sig. (2-tailed) N				1	.048 .644 94	.180 .083 94	.099 .343 94	.177 .087 94	.195 .679 94	.271 .008 94	.298 .003 94	.103 .325 94
Change in arousal		Pearson's (*r*) Sig. (2-tailed) N					1	.211 .041 94	.146 .162 94	-.031 .162 94	.043 .679 94	-.223 .030 94	.071 .496 94	-.182 .078 94
Perceived restorative-ness	Fascination	Pearson's (*r*) Sig. (2-tailed) N						1	.358 .000 95	.248 .016 95	.478 .000 95	.270 .008 95	.457 .000 95	.-76 .463 95
	Novelty	Pearson's (*r*) Sig. (2-tailed) N							1	.368 .000 95	.315 .002 95	.405 .000 95	.478 .000 95	.237 .021 95
	Escape	Pearson's (*r*) Sig. (2-tailed) N								1	.220 .032 95	.587 .000 95	.439 .000 95	.444 .000 95
	Coherence	Pearson's (*r*) Sig. (2-tailed) N									1	.347 .000 95	.449 .000 95	.233 .023 95
Reflection and restoration		Pearson's (*r*) Sig. (2-tailed) N										1	.646 .000 95	.530 .000 95
Attachment		Pearson's (*r*) Sig. (2-tailed) N											1	.447 .000 95
Restorative potential		Pearson's (*r*) Sig. (2-tailed) N												1

Note: Four participants removed as extreme outliers: two for fish abundance, one for fish species richness and one for change in mood.

4.2.2.4 Summary

Study 5 set out to address the following questions (see Section 4.1.3): 1) whether people underestimated fish species richness and abundance in the same way that they underestimate bird species and abundance; 2) whether systematic underestimation varied depending on type of marine life (Temperate or Tropical exhibit); 3) whether positive relationships existed between *actual* species richness/abundance and perceived restorativeness and well-being outcomes; and, finally, 4) whether positive relationships existed between *perceived* species richness/abundance (using accuracy scores and the generic perceived 'biodiversity score') and perceived restorativeness and well-being outcomes.

The results show that, overall, people significantly underestimate fish species richness and abundance, much as they have done with bird species. They could, however, still distinguish that the Tropical exhibit was more fully stocked than the Temperate exhibit. Furthermore, estimates tended to be more accurate at the lower stocking levels. Underestimation occurred regardless of whether the exhibit was Temperate or Tropical. However, as species richness and abundance were confounded, with each other and with exhibit type, is difficult to draw further conclusions.

There were some positive relationships between perceived levels stocking (that is, fish abundance, species richness and 'biodiversity score'), and Perceived Restorativeness of the exhibits, namely Novelty and Fascination items, and also Reflection and Restoration outcomes. Mood improved and arousal decreased as Reflection and Restoration scores increased. In contrast, as exhibit Fascination ratings increased, there was less of a decrease in arousal. Considering the Felt Arousal findings in Study 4, whereby a greater level of marine life was associated with higher levels of arousal than lower levels of or no marine life, this finding may suggest that increased Fascination is more stimulating (although as Fascination, as a restorative characteristic,

was not measured in Study 4 this is just a suggestion).

Both exhibit types scored reasonably highly on Perceived restorativeness, Reflection and Restoration, Restorative Potential and Attachment. There was little difference in ratings between the two exhibits, except during the Low stocking condition, where lower ratings for the Tropical exhibit were significant for two variables (Escape, and Reflection and Restoration). Overall, viewing either exhibit appeared to improve mood and decrease arousal, supporting Study 4 and the possibility that aquariums can be restorative environments.

4.3 Study 6: Perceptions of Species Richness and Abundance, and Associated Well-being Outcomes, When Viewing Two Exhibits

4.3.1 Methods

4.3.1.1 Preparatory Work

4.3.1.1.1 Questionnaire Development

The questionnaire used for Study 6 was identical to Study 5, except that a number of the measures (e.g. mood scales, Perceived 'biodiversity score' etc. – see Figure 22) were repeated in order to capture responses to the second exhibit. Three evaluation statements were also added to Study 6 to further compare the two exhibits. Finally, a small number of additional measures were added that were only exploratory in nature (Appendix I).

Study 6 extended Study 5 in two key ways. First, participants viewed both exhibit types enabling them to make comparative judgements. As data were collected from 60 participants this also increased statistical power by creating 120 data points. Second, the additional evaluation statements enabled a further comparison to be made between the two exhibit types - details of the additional measures are mentioned below (Section 4.3.1.4).

4.3.1.1.2 Estimates of Species Richness and Abundance

Study 6 ran at the higher stocking level only. Exhibit stocking levels were checked and only marginal changes in fish abundance were noted for the Tropical exhibit (approximately 622 individuals, compared to 634 in the 'High' Study 5 condition: 67 fish species). There were no noticeable changes in stocking level for the Temperate exhibit (approximately 226 individuals: 194 fish, 32 crabs/lobsters; 35 species: 28 fish species; seven crustaceans). The Shannon Wiener index for the Temperate exhibit averaged 2.81 and the Tropical exhibit averaged 3.15.

4.3.1.2 Participants

Due to the extra demands of Study 6 (i.e. the time it would take to view two exhibits and complete an extended questionnaire), and concerns it may distract from the enjoyment of a voluntary visit to the aquarium, the 60 participants who undertook Study 6 (40 females; Mean age 26.9) were members of Plymouth University's paid participant pool (n = 30) and university students participating for course credit (n = 30).

4.3.1.3 Procedure

On arrival at the Aquarium, participants were briefed about the nature of the study, informed of the confidentiality of their answers and their right to withdraw. The first part of the study proceeded in the same manner as Study 5, i.e. participants immediately completed two mood scales (T1) before proceeding to the first exhibit (Exhibit 1). Following the completion of questions and statements relating to Exhibit 1 (T2), participants completed the mood items again (T3) before proceeding to Exhibit 2. This exhibit was also viewed for 5 minutes, after which time participants completed mood scales again (T4), together with the remaining questions and statements pertaining to that exhibit, followed by the rest of study questionnaire (see Figure 24).

The order of exhibits was counter-balanced: half of the participants viewed the Temperate exhibit first and half viewed the Tropical exhibit first. On completion of the study, participants were thanked for their time and were either paid (£4) or received course credit, as applicable.

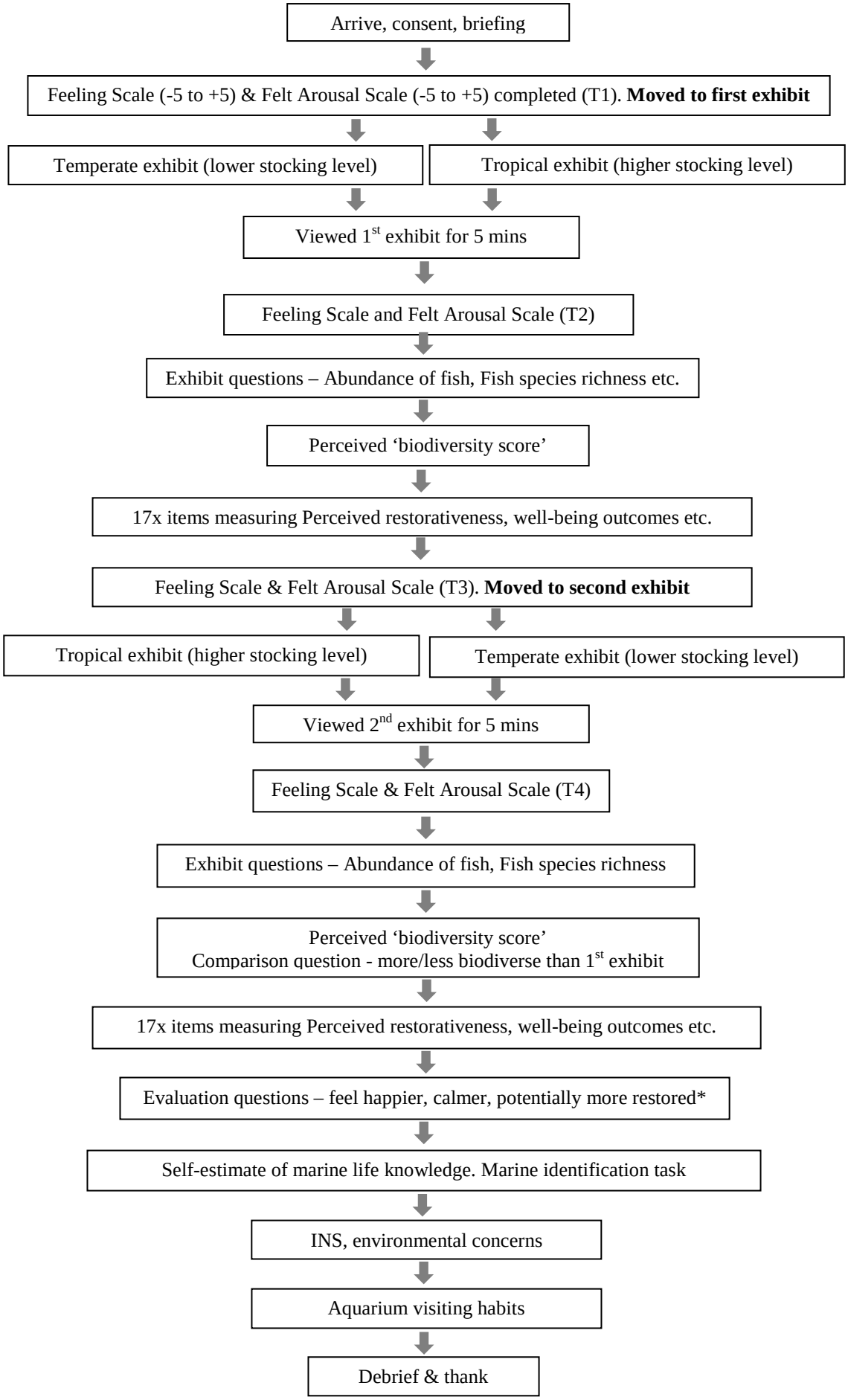


Figure 24. Study 6: Flowchart of procedure. *Note: Only 50% of participants completed the three evaluation questions

4.3.1.4 Measures

4.3.1.4.1 Perceptions of Stocking Levels

As in Study 5, perceived biota levels were measure in two ways: participants were asked to estimate the actual numbers of fish species richness and fish abundance, and allocate a generic perceived 'biodiversity score' for each exhibit, using the 1-10 scale (1 = Extremely low, 10 = Extremely high). Also, as Study 6 aimed to explore people's stocking level perceptions and psychological responses after viewing two exhibits, additional measures were included that further compared the two exhibits. Therefore, as well as asking participants to rate the stocking level in each exhibit using the Perceived 'biodiversity score', participants were asked to compare the stocking level of both exhibits: 'Compared to the first exhibit, I think this exhibit has a much lower (1)/about the same (3)/much higher (5) level of biodiversity' (5-point Likert scale).

4.3.1.4.2 Perceived Restorativeness, Restorative Potential and Well-being Outcomes

In addition to the well-being measures already mentioned, three additional well-being evaluation statements were developed with the aim of asking participants to directly compare how the second exhibit made them feel compared to the first exhibit e.g. 'Compared to the first exhibit, this exhibit makes me feel…*happier*/*calmer*/*potentially more restored*'. Participants were asked to rate their level of agreement with the three statements on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). These additional evaluations statements were added mid-study and therefore only half of Study 6 participants completed these measures.

Finally, a small number of exploratory questions were asked at the end of Study 6 (see Appendix J for measures and results). These questions were focused on the participants' relationship with nature (Inclusion of Nature in Self – INS; Schultz, 2001)

and their environmental concerns (Schultz, 2000).

4.3.1.4.3 Estimates and Actual Marine Life Knowledge, and Frequency of Aquarium Visits

Participants were again asked to self-estimate their taxonomic knowledge before undertaking the marine life identification task. Participants' aquarium visiting habits and basic demographics were also collected.

4.3.1.5 Data Preparation

Data preparation proceeded as per Study 5. Outlier analysis was conducted on participants' estimates of fish numbers and species, changes in mood and arousal, and perceived 'biodiversity score'. Following this analysis, four participants were removed from fish abundance analysis, two of whom were also removed from fish species richness analysis. 'Accuracy' scores for fish abundance and fish species were calculated and used in subsequent analyses.

4.3.1.6 Statistical Analysis

To investigate whether 'accuracy' scores differed depending on which exhibit type was viewed first, two 2 (Exhibit: Temperate or Tropical) x 2 (Viewing order: Temperate first or Tropical first) mixed factorial ANOVA with repeated measures on Exhibit were conducted, one each for fish abundance and species richness. Once again, one sample *t*-tests compared actual numbers of fish and fish species with estimates.

As per Study 5, similar mixed factorial ANOVA were used to investigate changes in mood and arousal over time (T1-T4). ANOVA was also used to investigate the effect of exhibit and viewing order on i) Perceived 'biodiversity score', ii) the four Perceived restorativeness, iii) Reflection and Restoration outcomes, iv) Restorative Potential of the exhibit, and v) Attachment (preferences) scores. Paired samples *t*-tests

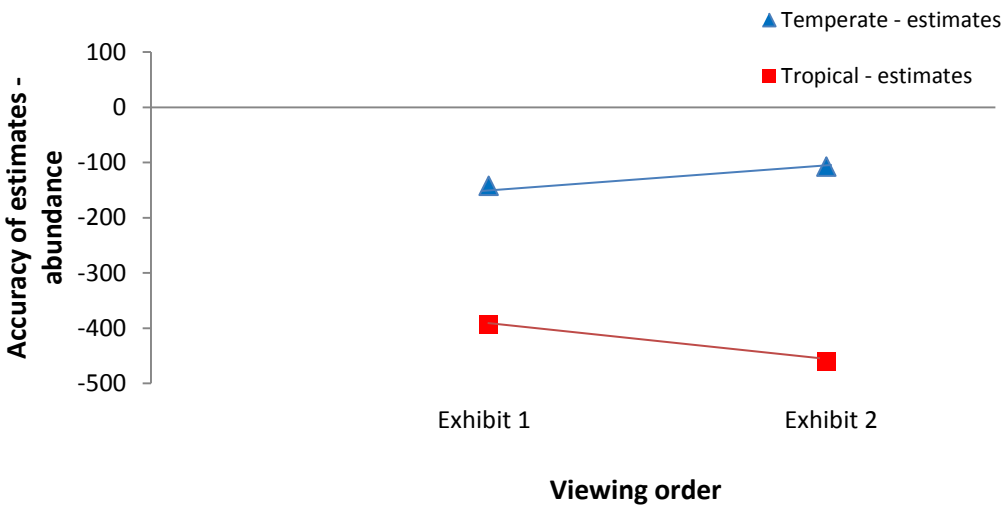
were again used to investigate any differences in mean Perceived restorativeness scores. Finally, bivariate correlations again examined relationships between biota estimates and well-being measures (again, change scores were computed for the positive affect and arousal).

4.3.2 Results

4.3.2.1 Perceptions of Stocking Levels

Repeated measures ANOVA of the accuracy of estimates for fish abundance found no significant interaction between viewing order and exhibit type $F(1,53) = 0.111$, $p = .740$. There was no main effect of viewing order, $F(1,53) = 2.28$, $p = .137$, but there was a significant effect of exhibit, $F(1,53) = 342.86$, $p = < .001$ (Figure 25a). Comparable effects were noted for species richness: no interaction, $F(1,55) = 3.08$, $p = .085$, or effect of viewing order, $F(1,55) = 0.257$, $p = .614$, but a significant effect of exhibit type, $F(1,55) = 77.61$, $p < .001$ (Figure 25b). For both fish abundance and fish species richness, the accuracy scores were poorer for the Tropical exhibit, potentially due to the higher numbers present.

a)



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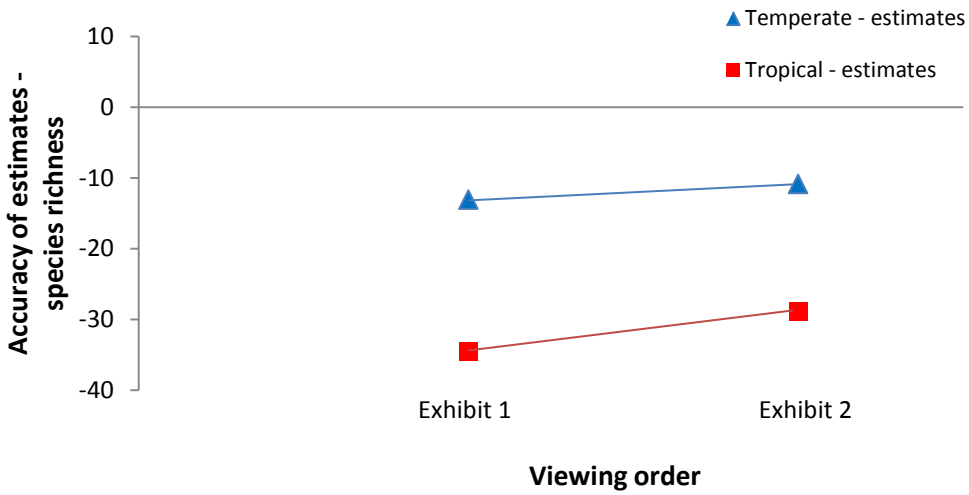


Figure 25. Study 6: Mean accuracy of estimates as a function of stocking level: a) Fish abundance; b) Fish species richness

In line with Study 5 (and previous studies with birds), almost all participants significantly underestimated the number of individual fish and fish species when viewing the first exhibit. One sample *t*-tests revealed a statistically significant difference between actual and perceived numbers for both abundance of individual fish

(Temperate: $t(26) = 36.88$, $p < .001$; Tropical: $t(27) = 9.61$, $p < .001$) and fish species richness (Temperate: $t(29) = 7.87$, $p < .001$; Tropical: $t(26) = 7.66$, $p < .001$). Importantly, viewing a second exhibit did not improve participants' estimates and they continued to perceive the exhibits to contain significantly fewer fish (Temperate: $t(27) = 10.99$, $p < .001$; Tropical: $t(27) = 20.99$, $p < .001$) and fish species (Temperate: $t(27) = 6.45$, $p < .001$; Tropical: $t(29) = 10.21$, $p < .001$) than were actually present. Participants again, however, correctly perceived that the Tropical exhibit contained a greater number of fish, $F(1,54) = 12.42$, $p = .001$, and fish species, $F(1,56) = 36.01$, $p < .001$, than the Temperate exhibit (although this time their judgements were based on viewing both exhibits).

Furthermore, also in keeping with findings from Study 5, viewing one exhibit resulted in extremely similar Perceived 'biodiversity scores', irrespective of whether the exhibit type was Tropical or Temperate. However, a repeated measures ANOVA revealed that viewing a second exhibit significantly altered participants' perception of biodiversity when using the Perceived biodiversity scale. While there was no significant interaction, $F(1,58) = 0.355$, $p = .554$, there was a significant effect of exhibit type, $F(1,58) = 72.86$, $p < .001$, and a significant effect of order in which the exhibits were viewed, $F(1,58) = 8.31$, $p = .006$: the Perceived 'biodiversity score' for the Tropical exhibit had increased, whereas the Temperate exhibit score had decreased (Figure 26).

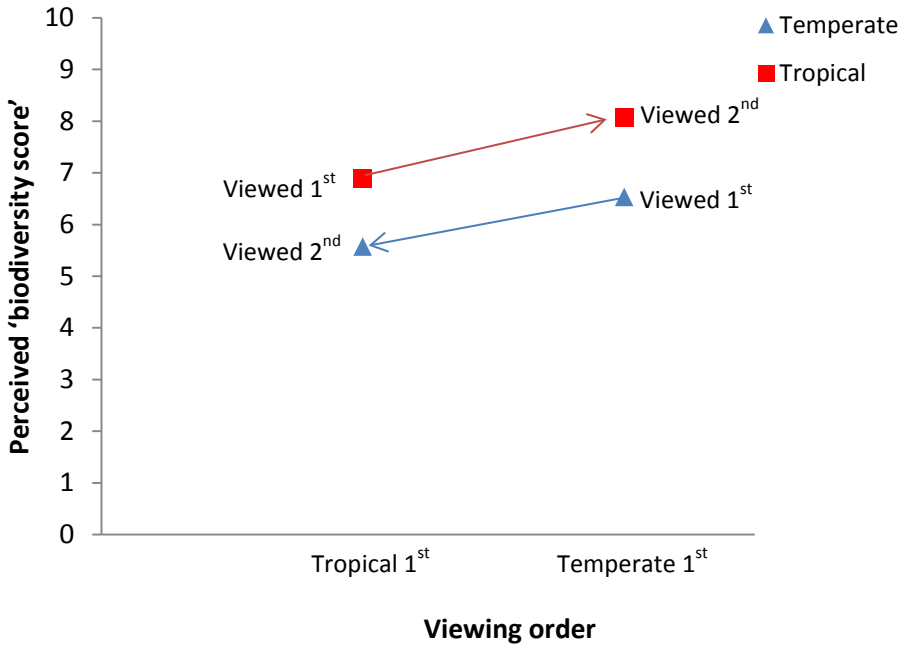


Figure 26. Study 6: Mean perceived 'biodiversity score' as a function of exhibit viewing order: Scale 1-10: 1 = Extremely low; 10 = Extremely high

Asking participants directly to make a comparative rating of whether they found the second exhibit more or less biodiverse than the first supported this finding: the Tropical exhibit was perceived as significantly more biodiverse than the Temperate exhibit $F(1,58) = 74.52$, $p < .001$.

4.3.2.2 Psychological Well-being

4.3.2.2.1 Mood and Arousal

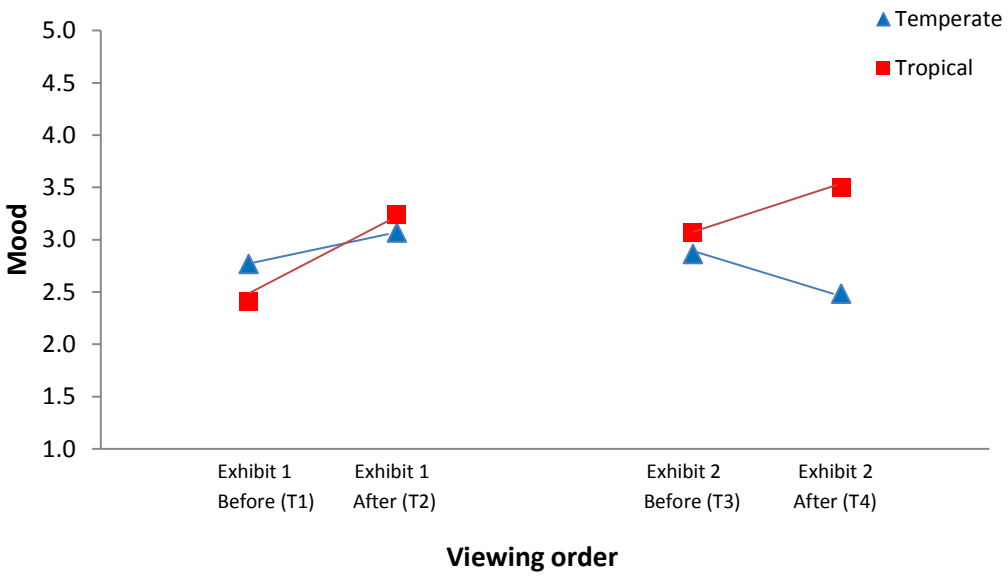
Once again, participants tended to arrive in a positive mood ($M = 2.60$, $SD = 1.22$). Investigation into whether mood changed over time and whether this was influenced by exhibit type and viewing order revealed a significant interaction between changes in mood and exhibit, $F(1,57) = 5.47$, $p = .023$: mood improved over time when the Tropical exhibit was viewed second but worsened when the Temperate exhibit was viewed second (Figure 27a). There was an increase in mood over time when viewing the marine life in the Tropical exhibit irrespective of whether the exhibit was viewed

first (before viewing *M* = 2.41, *SD* = 1.24; after viewing *M* = 3.24, *SD* = 1.33) or second (before viewing *M* = 3.07, *SD* 1.64; after viewing *M* = 3.50, *SD* = 1.61). In contrast, mood only improved when viewing the Temperate exhibit if this exhibit was viewed first (before viewing *M* = 2.77, *SD* = 1.22; after viewing *M* = 3.07; *SD* = 1.89); if viewed second, there was a decrease in mood (before viewing *M* = 2.86, *SD* = 1.38; after viewing *M* = 2.48, *SD* = 1.68).

Overall, there was a significant improvement in mood over time (i.e. before vs. after viewing the exhibit for 5 minutes), $F(1,57) = 8.82$, $p = .004$, and a significant effect of exhibit, $F(1,57) = 5.32$, $p = .025$, but there was no effect of viewing order $F(1,57) = 1.08$, $p = .302$. In short, both exhibits improved mood when viewed first but only the Tropical exhibit improved mood when viewed as the second exhibit.

With regard to arousal, participants arrived in only a very slight state of elevated arousal (*M* = 0.88, *SD* = 2.28). There was a significant interaction between exhibit and viewing order, $F(1,57) = 22.70$, $p < .001$, as well as an interaction between exhibit, viewing order and change in arousal over time, $F(1,57) = 21.24$, $p < .001$ (Figure 27b). Although, there was a significant overall decrease in arousal over time (5 minutes viewing), $F(1,57) = 43.40$, $p < .001$, there was no main effect of exhibit, $F(1,57) = 0.360$, $p = .551$ or viewing order, $F(1,57) = 0.203$, $p = .654$. In summary, both exhibits resulted in a decrease in arousal when viewed first (and this effect was slightly stronger for the Tropical exhibit: before viewing *M* = 1.03, *SD* = 2.32; after viewing -1.69, *SD* = 2.79, than the Temperate exhibit: before viewing *M* = .77, *SD* = 2.30; after viewing *M* = -1.13, *SD* = 3.07) but neither significantly decreased arousal further (Tropical exhibit: before viewing *M* = -1.03, *SD* = 2.88; after viewing *M* = -1.13, *SD* = 3.07; Temperate exhibit: before viewing M = -1.41, *SD* = 2.51; after viewing *M* = -1.52, *SD* = 2.57).

a)



b)

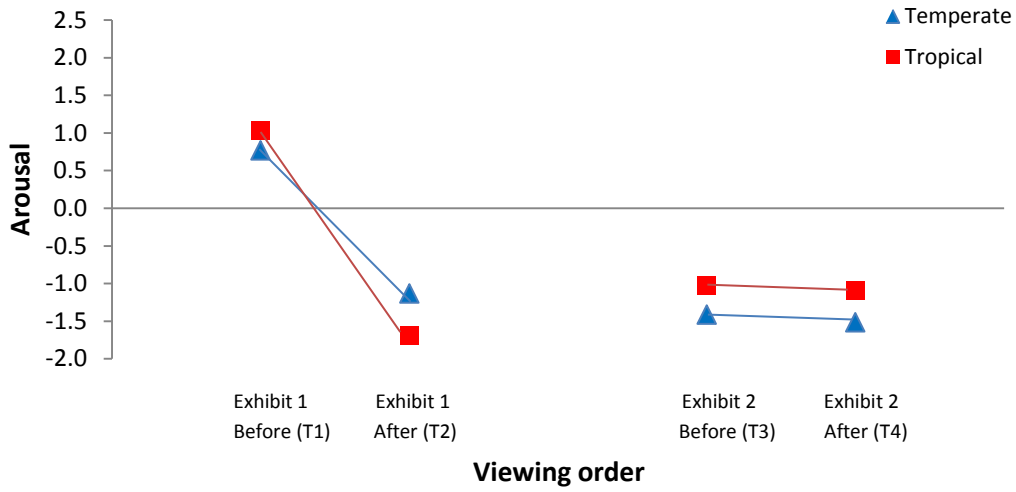


Figure 27. Study 6: a) Changes in mood over time as a function of exhibit viewing order: Feeling Scale; b) Changes in arousal over time as a function of viewing order: Felt Arousal Scale.
Note: 11-point scales (-5 to +5)

4.3.2.2.2 Perceived Restorativeness, Reflection and Restoration, Restorative Potential and Attachment

Perceived restorativeness scores were similar to those shown in Study 5 (≥ 3.45 on the 5-point scale), although means for the Tropical exhibit were consistently greater

than those for the Temperate exhibit and tended to be > 4. There were no significant interactions between exhibit type (Tropical/Temperate) and viewing order (Viewed 1st/Viewed 2nd) for Fascination, $F(1,58) = 0.008$, $p = .930$; Novelty, $F(1,58) = 0.00$, $p = 1.00$ or Coherence, $F(1,58) = 3.96$, $p = .051$ (see Figure 28a, b and d). However, there was a significant interaction for the Escape characteristic, $F(1,58) = 8.01$, $p = .006$; the Temperate exhibit was rated significantly lower when viewed as the second exhibit, compared to when it was viewed as the first exhibit (see Figure 28c). Furthermore, there was a significant main effect of exhibit type: the Tropical exhibit was rated significantly higher than the Temperate exhibit for three out of four perceived restorativeness characteristics: Fascination, $F(1,58) = 31.24$, $p < .001$; Novelty, $F(1,58) = 13.69$, $p < .001$ and Escape, $F(1,58) = 11.18$, $p = .001$ (Coherence: $F(1,58) = 3.24$, $p = .077$.).

Fascination was again the highest scoring Perceived Restorativeness item, ($M = 4.22$, $SD = .52$) and Novelty the lowest ($M = 3.63$, $SD = .76$). Scores for Coherence ($M = 4.06$, $SD = .68$) were higher than those for Escape ($M = 3.97$, $SD = .67$) but there was no statistically significant difference between them, $t(59) = .828$, $p = .411$. Novelty scored significantly poorer when compared with all other characteristics: Fascination, $t(59) = 6.33$, $p < .001$; Coherence, $t(59) = 4.07$, $p < .001$, and Escape, $t(59) = 3.15$, $p = 003$. Fascination scored significantly higher than Escape, $t(59) = 3.07$, $p = .003$, but not Coherence, $t(59) = 1.93$, $p = .059$.

The higher ratings for the Tropical exhibit occurred irrespective of the order in which the exhibits were viewed. There were no main effects of viewing order for any of the four Perceived restorativeness items.

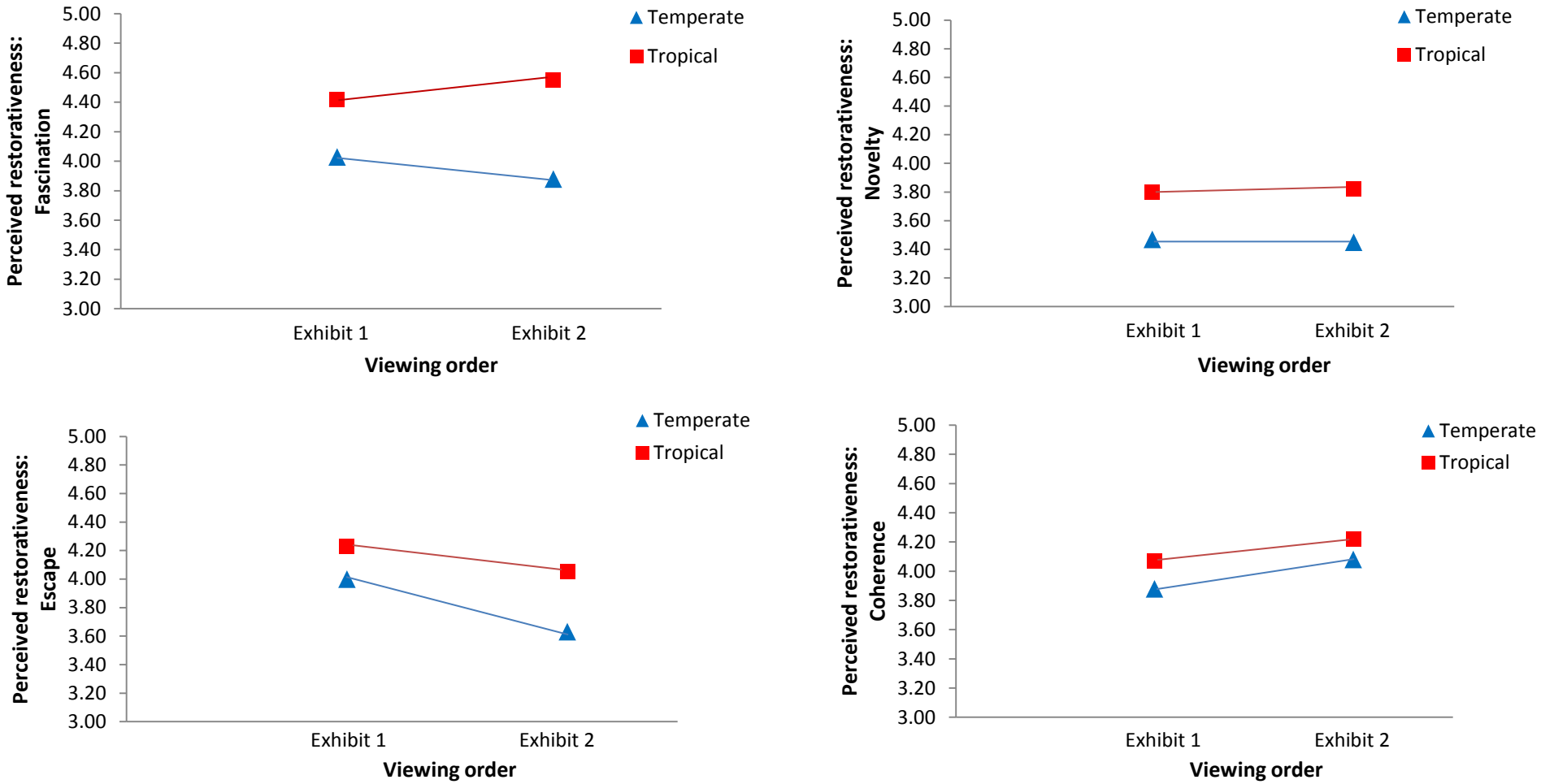


Figure 28. Study 5: Mean perceived restorativeness scores as a function of exhibit viewing order (a) Fascination, (b) Novelty, (c) Escape and (d) Coherence. Note: Scales 1-5 (1 = Strongly disagree; 5 = Strongly agree)

There was a significant interaction, $F(1,58) = 5.99$, $p = .017$, between exhibit and viewing order for the Restorative Potential item (Figure 29): when viewed second the Temperate exhibit was rated significantly lower. There was no main effect of exhibit, $F(1,94) = 0.30$, $p = .589$, or viewing order, $F(1,94) = 0.81$, $p = .372$ for this item.

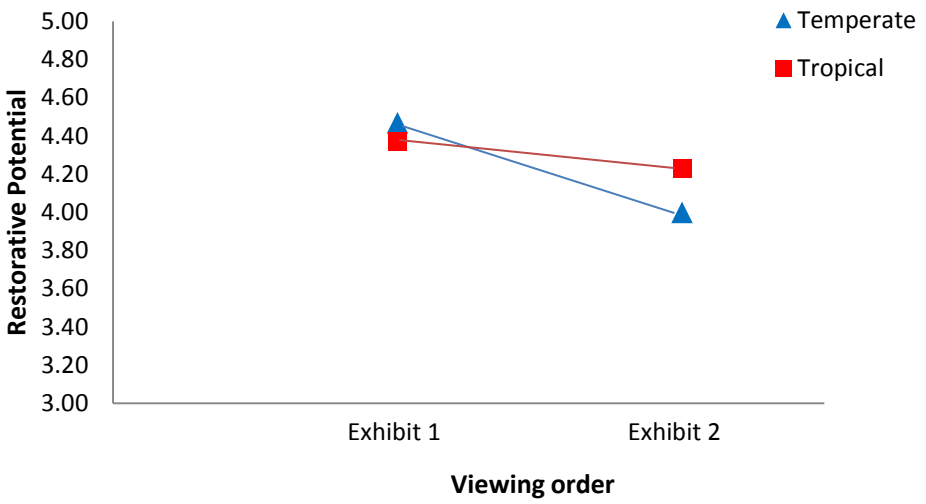


Figure 29. Study 6: Mean restorative potential score as a function of exhibit viewing order
Note: 1-5 scale (1 = Strongly disagree; 5 = Strongly agree)

There were significant interactions between exhibit type and viewing order for Reflection and Restoration outcomes, $F(1,58) = 14.59$, $p < .001$ (Figure 30), and Attachment (preferences), $F(1,58) = 8.35$, $p = .005$ (Figure 31): in both instances the Temperate exhibit was rated significantly lower when viewed as the second exhibit, rather than the first. There was a significant effect of exhibit, with the Tropical exhibit being rated significantly higher than the Temperate exhibit on both measures. There were no main effects of viewing order.

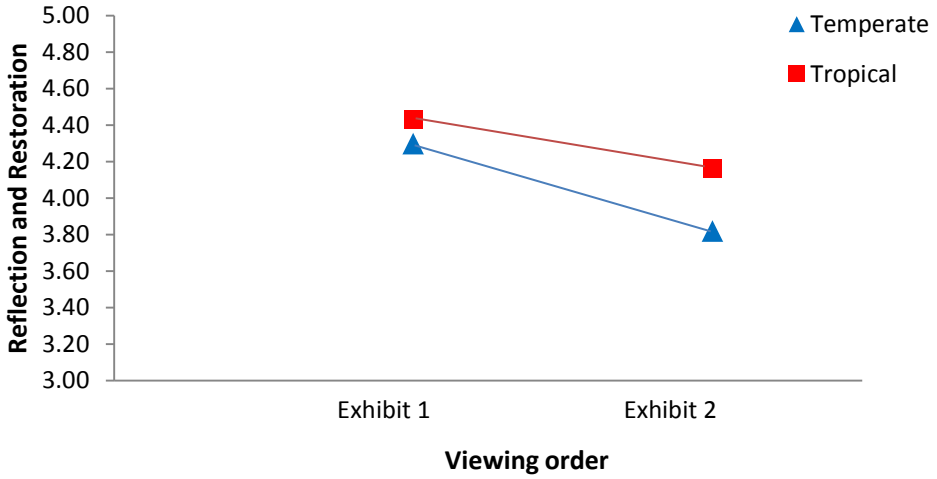


Figure 30. Study 6: Mean reflection and restoration score as a function of exhibit viewing order Note: 1-5 scale (1 = Strongly disagree; 5 = Strongly agree)

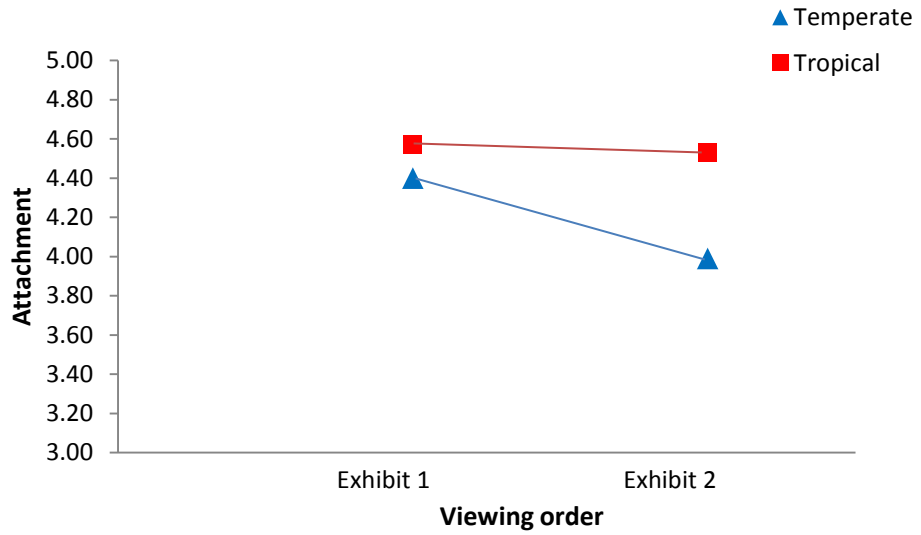


Figure 31. Study 6: Mean attachment score as a function of exhibit viewing order Note: 1-5 scale (1 = Strongly disagree; 5 = Strongly agree)

The three evaluation statements, completed by 30 participants in Study 6, provided a clearer indication of how the two exhibits affected mood. The Tropical exhibit made people feel significantly happier, $F(1,28) = 22.87$, $p < .001$, and potentially more restored, $F(1,28) = 4.92$, $p = .035$, than the Temperate exhibit. However, the Tropical exhibit was not significantly more calming, $F(1,28) = 1.84$, $p = .186$.

4.3.2.3 Relationships Between Well-being Outcomes and Perceptions of Stocking Levels, and Other Exploratory Analyses

Changes in positive affect or arousal were not correlated with Perceptions of marine life (that is, the converted 'accuracy' scores for fish species richness or fish abundance, and the Perceived 'biodiversity score') for either exhibit (Tables 9 and 10). Furthermore, the fish abundance and species richness 'accuracy' scores were not correlated with any of the four Perceived restorativeness, Reflection and Restoration outcomes, Restorative Potential, and Attachment (Preference) scores, for either exhibit, with one exception; Fascination was positively correlated with estimates of fish abundance in the Tropical exhibit, $r(56) = .281$, $p = .036$. The Perceived 'biodiversity score' for the Temperate exhibit was positively correlated with Fascination, $r(56) = .358$, $p = .007$; Novelty, $r(56) = .337$, $p = .011$; Coherence, $r(56) = .317$, $p = .017$, and Attachment (preference) items, $r(56) = .379$, $p = .004$. In comparison, the Perceived 'biodiversity score' for the Tropical exhibit was only positively correlated with Fascination, $r(56) = .354$, $p = .007$. As for relationships between the Perceived 'biodiversity score' and people's estimates (accuracy scores) of species richness or fish abundance; there was only a positive association between the Temperate exhibit's accuracy score for fish species richness $r(56) = .278$, $p = .038$. There were no other significant associations.

For the Temperate exhibit, increases in mood were positively correlated with Fascination, $r(56) = .340$, $p = .011$; Escape, $r(56) = .497$, $p < .001$; Restoration and Reflection outcomes, $r(56) = .712$, $p < .001$; Attachment, $r(56) = .456$, $p < .001$, and Restorative Potential items, $r(56) = .651$, $p < .001$. A decrease in arousal was negatively correlated with Escape, $r(56) = -.440$, $p = .001$; Restoration and Reflection, $r(56) = -.532$, $p < .001$; Attachment, $r(56) = -.280$, $p = .038$ and Restorative Potential. $r(56) = -.390$, $p = .003$. Intriguingly, however changes in arousal were positively associated with

Coherence, $r(56) = .267$, $p = .049$. In contrast, there were no linear correlations between changes in mood or arousal, and any of the perceived or actual well-being outcomes for the Tropical exhibit, with the exception of one positive correlation between an improvement in mood and increased Fascination, $r(56) = .365$, $p = .006$.

As in Study 5, participants visited public aquariums approximately every two to five years, their self-estimates of marine wildlife knowledge were below the mid-point ($M = 2.63$, $SD = .99$), and they were able to identify six out of 10 species ($M = 6.17$, $SD = 1.39$). Participants' ability to identify marine life was not correlated with accuracy scores for either fish species richness or abundance, for either exhibit. Marine life identification skills were, however, positively associated with the species richness estimates, $r(56) = .278$, $p = .038$, and the Perceived 'biodiversity score' for the Temperate exhibit, $r(56) = .303$, $p = .023$; the relationship between identification skills and the Perceived 'biodiversity score' for the Tropical exhibit was marginal, $r(56) = .237$, $p = .079$. Participants' identification skills were again strongly and positively correlated with frequency of aquarium visit, $r(56) = -.317$, $p = .017$ (i.e. the more frequently they visited aquariums, the greater their ability to correctly identify marine life).

Table 9. Study 6: Temperate exhibit - correlations between perceived stocking levels, perceived restorativeness and well-being

Measure			Abund-ance accuracy	Species richness accuracy	Perceived 'biodiversity score'	Change in mood	Change in arousal	Perceived restorativeness				Reflection and restoration	Attachment	Restorative potential
								Fascination	Novelty	Escape	Coherence			
Abundance accuracy		Pearson's (*r*) Sig. (2-tailed) N	1	.478 .000 55	.012 .933 55	.017 .902 54	.095 .493 54	.112 .418 55	.089 .518 55	-.115 .402 55	.125 .365 55	-.061 .657 55	.041 .764 55	-.018 .895 55
Species richness accuracy		Pearson's (*r*) Sig. (2-tailed) N		1	.278 .038 56	-.002 .988 55	.025 .856 55	.147 .279 55	-.034 .801 56	-.024 .863 56	.170 .211 56	.010 .942 56	.106 .435 56	.007 .960 56
Perceived 'biodiversity score'		Pearson's (*r*) Sig. (2-tailed) N			1	.089 .518 55	.115 .405 55	.358 .007 56	.337 .011 56	.229 .090 56	.317 .017 56	.225 .095 56	.379 .004 56	.262 .051 56
Change in mood		Pearson's (*r*) Sig. (2-tailed) N				1	-.460 .000 55	.340 .011 55	.117 .395 55	.497 .000 55	-.187 .172 55	.712 .000 55	.456 .000 55	.651 .000 55
Change in arousal		Pearson's (*r*) Sig. (2-tailed) N					1	-.026 .850 55	.013 .925 55	-.440 .001 55	.267 .049 55	-.532 .000 55	-.280 .038 55	-.390 .003 55
Perceived restorativeness	Fascination	Pearson's (*r*) Sig. (2-tailed) N						1	.434 .001 56	.457 .000 56	.211 .119 56	.538 .000 56	.715 .000 56	.581 .000 56
	Novelty	Pearson's (*r*) Sig. (2-tailed) N							1	.162 .234 56	.235 .081 56	.278 .038 56	.350 .008 56	.352 .008 56
	Escape	Pearson's (*r*) Sig. (2-tailed) N								1	.072 .600 56	.720 .000 .56	.520 .000 56	.609 .000 56
	Coherence	Pearson's (*r*) Sig. (2-tailed) N									1	.069 .612 56	.270 .044 56	.013 .927 56
Reflection and restoration		Pearson's (*r*) Sig. (2-tailed) N										1	.723 .000 56	.778 .000 56
Attachment		Pearson's (*r*) Sig. (2-tailed) N											1	.749 .000 56
Restorative potential		Pearson's (*r*) Sig. (2-tailed) N												1

Note: Four participants removed as extreme outliers: two for fish abundance, one for fish species richness and one for change in mood.

Table 10. Study 6: Tropical exhibit - correlations between perceived stocking levels, perceived restorativeness and well-being

Measure			Abund-ance accuracy	Species richness accuracy	Perceived 'biodiversity score'	Change in mood	Change in arousal	Perceived restorativeness				Reflection and restoration	Attachment	Restorative potential
								Fascination	Novelty	Escape	Coherence			
Abundance accuracy		Pearson's (*r*) Sig. (2-tailed) N	1	.350 .009 55	.170 .209 56	.025 .856 56	-.140 .303 56	.281 .036 56	.174 .199 56	.219 .104 56	-.009 .949 56	.159 .242 56	.159 .241 56	-.044 .746 56
Species richness accuracy		Pearson's (*r*) Sig. (2-tailed) N		1	.213 .119 55	-.046 .737 55	-.043 .756 55	.141 .306 55	.006 .965 55	.100 .467 55	-.160 .242 55	.021 .878 55	.061 .659 55	.026 8.52 55
Perceived 'biodiversity score'		Pearson's (*r*) Sig. (2-tailed) N			1	.025 .858 56	.074 .587 56	.354 .007 56	.159 .241 56	.111 .417 56	.237 .079 56	.127 .352 56	.105 .441 56	.075 .585 56
Change in mood		Pearson's (*r*) Sig. (2-tailed) N				1	-.224 .096 56	.216 .110 56	.145 .288 56	.100 .464 56	.226 .094 56	.145 .286 56	.365 .006 56	.230 .088 56
Change in arousal		Pearson's (*r*) Sig. (2-tailed) N					1	-.127 .351 56	-.192 .157 56	-.076 .578 56	.052 .704 56	-.127 .350 56	-.040 .770 56	-.026 .849 56
Perceived restorativeness	Fascination	Pearson's (*r*) Sig. (2-tailed) N						1	.518 .000 56	.611 .000 56	.568 .000 56	.664 .000 56	.674 .000 56	.501 .000 56
	Novelty	Pearson's (*r*) Sig. (2-tailed) N							1	.349 .008 56	.356 .007 56	.499 .000 56	.498 .000 56	.331 .013 56
	Escape	Pearson's (*r*) Sig. (2-tailed) N								1	.434 .001 56	.686 .000 56	.473 .000 56	.412 .002 56
	Coherence	Pearson's (*r*) Sig. (2-tailed) N									1	.574 .000 56	.552 .000 56	.361 .006 56
Reflection and restoration		Pearson's (*r*) Sig. (2-tailed) N										1	.678 .000 56	.609 .000 56
Attachment		Pearson's (*r*) Sig. (2-tailed) N											1	.554 .000 56
Restorative potential		Pearson's (*r*) Sig. (2-tailed) N												1

Note: Four participants removed as extreme outliers: two for fish abundance, one for fish species richness and one for change in mood.

4.3.2.4 Summary

Study 6 aimed to aimed to address the following questions (see Section 4.1.3): 1) whether people underestimated fish species richness and abundance; 2) whether systematic underestimation varied depending on setting (Temperate or Tropical exhibit); 3) whether positive relationships existed between actual species richness/abundance and either experienced well-being (e.g. changes in mood), perceived restorativeness, restorative potential of the exhibit and/or people's preferences; 4) whether positive relationships existed between perceived species richness/abundance and experienced well-being and/or perceived restorativeness/potential of the exhibit, and/or people's preferences; 5) whether estimates of species richness/abundance improved when viewing a second exhibit due to the presence of a comparator exhibit; and 6) whether viewing a second exhibit influenced experienced well-being and perceived restorativeness, and whether this was moderated by exhibit type.

As in Study 5, participants significantly underestimated fish species richness and abundance but were able to determine that the Tropical exhibit was more highly stocked than the Temperate exhibit. Significant underestimation occurred regardless of whether the exhibit was Temperate or Tropical, and viewing a second exhibit still resulted in significant underestimation of numbers. However, the generic Perceived biodiversity scale proved useful. While, there was no significant difference in the Perceived 'biodiversity score' after viewing one exhibit, after the second exhibit had been viewed there was a significant difference in scores: the Tropical exhibit was rated significantly more biodiverse than the Temperate exhibit.

There were no linear correlations between perceptions of fish species richness or abundance and changes in mood or arousal. The Perceived 'biodiversity score' was, however, related to three Perceived Restorativeness and Attachment (preference) items for the Temperate exhibit, and one Perceived Restorative item for the Tropical exhibit.

There was a significant improvement in mood when viewing the Tropical exhibit (irrespective of whether the exhibit was viewed first or second) but only a significant improvement in mood when the Temperate exhibit was viewed first: if viewed second, mood decreased. Furthermore, although the improvement in mood was greater for the Tropical exhibit than the Temperate exhibit both exhibits decreased arousal by similar levels. Both exhibits scored relatively highly on Perceived restorativeness, Reflection and Restoration outcomes, Restorative Potential and Attachment (preferences), although scores for the Tropical exhibit tended to be higher (> 4) on most of these measures, suggesting a level of agreement with these statements.

Generally, there appeared to be no relationships between well-being outcomes, and estimates of fish and fish species or ability to identify aquarium species. However, the Perceived 'biodiversity score' was positively associated with a number of Perceived Restorativeness items, especially for the Temperate exhibit.

4.4 Discussion

4.4.1 Summary of Findings and General Discussion

Overall, participants struggled to correctly estimate numbers of fish and fish species, and tended to significantly underestimate both. As discussed above, this is consistent with a number of studies that have investigated people's ability to estimate numbers of stimuli (e.g. Erwin, 1982; Frederick et al., 2003; Kemp, 1984; Miller & Baker, 1968). Of note, however, all of these previous studies used static stimuli (usually photographs) for their estimation tasks. However, as estimating static stimuli is likely to be easier than estimating numbers of moving stimuli, it is possible that my study added a further level of difficulty as my stimuli (live fish) were highly mobile.

Nevertheless, despite the general tendency to underestimate numbers, participants were able to broadly distinguish that the Tropical exhibit contained more

fish and fish species than the Temperate exhibit. With regard to the Perceived 'biodiversity score', there was only a statistically significant difference between exhibits after both exhibits had been viewed (Study 6). At this point, the score for the Tropical exhibit was significantly greater than the Temperate exhibit. This finding highlights the importance of context: being able to view, and therefore compare, both exhibit types influenced participants' perceptions of biodiversity resulting in a greater level of accuracy. As noted by Hsee and Zhang (2004), people cannot easily evaluate an 'attribute' when it cannot easily be compared with alternatives (see also Helson, 1964).

Across both studies viewing one exhibit for 5 minutes, irrespective of exhibit, tended to improve mood and decrease arousal. However, in Study 6, viewing a second exhibit did not consistently increase self-reported mood. That said, it should be noted that the majority of participants arrived for the studies in a reasonable good mood (around +3 on a -5 to +5 scale). Furthermore, as they were not subjected to a stressor task and were simply asked to watch a pleasant aquarium exhibit for 5 minutes, it is likely that this may have left little scope for measureable improvement. Although, overall, mood did not appear to be related to either the subjective estimates of species richness and abundance or the Perceived 'biodiversity score', in Study 6, the Tropical exhibit (which contained greater fish species and abundance), generally scored significantly higher on perceived restorativeness, such as Fascination, and restoration outcomes, than the Temperate exhibit, irrespective of the order in which the exhibits were viewed.

Study 5 revealed fewer differences between the two exhibits on measures such as Perceived restorativeness and Attachment (preferences) scores, yet, intriguingly, one result appeared contrary to the majority of findings in these two studies and the overall thesis. In Study 5, the Tropical exhibit rated significantly lower on Escape, and Reflection and Restoration that the Temperate exhibit in the Low stocking level

condition. There is, however, a potential explanation for this anomaly. In the Low stocking level condition, the Tropical exhibit not only contained fewer species and animals but, importantly, had a number of particularly 'charismatic' animals missing that were present in the High stocking level condition of Study 5. When participants were asked about the fish species they liked best, and the animals and behaviours that caught their attention, they frequently mentioned the rays and the turtle (see Appendix I). Hence, it is likely that the absence of these highly popular species in the Low stocking level condition of Study 5 may have influenced overall ratings (it should also be noted that rays were a constant presence, and the most liked species, in the Temperate exhibit). In Uyarra et al.'s (2009) study, turtles were the fourth highest rated biological attribute that contributed to diver enjoyment, and 6th out of all 20 attributes. At the least favourite dive sites, low fish abundance, dull reef colour, poor coral condition and an absence of turtles all contributed to a lack of enjoyment of the site.

As an aside, this does also highlight why conservation organisations frequently use 'charismatic megafauna' when wishing to draw attention to certain threatened habitats. Furthermore, there is also the possibility that visitors participating in the study had seen the Tropical exhibit when it contained a different combination and abundance of species. The numbers of species and animals in an aquarium can fluctuate up and down, over time, for a number of reasons: animals may be moved between exhibits or even to a different aquarium; new stock may be introduced; mortalities may occur or animals may be temporarily off display receiving routine or specific medical treatment (as in the case of the Loggerhead turtle in Study 5 – Low stocking level condition). It was interesting to note, therefore, that the Aquarium visitors in the Low stocking level condition had, on average, visited the aquarium more times than visitors in the High stocking level condition. It could be speculated that if the earlier visits had occur when the Tropical exhibit was more highly stocked, this may have influenced responses as

visitors may have remembered see the exhibit in a more marine life-rich condition.

Overall, there were improvements in affective mood over time for both studies, with a trend towards greater improvements when viewing the Tropical exhibit. There was a significant decrease in arousal during all studies, except Study 5 (High stocking level condition). Although, participant feedback indicated that watching the Aquarium exhibits was a relaxing and calming experience, it is conceivable that the visitors in Study 5 - High stocking level - were, by chance, more excited about the prospect of visiting the rest of the aquarium than visitors in Study 5 - Low stocking level. Differences between comparable groups (i.e. aquarium visitors in Study 5) are possibly indicative of the difficulties that can be encountered when undertaking field studies (i.e. with real visitors in situ, rather than paid or student participants as in Study 6). Nevertheless, it appears that exhibit content did influence mood as participants who viewed both exhibits, and completed the three evaluation items, indicated that they found the Tropical exhibit made them feel significantly happier and potentially more restored than the Temperate exhibit.

Although, overall, there was a positive relationship between people's ability to identify marine life and their self-estimates of knowledge and familiarity with aquariums, there was no evidence that greater identification skills positively influenced self-reported well-being outcomes or perceived restorativeness ratings in these studies. Interestingly, when Kaplan et al. (1993) investigated the restorative potential of an art museum they found no relationship between a person's knowledge about art and how restorative they found the visit. Instead, they noted that feeling comfortable in a particular type of setting and being able to easily find one's way around were greater predictors of perceived restoration. These factors, however, were not investigated in these studies.

4.4.2 Limitations and Future Work

There were a number of benefits of conducting this research in situ. These included conducting the study in a 'real' setting rather than a laboratory and exploring the responses of genuine aquarium visitors, as well as paid and student participants. Photographs and videos are common substitutes for real settings in landscape research (Huang 2009): they enable a number of different settings to be evaluated and have demonstrated the restorative potential of natural environments (especially when compared to urban settings) in many studies. Nevertheless, some studies suggest that viewing simulated environments cannot completely replicate or replace real settings and effects may be stronger in real settings (Kjellgren & Buhrkall 2010; Mayer et al. 2009). That said, although there was evidence that viewing a large aquarium exhibit improved mood, decreased arousal and was perceived as potentially restorative, using live exhibits in a functioning aquarium as a field study setting proved to be challenging. For instance, many aquarium visitors who were approached about participating in Study 5, particularly those with small children, were reluctant to participate. Following this discovery during the piloting stage, it was not possible to randomly select visitors. Visitors were, therefore, recruited on a 'continuous ask' basis.

The decision to use aquarium visitors, as well as student and paid participants, may have resulted in a further limitation. It was not possible to deliberately stress the aquarium visitors, who were simply arriving for a pleasant day out. The lack of stressor task, coupled with the fact that participants' tended to arrive at the aquarium in a positive mood, may certainly have hindered the ability to detect measurable changes in mood. This was highlighted by a visitor who actually did arrive stressed and in a particularly bad mood after experiencing difficulties parking, followed by getting caught in the rain. This participant's mood improved greatly within 5 minutes (changing from -4 to +4 on the Feeling Scale) but had to be excluded because this large

improvement was flagged as an extreme outlier. In view of this, the inclusion of a stressor task in future work would seem advisable, where feasible.

One of the main limitations with these studies, however, was that differences in species richness and abundance were confounded both in themselves and across exhibits. Although known number of species and individual animals were established for each exhibit, both species richness and abundance differed, rather than one or the other (i.e. the Tropical naturally had more species than the Temperate exhibit, but also higher numbers of individual fish). Furthermore, these differences were much larger in Study 6. Therefore, although participants rated the Tropical exhibit as 'more biodiverse', it was not possible ascertain whether participants were responding to the exhibit's greater species richness, higher abundance of individuals, or a combination of both.

It is also possible that the two exhibits were, in some ways, too similar in 'general appearance' to result in some measurable changes being detected. While the Tropical exhibit contained more fish and species than the Temperate exhibit, both exhibits could be considered to be of relatively high abundance and species richness. For instance, referring back to the photographs in Study 3 (Chapter 2), both exhibits would be categorised as being of 'High species richness/High abundance'. Future work may, therefore, consider also comparing responses to markedly different types of exhibits (e.g. low vs. high abundance/species richness), rather than comparing geographical variations of the same exhibit type. Interestingly, in Dallimer et al.'s work (2012), the Shannon-Wiener index (calculated for habitat diversity using percentage broad habitat types) across the 34 sites ranged from 0 to 1.84. In comparison, the two 'habitats' (exhibits) in Study 5 and 6 ranged from 2.81 to 3.15, a smaller difference (0.34) than Dallimer et al.'s (2012) sites. In view of this, if either Tropical or Temperate exhibit had been compared to an exhibit considerably lower in species richness and

abundance (e.g. an exhibit housing a single pair of fish), it is likely that greater differences between exhibits would have emerged.

Furthermore, the potential effects that individual species, or animal behaviours, may also have on participants' responses cannot be overlooked. Studies have found that certain animals are highly preferred over others (e.g. Kellert, 1993; Woods, 2000) and it is possible that presence of extremely charismatic animals will likely affect well-being outcomes. Colourful species may also influence preferences: for instance, Lindemann et al. (2010) commented that plant arrays containing herbs with colourful flowers often increased people's aesthetic preferences. It is also possible that other ambient factors, such as exhibit lighting and background sounds, may have affected responses. These factors could be considered and explored during future work, both related to well-being and also to aquarium design. Finally, it is possible that the different motivations for visiting the aquarium (i.e. a day out for aquarium visitors vs. paid participants and students who had deliberately signed up for a study) may have influenced responses and should be controlled for when considering future studies.

In view of the above limitations, this work could be expanded by exploring self-reported well-being responses to a range of exhibit categories (e.g. low abundance/species richness); examining people's responses to standardised changes in species richness and abundance; and examining any relationships that exist between these well-being responses and motivations to visit. This last point may be of particular interest when applying these findings to real world applications as, during participant debriefs, one female student stated that she would visit the Tropical exhibit if she wanted to feel happier (it was more 'colourful', there was more 'going on'), but would visit the Temperate exhibit if she wanted to feel more relaxed.

4.4.3 Implications

These two studies add to the thesis by examining people's perceptions of species richness and abundance in sub-aquatic settings and exploring how these perceptions may influence the restorative potential of aquarium exhibits. In these studies, viewing either exhibit was potentially restorative but mood and experience evaluations tended to be more positively affected by the exhibit containing the greater number and abundance of species. Furthermore, this work highlights why previous studies exploring biodiversity and health and well-being may have proved inconclusive. Other studies have often not accounted for species abundance or the importance of being able to make comparative judgements. This final point may be worth emphasising as experiencing more than one setting, enabling comparative evaluations to be made, could subtly affect psychological well-being. These prior experiences may 'anchor' future judgements, influencing and informing well-being evaluations. This is worth considering when reflecting on the well-being outcomes in previous studies in which assessments may have been based on responses to a single setting. Understanding the environmental nuances that influence health and well-being outcomes may be particularly beneficial when considering applications in workplace or healthcare settings.

4.4.4 Conclusions

In summary, viewing aquarium exhibits can facilitate psychological well-being and provide valuable restorative experiences that may be especially important for people with little access to natural environments. Exhibit content appears to affect well-being outcomes and experiences are, generally, more positive in settings where biota levels are greater. That said, people's responses may be influenced by certain animals or behaviours that they find especially appealing or fascinating to watch.

Chapter 5.

Discussion

5.1 Introduction

5.1.1 Review of Thesis Aims

This final chapter summarises and discusses the main findings drawn from the previous chapters and how these findings relate to each other and the current literature. Limitations of this work are discussed and future avenues of research are suggested.

There were four original aims for this body of work. First, in light of the comparative lack of research into 'blue space' settings (Volker and Kistemann, 2011; White et al., 2010), I wished to examine people's preferences for, and the restorative potential of, another type of blue space environment, specifically sub-aquatic scenes, in natural but mainly 'artificial'(human-made) settings. Extending the work by White et al. (2010), the first two studies 'set the scene' by investigating how natural and artificial underwater environments compared to more commonly researched environments. Study 1 compared people's aesthetic and behavioural preferences, positive affect and the perceived restorativeness of natural sub-aquatic scenes compared with natural green and blue space environments and urban settings. Using the same four measures, Study 2 extended this work by adding a fifth environment type – human-made underwater environments (public aquarium exhibits) – to investigate how this artificial setting compared with natural environments.

Second, also in consideration of the relative lack of research on the subject, I aimed to explore people's preferences for different examples of a particular setting 'type', using the same measures as Studies 1 and 2. As Study 2 had only employed a small selection of 'typical' aquarium exhibits, Study 3 built on these findings by systematically sub-categorising aquarium exhibits based on region, biological group,

species richness and abundance.

Third, in light of others' research into environment-related 'dose-responses', that is, responses to different quantities of a landscape feature (e.g. water - see White et al., 2010) or responses to exposures of differing duration, (e.g. self-selected length of stay – see Barton & Pretty, 2010; White et al., 2013b), Study 4 capitalised on a unique aquarium exhibit refurbishment opportunity to examine both visitors' behaviour and participants' psychological and physiological responses to the three stages of exhibit restocking. As the few studies that have previously examined the potential health benefits of aquaria have used small, hobbyist aquaria, often in a clinical or therapeutic capacity, I used a public aquarium setting, as there is already some existing evidence that public aquariums can provide restorative experiences (Falk et al. 2008; Packer & Bond, 2010). Furthermore, considering that not everyone can access the restorative benefits of natural settings, exploring the human health and well-being benefits of public aquariums – an artificial, yet more readily accessible, form of exposure to living things (nature) – was important.

Finally, although several studies have researched the links between 'biodiversity' and human health and well-being, relatively few of these studies have explored people's perceptions of biodiversity or how different factors, such as the biological components (e.g. species richness and abundance of individuals) or the presence of a comparator setting, could affect subsequent biodiversity judgements and, ultimately, influence human health and well-being outcomes. Therefore, the fourth aim of this work was to investigate people's ability to perceive sub-aquatic species richness when viewing one (Study 5) or two (Study 6) public aquarium exhibits, and explore how these perceptions might affect their psychological responses to the marine life they are viewing. Furthermore, as studies in terrestrial settings usually only focus on species richness (e.g. Dallimer et al., 2012; Fuller et al., 2007), Studies 5 and 6 also explored

the influence of species abundance and other factors that may influence well-being outcomes such as prior taxonomic knowledge.

5.2 How Well Do The Findings Fulfil the Thesis Aims?

5.2.1 How Do Natural and Artificial Sub-aquatic Environments Compare with Other Environments?

As noted in Chapter 1, there is, to date, a shorter body of research into the restorative benefits of 'blue space' environments than 'green space' settings (e.g. Bowler et al., 2010; White et al., 2010). Furthermore, there is even less research into the effects of sub-aquatic settings on human well-being, whether wholly natural (e.g. natural coral reefs), 'managed' (i.e. small aquaria) or simulated (e.g. photos). Studies 1 and 2 began to address this gap in the current literature.

Study 1 found that natural underwater settings were rated significantly higher than urban settings and lower than blue space (aquatic – above water) environments on the four variables: attractiveness, willingness to display an image of, positive affect and perceived restorative potential. There were no significant differences between natural underwater scenes and green space environments, except for positive affect which was higher for green space. Study 2 found artificial underwater settings (aquarium exhibits) were rated significantly higher than urban, green space and natural underwater settings on all four measures, and were rated similarly to blue space environments on attractiveness, willingness to display and positive affect (although lower than blue space on perceived restorativeness).

5.2.2 How Does Sub-aquatic Marine Life Affect Responses?

Anyone casually observing aquarium visitors will quickly notice that people have preferences for different exhibit types and specific animals, and that visitors can

display a variety of emotions during their visit. Exploring people's reactions to different sub-aquatic biodiversity therefore formed a large part of this thesis. Previous research has found that people's responses to different examples of the same environment 'type' can differ. This has been found in both 'green space' settings (e.g. different healing gardens - Tenngart Ivarsson & Hagerhall, 2008) and 'alternative' restorative environments (e.g. exhibitions within a museum - Pekarik et al., 1999).

There were two main ways in which I investigated people's responses to different species and abundance of individuals: i) Studies 3, 5 and 6 explored participants' responses to *different* types of aquarium exhibit, sub-categorised by geographical region, species richness, abundance and, for Study 3 only, biological group; ii) Study 4 explored participants' responses to three stocking levels of the *same* type of marine life.

5.2.2.1 Responses to Different Types of Aquarium Exhibit

Findings from my laboratory (Study 3) and field studies (Studies 5 & 6) supported anecdotal observations and findings from previous research. Study 3 showed that when participants viewed different types of typical aquarium exhibit, their responses (e.g. preferences, well-being outcomes) varied with exhibit type. Overall, in Study 3, participants displayed preferences for tropical (vs. temperate) exhibits; exhibits containing vertebrates (fish vs. invertebrates), and exhibits of high (vs. low) abundance. However, when compared with previous studies (e.g. Dallimer et al., 2012), the results for one sub-category, species richness, was less conclusive than anticipated. Although the Tropical High Species richness/High Abundance sub-category was the highest scoring exhibit sub-category overall, the Temperate equivalent scored poorly in this study and was rated lower than the Temperate Low Species Richness/High Abundance sub-category (see Section 2.4.1 for possible explanations for these poorer ratings).

In Studies 5 and 6, it was also clear that marine life influenced an exhibit's perceived restorativeness and likelihood of providing restoration. In Study 5, both tropical and temperate exhibit were perceived to possess restorative characteristics and provided restorative experiences. However, although both exhibits scored highly, the ratings for the tropical exhibit in the low stocking condition were, unusually, lower than those for the temperate exhibit. This may have been due to the fact that some particularly appealing animals, such as the Loggerhead turtle and Spotted eagle rays, were not present in the tropical exhibit at this time. In Study 6, which ran at the high stocking level only, participants viewing the marine life in both exhibits tended to prefer the tropical exhibit to the temperate exhibit and found it more restorative. Interestingly, in Study 1 when participants were asked about their preferences for different diving and snorkelling locations (tropical vs. temperate), the majority of participants stated that they preferred to undertake these activities in tropical seas. While this question in Study 1 was not specifically related to marine animals, just location, it is likely that the marine life in these settings is important. In Uyarra et al.'s (2009) study, the top three attributes that contributed to diver enjoyment of a dive site were all biological (i.e. fish abundance/species richness, vivid reef colours, coral condition) rather than environmental (e.g. clarity of water) or external (e.g. dive master guidance).

5.2.2.2 Psychological, Physiological and Behavioural Responses to Different Levels of the Same Type of Aquarium Exhibit

Study 4 focused on just one exhibit type (a large, mixed species temperate exhibit) and explored people's responses to three different stocking levels (Unstocked, Partially stocked, Fully stocked). Overall, this study provided evidence that differing levels of marine life could elicit different behavioural, psychological and physiological responses. For instance, visitor observations revealed that Aquarium visitors spent

longer in front of the exhibit as stocking level increased. Study 4 participants who were more closely monitored were also affected by exhibit stocking levels. Participants' experience evaluations of the Unstocked condition were positive but Partial restocking significantly improved all five evaluation measures, and a Fully stocked exhibit improved two of the ratings further. Mood significantly improved in the Partially and Fully stocked conditions only. Significant decreases in arousal occurred in all three conditions, although arousal decreased less in the Fully stocked condition than in the Unstocked and Partially stocked conditions. This potentially supports the evaluation statement that the Fully stocked condition was the most interesting and was perhaps more energising, than calming. There were no significant interactions between changes over time and stocking level for any of the four Activation Deactivation Adjective Check List (AD ACL) emotional states but there were significant changes over time for all states: ratings for Calm and Tiredness increased, whereas those for Energy and Tension decreased. Although, the AD ACL findings were suggestive of a relaxing experience, there were no significant differences between the three experimental conditions.

There were no significant interactions between time and stocking level for either blood pressure or heart rate. There were significant decreases in systolic and/or diastolic blood pressure but only for the Partially and Fully stocked conditions. In contrast, heart rate dropped significantly in all three conditions but was significantly greater in the Partially and Fully stocked conditions.

Overall, stronger psychophysiological benefits were found in the presence of marine life (with some evidence that greater stocking was more beneficial) and these benefits were most noticeable in the first five minutes of exposure, with few further changes being observed after 10 minutes of exposure. This suggests that even short exposures to aquaria (e.g. 5 minutes) could have meaningful psychological and

physiological impacts, and could potentially be used in applied settings such as organisational or medical contexts to help calm workers or patients.

5.2.2.2.1 Additional Comments

Although different in design and aim, it is worth noting that there appear to be similarities between some of the conditions presented in Studies 4 and 1. In Study 4, participants were exposed to 'Unstocked' or 'Stocked' conditions, whereas in Study 1, participants rated 'Scene-Only' and 'Scene + Animals/People/Objects' images. Although, however, some comparisons could be drawn between these two studies: the Unstocked (vs. Partially/Fully Stocked) condition in Study 4 and the 'Scene-Only' (vs. 'Scene + Animals') condition of Study 1, the findings were not the comparable. In Study 4, there were significant differences between psychological and physiological measures when comparing results from the 'Unstocked' and 'Stocked' conditions. In contrast, as discussed in Chapter 2, there were no significant differences between mean preference scores for the Natural sub-aquatic 'Scene-Only' and the 'Scene + Animals' images in Study 1.

It is possible that the findings for Study 1 indicate that people did not necessarily prefer images containing animals to images without. This could seem plausible considering that water is a dominant feature of preferred environments (Ulrich, 1983). However, I believe that there are a number of alternative explanations for the lack of differences between ratings for the Natural sub-aquatic 'Scene-Only' and 'Scene + Animal' images. For instance, due to the desire to keep the photo set manageable there were only a small number of images representing each sub-category (see Section 2.2.2.1 – eight images representing 'Scene-Only' and four representing 'Scene + Animals'). In light of such a small selection of images, it is possible that any particularly poorly rated images may have had a greater effect of the final mean score than if the photo set

categories had been larger. The lowest rated image in the 'Scene + Animals' category featured a large aggregation of spiny spider crabs and, as invertebrates, particularly those that are or resemble spiders, are particularly unpopular with people, it is possible that this image contributed to the overall low score for this category. It should also be noted that there is a significant difference between the animals represented in Study 1 images and those in the live exhibit in Study 4. Study 1 images tended to be of lower species richness and abundance than animals present in the Study 4 exhibit that, according to Study 3 findings and existing literature, is likely to lead to lower overall ratings. The only way to address the possibly image selection issues would be repeat Study 1 with a much larger quantity of images, and focus on comparing 'Scene-Only' and 'Scene + Animals' images only.

There are other factors that could account for the differences in findings and make Studies 1 and 4 less comparable. For instance, as mentioned, studies that use simulated environments (e.g. photos) are less able to completely replicate or replace real nature – and this may be particularly problematic when trying to simulate dynamic aquatic settings. Also, the design and variables measured also differed between studies and may therefore not be comparable as is difficult to determine how these factors would have influenced perceived outcomes. Finally, Study 4 'added' marine life to the same background scene, whereas Study 1 used a range of 'Scene-Only' and 'Scene + Animals' images which also makes these studies less comparable. Therefore, although there appear to be similarities between the studies, perhaps their differences make meaningful comparisons problematic.

5.2.3 Do Biodiversity Perceptions Influence Human Well-being Outcomes?

Previous studies have noted the difficulties people experience when estimating species richness (e.g. birds, butterflies, plants - Dallimer et al., 2012) and abundance

(e.g. birds – Erwin, 1982). As it has been suggested that people's perceptions of species richness can influence well-being outcomes, Studies 5 and 6 sought to examine people's perceptions of marine life and how this may affect an exhibit's restorative potential and restoration outcomes.

Studies 5 and 6 showed that, whether viewing one or two exhibits, people experienced difficulties when estimating species richness and abundance. Overall, and in line with previous studies on this subject (e.g. Erwin, 1982), numbers tended to be significantly underestimated, although participants could generally determine that the Tropical exhibit was more highly stocked than the Temperate exhibit. When viewing one exhibit (either the only exhibit in Study 5 or the first exhibit in Study 6), there were no significant differences between the perceived 'biodiversity scores' for the Temperate and Tropical exhibits. However, viewing a second exhibit (Study 6 only) altered both scores: the Tropical exhibit score increased, whereas the Temperate score decreased. There were no significant interactions or main effects between stocking level, exhibit type, and changes in mood or arousal in Study 5, although mood improved and arousal decreased significantly after viewing either exhibit for 5 minutes. In Study 6, however, there was a significant improvement in mood on viewing either exhibit first, but viewing a second exhibit only improved mood if the Tropical exhibit was viewed: if the Temperate exhibit was viewed second, mood worsened. Both exhibits decreased arousal when viewed first but viewing a second exhibit had no further significant effect on arousal.

Overall, both exhibits received relatively high ratings on all Perceived Restorativeness, Reflection and Restoration, Restorative Potential and Attachment (preferences) items. There was only one significant interaction between exhibit type and either stocking level (Study 5) or viewing order (Study 6): the Perceived Restorativeness item 'Escape'. Intriguingly, this item was rated higher for the

Temperate exhibit in Study 5, yet higher for the Tropical exhibit in Study 6. In Study 5, there were no significant interactions between stocking level and exhibit type on any other items (Reflection and Restoration, Restorative Potential, Attachment) except that the Temperate exhibit was rated more highly than the Tropical exhibit on Reflection and Restoration. In Study 6, exhibit ratings were influenced by viewing a second exhibit. Reflection and Restoration, Attachment and Restorative Potential items were rated significantly lower for the Temperate exhibit when viewed as the second exhibit. Evaluation statements supported these findings, as the Tropical exhibit was rated as making participants feel significantly happier and potentially more restored than the Temperate exhibit. Finally, in both studies there few linear correlations between well-being measures and outcomes, and estimates of, or ability to identify, aquarium marine life.

Overall, both large aquarium exhibits were rated positively but the Tropical exhibit, with a higher level of marine life, tended to be rated more positively. It should be noted, however, that the more highly stocked exhibit was Tropical and, according to findings in Study 3, Tropical exhibits tend to be preferred to Temperate exhibits anyway. This does make interpreting some of these results problematic. It is also worth noting that, in keeping with Study 4, the greatest well-being benefits tended to occur after viewing the first exhibit for five minutes. Viewing a second exhibit did not consistently improve mood, or decrease arousal, further.

Although both aquarium exhibits were rated as have perceived restorativeness and providing restorative experiences, how these outcomes related to perceptions of species richness and abundance was less clear. Although the poor estimates of numbers may have contributed to this, it is also possible that participants' general good mood on arrival (leaving little scope for measurable improvement), also had an effect. Study 6, however, clearly demonstrated the effect of viewing more than one setting and the

importance of a ‘comparator’ in order to provide context. Nevertheless, although the generic perceived ‘biodiversity score’ highlighted the differences in *level* of marine life, viewing a second exhibit did little to improve participants’ estimates of *actual* numbers of individuals or species.

Finally, although not a specific aim of these two studies, it was noticeable that the presence of ‘charismatic’ animals was observed to influence participants’ preferences (e.g. Dallimer et al., 2012; Kellert, 1993; Uyarra et al., 2009; Woods, 2000). Certain species, notably the rays and turtle, were particularly well-liked in Studies 5 and 6. As other studies have shown a link between preferences and restoration (e.g. van den Berg et al., 2003) it is possible that these animals play a particularly important role in restorative experiences.

5.2.4 Summary

Overall, these studies addressed the main aims of this thesis:

1. They have placed preferences for, and the (perceived) restorative potential of, natural and simulated sub-aquatic settings within the existing restorative environment literature that, in general, has centred on responses to ‘green’ and, to a lesser extent, ‘blue’ space;
2. They have shown that i) different exhibit types or ii) varying levels of one exhibit type can elicit different behavioural, psychological and/or physiological responses;
3. They have highlighted the difficulties people experience judging sub-aquatic biodiversity and the influence on well-being outcomes of a ‘comparator’ setting.

5.3 Implications of this Work to Restoration Theories

Contact with natural areas and features can reduce the risk of illnesses associated with chronic stress and improve subjective well-being, enabling people to maintain the adaptive resources required to meet the demands of daily life (Hartig et al., 2013). Although not a natural environment, public aquariums allow people to get close to living things and therefore the benefits that contact with nature can bring. Overall, the studies undertaken during the course of this thesis suggest that public aquariums can provide restorative experiences and this has a number of implications for the two main restoration theories, Attention Restoration Theory (ART) and Psychophysiological Stress Recovery Theory (PSRT), as well as relating to the Biophilia hypothesis.

To recap, ART proposes that engaging with certain intrinsically interesting aspects of nature (or components found in other restorative environments) can facilitate recovery for cognitive processes that have been fatigued from directed attention, whereas PSRT holds that, under conditions of acute stress, contact with nature can quickly induce positive affect, that helps block negative emotions and facilitates a reduction in physiological activation (Hartig et al., 2013).

According to ART, for a restorative effect to happen, an environment must possess four characteristics: soft fascination, being away, extent and compatibility. Public aquariums can provide all of these characteristics: fascinating animals to look at; an escape (physically and/or psychologically) from everyday activities; a sufficiently rich environment to explore; and a place someone has chosen to visit. Only Studies 5 and 6 specifically explored people's responses to two aquarium exhibits using the ART components Fascination, Extent (Coherence) and Being Away (Escape, Novelty), adapted from Pals et al., (2007) Perceived Restorative Characteristics Questionnaire. Both exhibits rated reasonably highly, with Fascination being the highest scoring characteristic, followed by Coherence and Escape, and lastly, Novelty. In their studies,

Pals et al. (2007) found Fascination and Escape to be the two best predictors of preferences. Although no specific attentional performance tasks (e.g. the Necker Cube Pattern Control task) were carried out during my studies, the findings do suggest that public aquarium exhibits potentially have the *components* necessary to aid recovery from mental fatigue.

My studies also provided implications for the PSRT. Although only Study 4 was specifically designed to measure actual restoration following a potential stressor, all other studies, in non-stressful situations, provided evidence of positive changes in emotions. For instance, in Studies 1-3 participants positively rated natural and/or artificial scenes on aesthetic and behavioural preferences, affective responses and restorative potential. Study 4 showed positive changes in valence and arousal, four emotional states (calm, energy, tension, tiredness) and participants' evaluations of interest, happiness and enjoyment, following viewing an aquarium exhibit. Finally, in Studies 5 and 6, participants experienced more positively toned emotions after viewing one or two aquarium exhibits.

Although the Biophilia hypothesis is not an actual 'restoration theory', I believe it also has relevance to this body of work. Public aquariums offer the opportunity to spend time in close proximity to a variety of fascinating animals and therefore indulge human beings' "innately emotional affiliation to other living organisms" (Wilson, 1993, p. 31). Of particular interest, however, was how different species affected people's responses. Supplementary data collected for Studies 5 and 6 (Appendix G), particularly shed light on people's preferences for certain animals and their behaviours. Across both studies, rays and the Loggerhead turtles were, by far, the most preferred or noticed animals, and shoaling the most recalled behaviour.

5.3.1 The Effect of Water Alone

According to PSRT, evolution is likely to favour individuals who learned and retained two types of adaptive response to nature; either a restoration response following a stressful event or, in the absence of stress, a liking/attention/approach response for particular environmental features (e.g. vegetation, water) or circumstances that aided well-being or survival, e.g. the potential for food, with minimal risk (Ulrich et al., 1991). Although the stressor task in Study 4 did not significantly stress participants, a number of psychological and physiological improvements were noted. Some of these improvements were greater when the exhibit had a level of marine life, whether Partially or Fully stocked (e.g. decreases in heart rate and blood pressure, improvements in mood, evaluation statements). However, the presence of marine life was less influential for some measures. For instance, arousal decreased in all three conditions, and results for the four AD ACL emotional states (increases in calm and tiredness, decreases in tension and energy) were not significantly different across conditions. Even when viewing an empty exhibit, participants were, on average, willing to continue looking at the exhibit for a further 7 minutes. This may suggest that participants found certain elements of the exhibit, even when devoid of marine life, potentially restorative. The same may also be said of Study 1's findings, that is, the lack of differences between ratings for Natural sub-aquatic 'Scene-Only' and 'Scene + Animals' images. Nevertheless, in this instance, I believe that there are a number of potential reasons why no differences were found (See Section 5.2.2.2.1)

Water is a landscape feature that almost always enhances the quality of a scene – it is interesting and aesthetically pleasing to look at, and evokes positive feelings, such as tranquillity (Ulrich, 1983). Therefore, as a common feature of preferred environments, it is possible that viewing the water alone offered participants some positive benefits, by producing a wakeful relaxation response (Ulrich et al., 1991).

5.4 Limitations

5.4.1 Study Locations: Laboratory vs. Field Settings

Overall, the mix of laboratory and field studies worked well for this body of work. Photo studies enabled preferences and the restorative potential of both broad environment categories (e.g. green and blue space) and sub-categories of one environment type (e.g. aquarium exhibits) to be investigated, and for differences between responses to these environments to be established. Nevertheless, using simulated environments does have limitations. Although viewing artificial representations of nature can provide a variety of well-being benefits, simulated nature cannot completely replace real natural settings which tend to increase benefits further (e.g. Kjellgren & Buhrkall, 2010). Furthermore, static images may not be the best way to represent the dynamic elements of aquatic settings (see e.g. Huang, 2009): this is likely to be even more problematic when try to replicate aquatic environments containing highly mobile species as the dynamics of these animals may enhance the restorative experience.

Conducting field studies, however, proved to be challenging. For instance, although aquarium visitors were the participant group most generalisable to the wider population, their participation often limited study design. In Study 5, it was not possible to 'stress' aquarium visitors before asking them to view an exhibit which is likely to have influenced the ability to detect changes in their mood and arousal, especially as they were usually very happy at the start of their visit. There was also insufficient time to set up and take physiological measures or ask visitors to view a second exhibit. However, the physical aquarium environment itself was probably the most testing aspect in my field studies: there was no control over stocking levels, visitor numbers or background noise, making the control of variables less rigorous than I would have liked.

5.4.2 Measuring "Restoration": Psychological vs. Physiological Measures

The optimum means of monitoring "restoration" would be to undertake a suite of psychological, physiological and cognitive measures (Ulrich et al., 1991). However, while the overall aim of the thesis was to explore the potential for aquariums to provide restorative experiences, for practical reasons, this could only mostly be achieved by asking about the 'perceived restorativeness' of exhibits and by using self-reported and mood scales (Studies 4, 5 and 6). Only one study (Study 4) was designed to measure actual 'restoration', following a potentially stressful event, using affective and physiological responses. However, the stressor task administered in Study 4 did not significantly stress participants, i.e. there were no significant changes in physiological measures (e.g. an increase in heart rate). It is difficult to discern whether this was the result of a particularly weak stressor task, especially as some people try to figure out anagrams as a leisure activity, or the fact that many of the participants were quite happy and/or excited to be in the aquarium and perhaps the stressor task was not of particular concern to them. Furthermore, as responses to the psychological scales (e.g. the Feeling Scale) were more illuminating than the physiological measures in Study 4, it may have been preferable to administer these scales before and after the stressor task, rather than just after. Overall, however, there was consistency between the psychological and physiological measures in this study (mood improved, arousal decreased and heart rate and blood pressure dropped, implying greater relaxation), justifying a greater confidence in the findings.

Although Study 4 was the only study that set out to deliberately stress participants, in studies where, by chance, there were some 'stressed' individuals (i.e. Study 5's participant), particularly strong gains in mood were noted. This finding supports previous work by Hartig and Staats (2006) whose study highlighted how within-individual differences (i.e. a person's need for psychological restoration) could

determine a person's attitude towards the perceived restorative potential of a given environment. Hartig and Staats measured participants' attitudes towards walking in a forest or a city centre (following presentation of the environment in a slideshow), and their evaluation and likelihood of behavioural outcomes (e.g. attentional recovery) under different levels of attentional fatigue. Although students who were more fatigued (i.e. who had participated in the study after an afternoon lecture) and less fatigued (participated before a morning lecture) both reported favouring a walk in a forest, compared with a walk in the city, the difference was larger with the more fatigued participants.

Generally, however, most of my study subjects, whether actual aquarium visitors or student participants, tended to arrive at the aquarium in a reasonably good mood. For instance, some aquarium visitors scored their mood on arrival as +5 on a -5 to +5 scale leaving no opportunity for the scores to become any more positive. Although this may have made measuring restorative potential problematic there was, fortunately, enough variation in most studies for measurable changes in mood to be detected leading to the overall conclusion that aquariums may indeed be suitable environments for relaxation and restoration. This does, however, highlight that a further way to take this work forward would be to compare a 'typical' experience with experiences in others setting where people can face demands or find possibilities for restoration.

5.4.3 Quantifying the Influence of 'Biodiversity'

One of the most frequently encountered difficulties throughout this thesis has been that species richness and abundance were usually confounded in the studies. For instance, in Study 4, although species richness in the Fully stocked condition was approximately double that of the Partially stocked condition, so was abundance. This confound has primarily been the result of undertaking some of the studies in a working

aquarium environment. While conducting studies in the actual setting under investigation improved validity, it was very difficult for me to have any control over exhibit stocking levels. In view of this, determining the effect that increases in species richness or abundance had on any of the behavioural, psychological or physiological measures was problematic. Some other studies have not suffered from this issue as they have only investigated people's responses to species richness (not necessarily accurately measured at the exact time of assessing well-being, e.g. Dallimer et al., 2012; Fuller et al., 2007) and have not taken into account the potential effects that species abundance may have on well-being (or the influence of certain species or species' behaviours).

5.4.4 Participants: Demographics, Characteristics and Motivations

There were two further issues that possibly limit the application of some findings: 'student' participants and 'healthy' participants. The use of student participants is common in psychology research. Usually it is a requirement of the course that students undertake a number of studies for 'course credit' and this makes them a convenient sample for psychology-based studies. As well as being a readily accessible sample, the use of psychology students does have other advantages. Student participants are familiar with study protocols and thus there are fewer difficulties with asking them to undertake tasks that may either be unsuitable (e.g. a stressor task) or too time-consuming for members of the public. In my studies, visitors were used when feasible. In Study 4a it was possible to observe actual visitor behaviour as this could be achieved unobtrusively and without interruption to a visitor's trip to the aquarium. However, for the lengthier, more intrusive aspects of Study 4 (i.e. 4b, the close monitoring of physiological and psychological measures and the administration of the stressor task), student participants were more appropriate. Visitors were also used in Study 5 where they were asked about their thoughts and feelings related to an exhibit. Participation in

Study 5 took about 15 minutes and, as many visitors who were approached about participating (especially those with small children) were reluctant to spare any time at all, 15 minutes was about as long as I felt was appropriate to commandeer visitors on arrival. However, students' familiarity with study protocols may also have some downsides that threaten the reliability of their responses. Some students may simply rush through their responses, simply eager to collect their 'credit', whereas others may guess the purpose of a study which could bias their responses.

There is also much debate on whether student participants are generalisable to the wider population: some researchers argue that students are not 'fully formed', i.e. they lack the life experience of older individuals (Peterson, 2001). Although the use of 'young' psychology students (mostly female undergraduates, 19-21 years old) may not be wholly representative of the general population, Stamps (1999) conducted a meta-analysis that suggests that results obtained from students may generalise to the general public. In support of this suggestion, is it worth noting the similarity between visitor responses in Study 5 and those of students and paid participants in Study 6. Although in Study 6, participants viewed both exhibits and answered some additional questions, the study design and measures were more or less identical to those in Study 5. Comparing participants' responses across the two studies highlights how similar they were in both direction of response and actual means. For instance, in both studies viewing one exhibit (Study 5) or the first exhibit (Study 6) improved mood and decreased arousal. In both studies participants' Perceived Restorativeness and Preferences scores were similar, rating both exhibits relatively highly on both measures. Also, participants from both studies tended to visit aquariums every two to five years; self-rated their ability to estimate marine life as slightly below average and were able to identify the same number of species. Therefore, as the responses from younger adults in Study 6 were

comparable to those of the older adults (general public) in Study 5, I feel that the use of student participants throughout this research is acceptable.

A further participant-related issue may be the use of 'healthy' participants for the studies, notably Study 4b. While comments in Section 5.4.2 above mention the unsuccessful attempt to deliberately stress participants in this study, the fact that participants were not a clinically 'challenged' group (e.g. hypertensive) may also have influenced responses. Katcher et al. (1983) investigated blood pressure changes in two groups of participants who undertook their relaxation experiment (watching a fish tank). One group of participants consisted of students and university employees; all were relatively young and had blood pressures that were at the lower end of the normal blood pressure range. In contrast, the second group of participants were older individuals and all had clinical hypertension. The researchers found that although blood pressure dropped for both groups there were particularly large decreases in systolic and diastolic blood pressure for the hypertensive group. Furthermore, they reported that for this group, the blood pressure levels fell to within the normal range while watching fish. Therefore, further work building on the studies in the current thesis could target particular cohorts who may be in particular need of stress reduction.

Finally, there are two other points that should be mentioned in conjunction with this work. First, and most obvious, there are times when public aquariums are far from 'restorative' environments: they can be both busy and noisy, as anyone who has visited on a wet bank holiday or the presence of multiple school groups will testify. However, although there were instances when conditions within the aquarium were less than ideal for my studies, I was often surprised by how engrossed participants could become when watching the fish and how little they appeared to be aware of their surroundings - they frequently failed to notice noisy interruptions, such as excited school children. This observation appeared to be reflected in results as, overall, there appeared to be few

detrimental effects on well-being outcomes, thus supporting the findings elsewhere (e.g. museum-type research such as Packer & Ballantyne, 2002) that public aquariums serve as restorative settings.

Second, and connected to the first point, people visit public aquariums for a number of reasons (e.g. entertainment, learning experiences). This can make it difficult to separate the 'well-being' benefits associated with biodiversity from those of, say, spending time with family and friends. Nevertheless, as mentioned in Section 1.3.3, Falk et al. (2008) did identity that a small percentage of aquarium visitors (Spiritual Pilgrims) are primarily driven by restorative and/or contemplative experiences that can be particularly enhanced by the presence of certain animals: one participant described the jellyfish as "very soothing to watch…very relaxing" (p. 68). Although aquarium visitors in Study 5 were not asked about their reasons for visiting, their overall positive well-being outcomes, coupled with their preferences for different animals highlight how important it is to investigate how biodiversity can influence humans health and well-being perceptions.

5.5 Future Work

Although this work has added to the existing knowledge regarding how biodiversity can influence human's perceived health and well-being, there is certainly scope for furthering this line of research. There are many other factors that could be affecting biodiversity preferences, and health and well-being. For instance, specific species may be more or less fascinating to watch, and preferences and perceived restorative potential may be influenced by colour, size, movement patterns or other behaviours. Within the aquarium building itself, there could be physical factors that impact on the potential for restoration. These may include lighting, heating, sound, wayfinding, exhibit messaging, seating, background noise and the presence of other

visitors. Motivations for visiting and visitor 'goals' (e.g. enjoyment, learning) may also influence well-being, as may a visitor's background and underlying health.

I shall expand on some of these potential areas for future research below.

5.5.1 The Role of Charismatic Animals and Behaviours

While the majority of work in terrestrial environments focuses on the impacts of greater biodiversity (species richness), with the inference that greater species richness results in greater human well-being, I am not convinced that the picture is quite so simple. To illustrate my point: if a dozen common birds were spotted during a riverside walk (e.g. five starlings, four wood pigeons, two sparrows and a blackbird) this could be undoubtedly be perceived as a more species-rich (and potentially more restorative) experience than if only a single bird (e.g. a sparrow) was spotted during the walk. However, what if the single bird spotted was not a sparrow but a kingfisher? The group of twelve birds is undoubtedly greater in both species richness and abundance than a single bird, yet 'charismatic' species, such as the kingfisher, may have a disproportionate effect on people's emotions, and tend to elicit greater feelings of joy, awe or excitement than more 'common' species. Therefore, perhaps, spotting an individual bird may not necessarily be less restorative than the larger group of birds, or even equally as restorative as seeing a single bird of another species.

Therefore, while there is understandable, global concern about the rate at which species are currently disappearing, when considering the impacts that flora and fauna have on human health and well-being outcomes, there may be more to consider than simply the 'number' of species. Other factors such as the abundance of a species or particularly 'charismatic' species may also impact on well-being outcomes. For example, although not part of this thesis, the influence of charismatic animals potentially influenced findings in one study. There has been a tendency throughout this

thesis for tropical exhibits to be significantly more preferred than temperate exhibits, yet this was not the case in the Low stocking level condition in Study 5. In this instance, the tropical exhibit was significantly less preferred than the temperate exhibit. This could potentially be explained by the absence of several charismatic animals in the tropical exhibit at this time, specifically, the Loggerhead turtle (*Caretta caretta*) and six Spotted eagle rays (*Aetobatus narinari*). When present, both of these species tended to dominate participants' responses to questions such as 'Which species of fish do you like best?' far more than all other species (see Appendix I). It would be interesting to extend this work by exploring the reasons for people's preferences in greater detail. This could be achieved using a similar methodology as Woods (2000), who asked respondents to list their five most (and least) favourite animals and the reasons for considering these animals (un)favourably, using open-ended responses.

The role of species' behaviours should also be explored in greater depth. In Study 5 and 6, shoaling was one of the most consistently noticed fish behaviours and in Study 3 participants preferred images of Temperate schooling fish (a high abundance of one species) to Temperate images containing greater species richness. Although static images were used in Study 3, potentially the inferred movement (the 'bait ball' motions typically seen in underwater wildlife documentaries) may have been especially fascinating for participants. It is suggested that certain movement patterns are associated with safety and tranquillity, while others signify danger. "Heraclitean" motion is a soft pattern of movement indicative of safety - the movement "always changes, yet always stays the same" (Heerwagen, 2009, p. 48). Examples of Heraclitean motion include waves lapping on the shore or a light breeze moving through a field of wheat. Watching fish in an aquarium is another example (Heerwagen, 2009). Perhaps certain aquarium species and their behaviours (e.g. schooling fish) are particularly hypnotic and relaxing to watch. As mentioned earlier, a visitor in Falk et al.'s (2008) study commented on

how soothing he found the jellyfish.

As my studies have highlighted that perceived human health and well-being outcomes may be influenced by more than just 'species richness' (and abundance), particular species and their behaviours, also need to be looked at more closely. Teasing apart the effects of these different biological components, however, would doubtless need to be undertaken in a laboratory setting where individual components could be more readily controlled and tested.

5.5.2 Species Richness and Abundance

One of the main difficulties encountered during this thesis, especially when conducting field work at the National Marine Aquarium, was that species richness and abundance were confounded. This was problematic in Study 4, as both species richness and abundance doubled during restocking, and also in Studies 5 and 6, where the tropical tank had both higher levels of richness and abundance than the temperate tank, making it difficult to determine whether the gains in well-being were due to species richness, abundance or both (or the fact that people particularly like tropical exhibits). Previous studies (e.g. Dallimer et al., 2012) have usually focused on species richness only. However, as much less is known about the role of species abundance in human well-being studies, it is important that future research also investigates the effects of abundance, as well as species richness and, by extension, examines the interactions between the two. Again, this work would also need to be carried out in a laboratory environment as it is unlikely that any researcher would be able to control the restocking of an aquarium's exhibits.

Overall, in my work, greater preferences and well-being outcomes were associated with greater stocking levels (Studies 3, 4, 5 & 6) but when considering future work on the restorative effects of species richness and abundance (and trying to unpick

the two), it is worth mentioning again the difficulties that people experience trying to accurately estimate large numbers of a given stimuli (as highlighted in both the literature, e.g. Erwin, 1982, and Studies 5 and 6). Future work should therefore ensure that perceptions of species richness and abundance are determined and, where possible, that comparators are included. Although comparators were only helpful when using the generic biodiversity scale in Study 6, there may be underlying reasons for this. Depending on study design or biodiversity numbers, comparators may be more beneficial in future work.

5.5.3 Cognitive Benefits

This thesis focused on the psychological and physiological effects of exposure to sub-aquatic biodiversity. One area that was not explored for this work was the effect of sub-aquatic biodiversity on recovery from mental fatigue. Although questionnaire items exploring components of ART were used in Studies 5 and 6 to examine and compare the perceived restorative potential of a tropical and temperate exhibit, no measures of cognitive recovery were taken. Considering the positive effects that exposure to restorative environments can have on recovery from mental fatigue following undertaking specific attention-depleting tasks (e.g. backward digit span – Berman et al., 2008; Sustained Attention to Response Test: SART – Berto, 2005) extending this research to incorporate various categories of sub-aquatic environments could be a logical and interesting next step.

5.5.4 Participant Characteristics and Motivations

Genuine aquarium visitors were used for two of my studies but most of my research was conducted on young, ‘healthy’ UK university students (the limitations of which have been discussed above – Section 5.4.3). Future research could benefit from

pursuing two distinct participant avenues: i) the general population; ii) specific sectors of the population, such as children, the elderly, people with special educational needs, and people with physical (e.g. high blood pressure) and/or mental health problems (e.g. anxiety and depression). More extensive use of the wider population will improve the generalisability of the findings, whereas research using different sectors of the population with more specialist needs may help formulate and design more effective healthcare interventions. In both instances, this may result in positive changes to conservation policy as the benefits to human well-being are realised.

Although this thesis has predominately centred on the biological components that can help promote stress-reduction and relaxation, biodiversity may influence other human 'states'. One participant in Study 6, stated that the exhibit she would prefer to view would depend on her underlying emotions, that is, whether she wanted to be 'cheered up' (tropical exhibit) or 'relaxed' (temperate exhibit). This is clearly an example of emotion regulation guiding environmental choice (Korpela et al., 2001). Therefore, a greater understanding of how different biological components can affect a range of emotions would be extremely beneficial as there may be instances, for example in a clinical environment, where it is more beneficial to energise or stimulate a person, rather than relax them.

Along these lines, a study by Edwards and Beck (2002) revealed how even one tank of fish can elicit different responses depending on a person's characteristics. When these researchers introduced a fish tank into the day room in a clinic that cared for Alzheimer's patients, they noted two general types of response: patients who were lethargic were more alert in the presence of the fish tank and those who were usually agitated, and spent time pacing, were much calmer. Interestingly, both responses resulted in an increase in the quantity of food eaten by the patients: the lethargic patients were more focused and ate more food, and the patients who usually paced, spent more

time at the table and consumed more food. As the researchers in this study were interested in ways of increasing food uptake in Alzheimer's patients, the addition of a fish tank appeared to provide a 'win-win' solution.

In a similar vein, underlying motivations for visiting an aquarium may also influence restorative experiences. As touched on in Chapters 1 and 4, there are many reasons why people visit aquariums, ranging from a fun day out with the family to spending time in a restorative setting (e.g. Packer & Ballantyne, 2002; Falk et al., 2008). Further work could explore how these underlying motivations influence how people respond to the biodiversity on display within an aquarium. Parents with young children may prefer stimulating and entertaining exhibits, whereas a person motivated by the opportunity for restoration may be more 'sensitive' to the biodiversity in the exhibits and prefer to spend time viewing calm, soothing tanks. It is also possible that some visitors may also prefer to visit alone as visiting natural settings with children may be less restorative (White et al., 2013b).

While this thesis aimed to develop a greater understanding of how variation in sub-aquatic species can impact on perceived health and well-being outcomes, these examples clearly illustrate that there may be a number of factors, such as a person's current mood and motivations, that influence the effect that biodiversity has on them.

5.5.5 Impacts of the Physical Aquarium Environment

The physical characteristics of the aquarium setting may also be important in determining restorative outcomes. A person seeking a restorative experience, consciously or otherwise, may be more aware of factors such as lighting (dim vs. bright), presence (few vs. many) and behaviours (quiet vs. loud) of other visitors, and sound (natural vs. human). Sound, for example, has already been shown to affect recovery from psychological stress. Alvarsson, Wiens and Nilsson (2010) compared the

effects on stress recovery of four different sound conditions: 'Nature' (water from a fountain and birds tweeting - 50 dB), 'High noise' (road traffic – 80 dB), 'Low noise' (road traffic – 50 dB) and 'Ambient noise' (quiet back yard with sounds of ventilation systems – 40 dB). They found that recovery from a stressor task, measured by a decrease in skin conductance level (indicating a decrease in sympathetic activation), was significantly faster during the 'Nature' condition (rated as the most pleasant sound) than the 'High noise' condition (rated as the least pleasant sound.

In an aquarium setting it would be interesting to, first, test whether there were differences in restorativeness potential when comparing settings with and without congruent sounds. Second, to test whether incongruent aquatic water sounds, e.g. whale sound in a rock pool area or waves in a deep sea exhibit, affect restorative experiences. Finally, the effect of sound levels (dB) themselves could be explored.

Lighting is another key area worth investigating. Studies have found that indoor lighting (e.g. Knez) and natural daylight (e.g. Beuke & de Kort, 2014) can influence a number of health outcomes, including mood and cognitive performance. Lighting could be manipulated in both 'dryside' exhibit areas and in the exhibits themselves in order to enhance restorative quality[10].

5.5.6 Conservation Implications

Although the aim of this thesis was the investigation of the effects of sub-aquatic biodiversity on perceived human health and well-being outcomes, there are other potential avenues for this work, such as how it may impact on biodiversity conservation. As mentioned in Chapter 1, humans are inextricably linked to biodiversity and the range of ecosystem services biodiversity provides (Díaz et al. 2006), yet it is clear that human

[10] Note: Animal welfare would, of course, be the primary consideration when looking to explore any changes in exhibit settings (lighting, sound etc.).

activities are causing large scale biodiversity loss (Rudd, 2011) - and there is little evidence of its reversal (Miller, 2005).

Conservation organisations frequently focus on the threats to a specific charismatic species (e.g. the indiscriminate killing of dolphins, sea turtles and sharks in longlines) when raising awareness of biodiversity loss with the general public. Efforts to preserve a particular iconic species are thought to have an 'umbrella' effect and save the more mundane animals that live in the same habitat and suffer the same fate (Marris, 2013). Mlambo (2012) suggests that focusing on conserving the environment (e.g. species and ecosystems) has limited the efforts to bring issues concerning biodiversity conservation to the attention of the general public. Instead, Mlambo (2012) proposes that incorporating human well-being into biodiversity research and focusing attention on the implications for human health may be the only sustainable way to counter biodiversity loss.

Miller (2005) has a different perspective: "conservationists have failed to convey the importance, wonder and relevance of biodiversity to the general public, preaching to the choir rather than reaching the unconverted" (p. 430). Further, Miller believes that increasing urbanisation and the resulting disconnection from nature is to blame and that efforts should be made to integrate the natural world into people's everyday lives. Evidence suggests that people who establish personal connections with natural environments, and the species therein, are more likely to value and protect these environments and species (Miller, 2005; Stokes, 2007). Therefore, increasing opportunities to engage with nature and gaining a greater understanding of the impact that certain species may have on human health and well-being, may provide evidence-based health advice that may ultimately encourage people to experience, and ultimately value, nature (Hughes et al., 2013). Public aquariums provide convenient access to living things ('nature') and may be especially useful considering that the presence of

visitors to natural environments can cause habitat destruction (e.g. Davis, 1977) or adversely affect an animal's natural behaviour (e.g. Constantine, Brunton & Dennis, 2004). Engaging people with nature, via proxy settings such as public aquariums, could therefore also benefit natural environments by alleviating detrimental anthropogenic impacts such as littering (e.g. Wyles et al., 2015).

Finally, some believe that keeping animals in captivity is unethical, and others argue that biodiversity has an intrinsic value and that species have a right to exist, irrespective of the benefits they provide to humans (Ghilarov, 2000). However, it is worth mentioning that most reputable zoos or aquariums are members of an 'association for zoos and aquariums' (e.g. the World Association of Zoos and Aquariums (WAZA) or the British and Irish Association of Zoos and Aquariums (BIAZA)), and have codes of practice in place that focus on the conservation and survival of species, improving animal welfare, encouraging research, and promoting public education (WAZA, 2016 - see Appendix K for Code of Ethics and Animal Welfare). A multi-institutional study involving a number of zoos and aquariums in the US, found that zoos and aquariums "prompt individuals to reconsider their role in environmental problems and conservation action, and to see themselves as part of the solution" (Falk, Reinhard, Vernon, Bronnenkant, Heimlich & Deans, 2007, p. 3). The study found that visitors believed that zoos and aquariums played an important role in animal care and conservation education. Moreover, visitors felt more connected to nature as a result of their visit. These visitors' comments are undoubtedly positive, and support Miller's (2005) suggestion that opportunities to connect with nature may, ultimately, lead to the greater protection of species and environments. Nevertheless, returning to Mlambo's (2012) point, this alone may not be enough to halt biodiversity loss and improve conservation efforts. Therefore, while keeping animals in captivity may sit uncomfortably with some conservationists, zoo and aquarium animals may provide a

necessary means of incorporating human health and well-being into biodiversity research and providing a potential avenue to help counter biodiversity loss.

5.6 Potential Applications

5.6.1 Well-being Enhancement

This thesis has focused on the restorative potential of public aquarium exhibits and how a greater understanding of which fish species and combinations of species influence and optimise perceived health and well-being outcomes. In general, greater psychological, physiological and behavioural outcomes (e.g. improvements in positive mood; reductions in heart rate; sustained interest, higher preferences and perceived restorativeness) were associated with greater levels of marine life (especially tropical fish).

As highlighted in this work (and also elsewhere in studies looking at museum-type settings), visiting an aquarium may provide restorative experiences. Although aquariums may not always be totally 'quiet' places to be, the presence of other people makes it more generalizable for healthcare environments or the workplace where other people are likely to be present. Therefore, while aquariums may provide valuable restorative experiences for the general public, the opportunity to engage with managed nature may be even more important for particularly stressed and anxious individuals and/or those unable to visit and benefit from restorative natural settings.

For those individuals who are more sensitive to extraneous noise or the presence of large numbers of other people, aquariums may be able to create special 'quiet areas' that could still provide restorative experiences and/or alternatively open out of hours for specialist visits for those sectors of the population who may benefit from a more 'therapeutic' environment (e.g. those with special educational needs). At the National Marine Aquarium we already host 'Adult Lates', special themed evening events that

adults can attend without the presence of children. This work could inform the development of specific ‘therapeutic’ exhibits for special areas within the aquarium.

Even though many of my studies took place in a working aquarium and, as such, involved large, live aquarium exhibits, the rest of my studies used photographs to determine people’s preferences and the restorative potential of the different levels of biodiversity. These findings may be equally relevant as placing very large tanks in healthcare and workplace settings may not always be feasible. These studies, therefore, still provide valuable information on the configurations of fish and other marine species that could be represented in small (live) aquaria or simulations of larger aquaria using formats such as video footage. This last point may be especially interesting. As different exhibit types may elicit different responses (relaxing vs. engaging), the use of video could also enable different combinations of marine life to be trialled in healthcare and workplace settings with the aim of testing how various species influence a range of health conditions (e.g. anxiety or depression).

Equally, in addition to testing the effects of different species on stress-reduction, the combinations of species that provide a stimulating environment could also be tested. For instance, while the reduction of stress could be important in the workplace and may help mitigate both ‘absenteeism’ and ‘presenteeism’, offering a stimulating setting may also be of use. Studies have shown how ornamental plants in an office can provide a number of perceived benefits in the workplace, such as increased productivity (especially when a task required a degree of creativity or problem-solving), reduced stress and physical discomfort, and improved mood and positive affect (Thomsen, Sønderstrup-Andersen & Müller, 2011). Interestingly, studies on plants have found that size, species, and condition of the plants (e.g. healthy, flowering) have the ability to influence mood and emotions (Thomsen et al., 2011), so it is not surprising that this extends to other species. A quick search on the internet will reveal a number of

companies that specialise in renting fish tanks to offices and other work place settings (e.g. http://www.aquarentals.co.uk/), and promoting the relaxing and calming atmosphere that they create for staff and visitors.

5.6.2 Aquarium Design

Interestingly, as aquarium exhibits have the potential to elicit different emotions, it is possible that different exhibit types could influence the uptake of conservation messages. For instance, would it be best to place an important conservation message near a more stimulating, potentially exciting exhibit (e.g. one containing large sharks) or a relaxing, more soothing exhibit (e.g. jellyfish)? Would the stimulating exhibit be too distracting or would it encourage information uptake and engagement? Would the message be better placed next to a calm exhibit that gives the visitor chance to recover from the 'sensory overload' of viewing vibrant exhibits? All these options are potential applications that could be explored.

5.7 Conclusions

The overarching aim of this thesis was the investigation of the restorative potential of sub-aquatic environments and, specifically, whether the biological diversity found within public aquariums could improve human well-being. My six studies investigated this aim by employing a variety of different measures (behavioural, psychological and physiological) and participants (genuine aquarium visitors, students and paid participants), in both laboratory and field settings.

I found that real and simulated public aquarium exhibits were able to provide restorative experiences and that these restorative experiences were influenced by biodiversity characteristics, such as species richness and abundance. Public aquariums, or representations of their exhibits, may therefore provide valuable opportunities for

easy and regular access to a restorative natural environment. As well as being beneficial for those with little or no access to natural environments, more broadly, this extends to the wider population in general who are exposed to increasingly stressful and urbanised lives. A greater understanding of people's responses to different exhibit characteristics may be especially important as certain animals or behaviours may prove particularly relaxing, uplifting or stimulating to watch. This information may be vital when trying to establish the 'optimum' exhibit for other environments, such as a stressful workplace or a healthcare setting.

In today's increasingly stressful world, quick and easy access to restorative environments that promote positive emotions and help reduce stress may be extremely important. Greater contact with nature, in whatever setting, however, may provide more than human health and well-being benefits. Connecting people to the marine environment and its species may lead to a better understanding and appreciation of the benefits of natural environments and help increase motivations to conserve and protect species and habitats in the wild.

Appendices

Appendix A:

Species List for Stage 2 (Partially stocked) & Stage 3 (Fully stocked) conditions

STAGE 2							
Class	**Order**	**Family**	**Genus**	**Species**	**Common name**	**Nos. of individuals added**	**Total no. of individuals**
Malacostraca	Decapoda	Cancridae	*Cancer*	*pagurus*	Edible crab	6	6
Malacostraca	Decapoda	Majoidae	*Maja*	*squinado*	Spiny spider crab	8	8
Actinopterygii	Anguilliformes	Congridae	*Conger*	*conger*	Conger eel	3	3
Actinopterygii	Mugiliformes	Mugilidae	*Chelon*	*labrosus*	Grey mullet	34	34
Actinopterygii	Perciformes	Carangidae	*Trachurus*	*trachurus*	Scad	11	11
Actinopterygii	Pleuronectiformes	Pleuronectidae	*Platichthys*	*flesus*	Flounder	3	3
Actinopterygii	Pleuronectiformes	Pleuronectidae	*Pleuronectes*	*platessa*	Plaice	1	1
Elasmobranchii	Carcharhiniformes	Scyliorhinidae	*Scyliorhinus*	*canicula*	Lesser spotted dogfish	18	18
Elasmobranchii	Carcharhiniformes	Scyliorhinidae	*Scyliorhinus*	*stellaris*	Bull Huss	7	7
Elasmobranchii	Carcharhiniformes	Triakae	*Mustelus*	*asterias*	Starry smoothhound	1	1
Elasmobranchii	Rajiformes	Rajidae	*Raja*	*microocellata*	Small eyed ray	1	1
Elasmobranchii	Rajiformes	Rajidae	*Raja*	*undulata*	Undulate ray	1	1
							94

STAGE 3							
Class	**Order**	**Family**	**Genus**	**Species**	**Common name**	**Nos. of individuals added**	**Total no. of individuals**
Malacostraca	Decapoda	Cancridae	*Cancer*	*pagurus*	Edible crab	0	5 (1 mortality)
Malacostraca	Decapoda	Majoidae	*Maja*	*squinado*	Spiny spider crab	0	5 (3 mortalities)
Malacostraca	Decapoda	Palinuridae	*Palinurus*	*elephas*	Spiny lobster	3	3
Actinopterygii	Anguilliformes	Congridae	*Conger*	*conger*	Conger eel	2	5
Actinopterygii	Gadiformes	Lotidae	*Gaidropsarus*	*mediterraneus*	Shore rockling	1	1
Actinopterygii	Mugiliformes	Mugilidae	*Chelon*	*labrosus*	Grey mullet	8	42
Actinopterygii	Perciformes	Carangidae	*Trachurus*	*trachurus*	Scad	0	11
Actinopterygii	Perciformes	Labridae	*Ctenolabrus*	*rupestris*	Goldsinny	1	1
Actinopterygii	Perciformes	Labridae	*Labrus*	*bergylta*	Ballan wrasse	17	17
Actinopterygii	Perciformes	Labridae	*Symphodus*	*melops*	Corkwing wrasse	8	8
Actinopterygii	Perciformes	Polyprionidae	*Polyprion*	*americanus*	Wreckfish	1	1
Actinopterygii	Pleuronectiformes	Pleuronectidae	*Platichthys*	*flesus*	Flounder	0	3
Actinopterygii	Pleuronectiformes	Pleuronectidae	*Pleuronectes*	*platessa*	Plaice	0	2 (1 mortality)
Actinopterygii	Pleuronectiformes	Scophthalmidae	*Scopthhalmus*	*maximus*	Turbot	7	7
Actinopterygii	Pleuronectiformes	Scophthalmidae	*Scophthalmus*	*rhombus*	Brill	1	1
Actinopterygii	Scorpaeniformes	Triglidae	*Chelidonichthys*	*lucernus*	Tub gurnard	1	1
Elasmobranchii	Carcharhiniformes	Scyliorhinidae	*Scyliorhinus*	*canicula*	Lesser spotted dogfish	0	18
Elasmobranchii	Carcharhiniformes	Scyliorhinidae	*Scyliorhinus*	*stellaris*	Bull Huss	2	9
Elasmobranchii	Carcharhiniformes	Triakae	*Mustelus*	*asterias*	Starry smoothhound	0	1
Elasmobranchii	Rajiformes	Rajidae	*Raja*	*clavata*	Thornback ray	0	4
Elasmobranchii	Rajiformes	Rajidae	*Raja*	*microocellata*	Small eyed ray	4	5
Elasmobranchii	Rajiformes	Rajidae	*Raja*	*undulata*	Undulate ray	0	1
							151

Appendix B

Example of Anagram Task

Participant ID_____

Anagram response sheet

Please write your answer in the appropriate space next to the anagram.

1. ESTS……..……..
2. CKOS…….
3. TURFI……
4. VERSEDION…….....
5. DEBRIG…….
6. SWNREA……
7. TCELIRAPUTA…….
8. MARERMOTGH……
9. VETIIFUG……..
10. NIACUSEOT……..
11. LANAIINRIPOST……..
12. TAHEREN……
13. RISECET…….
14. GEIDLH……
15. HISTELR……..
16. ALLRGON…….
17. ACANSETIF…….
18. EETMAID……
19. PEISHLTE…….
20. EYEHLR……
21. CEENRYEGM……
22. COMEPR……
23. ARSKEM…….
24. HREAFTS……
25. ICCIRMOSCC…….
26. OLINUES……
27. RPECACI……
28. AINNTRTSO……
29. TAESSIG……
30. OFFCITTECN……
31. CLADIR……..
32. DNOEIG……
33. AIPTLRA……
34. PPSORALP……
35. OLWGFNA…….
36. TRNTHEGS……
37. IUTRUKE…….....
38. OSLURDEH…….
39. DEDTGYIA……
40. POELJNETA……

SCRIBBLE PAD

Appendix C:

Activation-Deactivation Adjective Checklist (AD ACL): Explanation for Participants

Mood Scale 1

Brief: You will be presented with a list of words. Each word describes feelings or mood.

Please use the rating scale next to each word to describe your feelings at this moment.

Here is an example:

relaxed	**3**	2	1	0	If you circle number **3** it means that you *definitely* feel relaxed *at the moment*.
relaxed	3	**2**	1	0	If you circle number **2** it means that you feel *slightly* relaxed *at the moment.*
relaxed	3	2	**1**	0	If you circle number **1** it means that the word does not apply or you cannot decide if you feel relaxed *at the moment.*
relaxed	3	2	1	**0**	If you circle **0** it means that you are *definitely not* relaxed *at the moment.*

Please circle the most appropriate number that corresponds to how you feel.

Work rapidly, but please respond to all the words. Your first reaction is best.

This should take only a minute or two.

Appendix D:

Paperwork Recording Participants' Responses

Mood Scales – Time 2	Participant No.

Mood Scale 1

Brief: You will be presented with a list of words. Each word describes feelings or mood. Please use the rating scale next to each word to describe your feelings at this moment.

Please circle the most appropriate number that corresponds to how you feel.

Work rapidly, but please respond to all the words. Your first reaction is best.

This should take only a minute or two.

	definitely do not feel	cannot decide	feel slightly	definitely feel
Active	0	1	2	3
Nervy	0	1	2	3
Placid	0	1	2	3
Wide-awake	0	1	2	3
Drowsy	0	1	2	3
Tense	0	1	2	3
Tired	0	1	2	3
Fearful	0	1	2	3
Lively	0	1	2	3
Intense	0	1	2	3
Sleepy	0	1	2	3
Vigorous	0	1	2	3
Calm	0	1	2	3
Energetic	0	1	2	3
Wakeful	0	1	2	3
Quiet	0	1	2	3
Still	0	1	2	3
Anxious	0	1	2	3
Full of vitality	0	1	2	3
At rest	0	1	2	3

Mood Scale 2

Brief: This scale has been designed to record the mood you are currently feeling.

Please indicate how you are feeling, right now, by circling the most appropriate number.

Very bad		Bad		Fairly bad	Neutral	Fairly good		Good		Very good
-5	-4	-3	-2	-1	0	1	2	3	4	5

Mood Scale 3

Brief: This scale has been designed to record how aroused you actually feel. Do this by circling the appropriate number.

By “arousal” we mean how “worked-up” you feel.

You might experience high arousal in one of a variety of ways, for example as excitement or anxiety or anger.

Low arousal might also be experienced by you in one of a number of different ways, for example as relaxation or boredom or calmness.

Low arousal						**High arousal**
0	1	2	3	4	5	6

Mood Scales – Time 3	Participant No.

Mood Scale 2

Brief: This scale has been designed to record the mood you are currently feeling.

Please indicate how you are feeling, right now, by circling the most appropriate number.

Very bad		Bad		Fairly bad	Neutral	Fairly good		Good		Very good
-5	-4	-3	-2	-1	0	1	2	3	4	5

Mood Scale 3

Brief: This scale has been designed to record how aroused you actually feel. Do this by circling the appropriate number.

By "arousal" we mean how "worked-up" you feel.

You might experience high arousal in one of a variety of ways, for example as excitement or anxiety or anger.

Low arousal might also be experienced by you in one of a number of different ways, for example as relaxation or boredom or calmness.

Low arousal						**High arousal**
0	1	2	3	4	5	6

Time Perception

Brief: We are interested in knowing how long you think you have been watching the tank.

Please indicate how many minutes you think you have been watching the tank by circling one of the numbers below.

Number of minutes observing the tank																							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

Mood Scales – Time 4

Participant No.

Time Perception

Brief: We are interested in knowing how long you think you have been watching the tank.

Please indicate how many minutes you think you have been watching the tank IN TOTAL by circling one of the numbers below.

Number of minutes observing the tank IN TOTAL																								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

Mood Scale 1

Brief: You will be presented with a list of words. Each word describes feelings or mood. Please use the rating scale next to each word to describe your feelings at this moment.

Please circle the most appropriate number that corresponds to how you feel.
Work rapidly, but please respond to all the words. Your first reaction is best.
This should take only a minute or two.

	definitely do not feel	cannot decide	feel slightly	definitely feel
Drowsy	0	1	2	3
Energetic	0	1	2	3
Intense	0	1	2	3
Quiet	0	1	2	3
Full of vitality	0	1	2	3
Placid	0	1	2	3
Active	0	1	2	3
Tired	0	1	2	3
Calm	0	1	2	3
Wakeful	0	1	2	3
Still	0	1	2	3
Lively	0	1	2	3
Sleepy	0	1	2	3
Nervy	0	1	2	3
Fearful	0	1	2	3
Wide-awake	0	1	2	3
Anxious	0	1	2	3
At-rest	0	1	2	3
Vigorous	0	1	2	3
Tense	0	1	2	3

Mood Scale 2

Brief: This scale has been designed to record the mood you are currently feeling.

Please indicate how you are feeling, right now, by circling the most appropriate number.

Very bad		Bad		Fairly bad	Neutral	Fairly good		Good		Very good
-5	-4	-3	-2	-1	0	1	2	3	4	5

Mood Scale 3

Brief: This scale has been designed to record how aroused you actually feel. Do this by circling the appropriate number.

By “arousal” we mean how “worked-up” you feel.

You might experience high arousal in one of a variety of ways, for example as excitement or anxiety or anger.

Low arousal might also be experienced by you in one of a number of different ways, for example as relaxation or boredom or calmness.

Low arousal						**High arousal**
0	1	2	3	4	5	6

Evaluation

Brief: These scales are designed to record how you feel about today's activity. Please respond to the following five statements by circling the most appropriate response.

1. I enjoyed watching this tank

Not at all						**Very much**
0	1	2	3	4	5	6

2. I would be happy to watch this tank again

Not at all						**Very much**
0	1	2	3	4	5	6

3. I feel better after watching this tank

Not at all						**Very much**
0	1	2	3	4	5	6

4. I found watching this tank

Very boring	**Boring**	**Slightly boring**	**Neither boring nor interesting**	**Slightly interesting**	**Interesting**	**Very interesting**
1	2	3	4	5	6	7

5. I would have been happy to watch this tank for another

5 mins	10 mins	15 mins	20 mins

Appendix E:

Field Notes: Observation Sheet

Date					
Time					
Participant Nos.					
No. of Visitors (T1)	Low (0-10)	Low-Med (11-20)	Med (21-35)	Med-High (36-50)	High (50+)
Level of Noise	Low (silence or low conversation)		Medium		High (screaming child)
No. of Visitors (T2)	Low (0-10)	Low-Med (11-20)	Med (21-35)	Med-High (36-50)	High (50+)
Level of Noise	Low (silence or low conversation)		Medium		High (screaming child)
No. of Visitors (T3)	Low (0-10)	Low-Med (11-20)	Med (21-35)	Med-High (36-50)	High (50+)
Level of Noise	Low (silence or low conversation)		Medium		High (screaming child)
No. of Visitors (T4)	Low (0-10)	Low-Med (11-20)	Med (21-35)	Med-High (36-50)	High (50+)
Level of Noise	Low (silence or low conversation)		Medium		High (screaming child)
Tank description					
Comments					

Appendix F:

Study 5 – Questionnaire (Visitors)

PARTICIPANT I.D._ _ _ _ _ EXHIBIT _ _ _ _ _ _ DATE _ _ _ _ TIME _ _ _

We are interested in hearing people's opinions about our exhibits.

We would like to ask you two quick questions before showing you one of our exhibits and then asking a few more questions.

1. Your mood

Please indicate how you are feeling, right now, by circling the most appropriate number on the two scales below.

(a)

Very sad										Very happy
-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5

(b)

Very calm										Very excited
-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5

Please let the researcher know that you've finished this section. You will now be shown to an exhibit.

You should now have watched the exhibit for about five minutes. Below are a few more questions about how you feel and what you saw.

2. Your mood again

Please indicate how you are feeling, right now, by circling the most appropriate number on the scales below.

(a)

Very sad										Very happy
-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5

(b)

Very calm										Very excited
-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5

3. What's in the exhibit?

a) In this next section are questions about what you saw in the exhibit.

Our Question	Your Answer
How many different types of fish do you think you saw in the exhibit?	_ _ _ _ _ _ _ _ _ species of fish.
How many individual fish do you think are in the exhibit?	_ _ _ _ _ _ fish.
Which species of fish do you like best? (You can ask the researcher for their names)	
Which species of fish most catches your eye? (You can ask the researcher for their names)	
Did you notice any particular fish behaviours?	
Other than fish, was there anything else in the exhibit that caught your attention?	

b) "Biological diversity" is made up of (i) the number of different kinds of animals there are, and (ii) how many individuals of each different kind there are. Based on this, how much biodiversity do you think is in this exhibit, on a scale of 1 to 10? Please circle the most appropriate answer.

Extremely LOW biodiversity									Extremely HIGH biodiversity
1	2	3	4	5	6	7	8	9	10

4. Your thoughts on the exhibit

We'd like to know a bit more about what you think of this exhibit and how it makes you feel. Please indicate how much you agree with each statement about this exhibit.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
There is much to discover in this exhibit.	☐	☐	☐	☐	☐
I feel peaceful when I am in front of this exhibit.	☐	☐	☐	☐	☐
This exhibit is unique.	☐	☐	☐	☐	☐
I feel happy when I am watching this exhibit.	☐	☐	☐	☐	☐
When I am at this exhibit I feel free from my daily routine.	☐	☐	☐	☐	☐
Watching this exhibit clears my head.	☐	☐	☐	☐	☐
Everything I see in this exhibit goes well together.	☐	☐	☐	☐	☐
I do not gain pleasure from this exhibit.	☐	☐	☐	☐	☐
There are many things in this exhibit that attract my attention effortlessly.	☐	☐	☐	☐	☐
I do not feel calm when I watch this exhibit.	☐	☐	☐	☐	☐
This exhibit is not novel.	☐	☐	☐	☐	☐
I like this exhibit.	☐	☐	☐	☐	☐
At this exhibit I can forget about my obligations.	☐	☐	☐	☐	☐
Watching this exhibit makes me feel more connected to nature.	☐	☐	☐	☐	☐
Everything I see in this exhibit fits there.	☐	☐	☐	☐	☐
I am not satisfied with this exhibit.	☐	☐	☐	☐	☐
This exhibit is a good place to relax.	☐	☐	☐	☐	☐

5. Your marine wildlife knowledge

(a) How much do you think you know about marine animals compared to the average person of your age and gender? Do you think you'd be better or worse than other people at naming fish from pictures of them? On the scale below rate how you think you compare to others.

I think my knowledge of marine wildlife is…

Well below average		Average		Well above average
☐	☐	☐	☐	☐

(b) On the table in front of you is a sheet with pictures of 10 marine species on it. Please attempt to name the species in the numbered boxes below. If you're not sure of a species then feel free to guess its name or leave the box empty.

Picture number	Species name	Picture number	Species name
1		6	
2		7	
3		8	
4		9	
5		10	

6. A bit about yourself

Almost there! To finish we would like to know a little about you and your visiting habits to our aquarium. All your answers are kept anonymous and confidential, but please feel free to pass questions you are not comfortable answering.

1. How many times have you visited this Aquarium?	_ _ _ _ _ _ times

2. Overall, how often do you visit aquariums (this aquarium or any other)? Please circle the statement that most applies.

Weekly	More than once a month	Once a month
Once every 2 – 3 months	Once every 6 – 9 months	Once a year
Once in 2 – 5 years	Once every 5 years or more	This is my first visit to an aquarium

3. Are you a member of this Aquarium?	Yes	No
4. Do you have a Day Plus Pass ticket?	Yes	No
5. Where have you travelled from today? (Please tell us just the first half of your postcode e.g. PL9)	_ _ _ _ _ _ _ _ _	

6. Who have you come with today? (Please circle the statement that most applies)

On my own	With a partner	With my children	With a partner and my children
With a friend(s)	With a large group	Other (please specify) _ _ _ _ _ _ _ _	

7. What is your gender? (please circle)	Male	Female
8. In what year were you born? _ _ _ _ _ _ _		

Thanks again for taking part - it's greatly appreciated. We hope to improve the experience for future visitors using the information you've provided. The researcher will be happy to answer any questions you may have. Have a good visit!

Appendix G:

Additional Information: Marine Life Preferences and Other Exhibit Observations (Studies 5 and 6)

1.0 Measures

In order to gain some additional information on how participants felt about the animals they were viewing, the following questions were asked:

a) Which species of fish do you like best?

b) Which species of fish most catches your eye?

c) Do you notice any particular fish behaviours?

d) Other than fish, was there anything else in the exhibit that caught your attention?

2.0 Results

Table 1. Study 5: most frequently preferred animals, observed behaviours and non-fish exhibit contents

Question	Exhibit viewed (Low stocking level)		Exhibit viewed (High stocking level)	
	Temperate	**Tropical**	**Temperate**	**Tropical**
1. Which species of fish do you like best?	Rays	No overall preferences noted	Rays, small sharks	Rays
2. Which species of fish most catches your eye?	Rays	Wrasse	Rays, small sharks	Rays
3. Do you notice any particular fish behaviours?	Ray behaviours, shoaling	Shoaling	Calm, resting behaviours	Shoaling
4. Other than fish, was there anything else in the exhibit that caught your attention?	Exhibit decoration (e.g. artificial seaweed, corals), crabs	Exhibit decoration (artificial corals)	Exhibit decoration (e.g. artificial seaweed, corals)	Turtle

Table 2. Study 6: most frequently preferred animals, observed behaviours and non-fish exhibit contents

Question	Exhibit viewed first (High stocking level)		Exhibit viewed second (High stocking level)	
	Temperate	**Tropical**	**Temperate**	**Tropical**
1. Which species of fish do you like best?	Rays, flatfish	Rays	Rays, red gurnard, flatfish	Rays, yellow bar angelfish, oriental sweetlips
2. Which species of fish most catches your eye?	Red gurnard	Rays	Red gurnard, rays	Yellow bar angelfish, rays, oriental sweetlips
3. Do you notice any particular fish behaviours?	Fish coming up to the glass	Shoaling	Hiding, sleeping, resting	Shoaling
4. Other than fish, was there anything else in the exhibit that caught your attention?	Exhibit decoration	Turtle, exhibit decoration (artificial corals)	Exhibit decoration	Turtle, exhibit decoration (artificial corals)

3. Summary of Findings and Discussion

People's preferences for different animals were quite consistent. Across both studies, when species of ray (*Raja* spp.) were present they were, by far, the most frequently mention fish species when participants stated which fish they liked best. In Study 5 - High stocking level condition, rays were participants' overall favourite fish, mentioned by 52% of visitors viewing the Tropical exhibit and 21% of visitors in the Temperate exhibit (although small sharks were the most liked fish in this instance, mentioned by 25% of visitors). In the Low stocking level condition rays were only present in the Temperate exhibit and, on this occasion, were mentioned by 50% of visitors.

Rays were also the fish most likely to catch people's eye: in the High stocking level condition they were mentioned by 48% of participants who viewed the Tropical

exhibit and 46% of participants who viewed the Temperate exhibit. In the Low stocking level condition, rays were mentioned by 54% of participants watching the Temperate exhibit. When not present (Tropical exhibit – Low stocking level condition only) there appeared to be no overall strong preference for a particular species; species noted in Table 1 (Qu.1) were mentioned by similar number of participants each.

Ray behaviour' was also one of the most frequently noted behaviours, in addition to shoaling. Interestingly, for the Temperate exhibit, 'calm' behaviours (e.g. 'calm movement', 'sleeping', 'resting') were most frequently mentioned, potentially supporting the female participant's comment mentioned earlier (Section 4.4.2. The turtle was only present in the Tropical High stocking level condition in Study 5 but was mentioned by 48% of participants.

In Study 6, the rays also dominated participants' responses: they were the species of fish liked best and most noticed (although the single red gurnard present in the Temperate exhibit was also frequently mentioned, quite possibly because of its bright red colour and its habit of spending much of its time in a highly visible location at the front of the Temperate exhibit). Again, shoaling was the most consistently noticed behaviour in the Tropical exhibit, whereas in the Temperate exhibit, participants were again most likely to comment on less active fish behaviours such as hiding, resting and 'sleeping', probably as there were fewer shoaling species in this exhibit. The turtle, present in the Tropical exhibit (except the Low stocking level condition) caught people's attention most, followed by exhibit decoration, such as artificial corals and seaweed. Interestingly, despite the overall preference for Tropical exhibits in this study, and generally throughout this thesis, the one study in which neither the turtle nor the rays were present in the Tropical exhibit (Low stocking level condition only), resulted in this exhibit being rated lower on perceived restorative potential than the Temperate exhibit.

Appendix H:

Species Identification Task

1.

2.

3.

4.

5.

6.

7.

8.

9.

10.

Appendix I:

Study 6 – Questionnaire (Students/Paid Participants)

We are interested in hearing people's opinions about our exhibits.

We would like to ask you two quick questions before showing you to one of our exhibits and then asking a few more questions.

1. Your mood

Please indicate how you are feeling, right now, by circling the most appropriate number on the two scales below.

(a)

Very sad										Very happy
-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5

(b)

Very calm										Very excited
-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5

Please let the researcher know that you've finished this section. You will now be shown to the first exhibit.

You should now have watched the exhibit for about five minutes. Below are a few more questions about how you feel and what you saw.

2. Your mood again

Please indicate how you are feeling, right now, by circling the most appropriate number on the two scales below.

(a)

Very sad										Very happy
-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5

(b)

Very calm										Very excited
-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5

3. What's in the exhibit?

a) In this next section are questions about what you saw in this exhibit.

Our Question	Your Answer
How many different types of fish do you think you saw in the exhibit?	_ _ _ _ _ _ _ _ _ types (species) of fish.
How many individual fish do you think are in the exhibit?	_ _ _ _ _ _ fish.
Which species of fish do you like best? (You can ask the researcher for their names)	
Which species of fish most catches your eye? (You can ask the researcher for their names)	
Did you notice any particular fish behaviours?	
Other than fish, was there anything else in the exhibit that caught your attention?	

b) In this exhibit the "Biological diversity" is made up of (i) the number of different kinds of marine animals there are, and (ii) how many individuals of each different kind there are. Based on this, how much biodiversity do you think is in this tank, on a scale of 1 to 10? Please circle the most appropriate answer.

Extremely LOW biodiversity									Extremely HIGH biodiversity
1	2	3	4	5	6	7	8	9	10

4. Your thoughts on the exhibit

We'd like to know a bit more about what you think of this exhibit and how it makes you feel. Please indicate how much you agree with each statement about this exhibit.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
There is much to discover in this exhibit.	☐	☐	☐	☐	☐
I feel peaceful when I am in front of this exhibit.	☐	☐	☐	☐	☐
This exhibit is unique.	☐	☐	☐	☐	☐
I feel happy when I am watching this exhibit.	☐	☐	☐	☐	☐
When I am at this exhibit I feel free from my daily routine.	☐	☐	☐	☐	☐
Watching this exhibit clears my head.	☐	☐	☐	☐	☐
Everything I see in this exhibit goes well together.	☐	☐	☐	☐	☐
I do not gain pleasure from this exhibit.	☐	☐	☐	☐	☐
There are many things in this exhibit that attract my attention effortlessly.	☐	☐	☐	☐	☐
I do not feel calm when I watch this exhibit.	☐	☐	☐	☐	☐
This exhibit is not novel.	☐	☐	☐	☐	☐
I like this exhibit.	☐	☐	☐	☐	☐
At this exhibit I can forget about my obligations.	☐	☐	☐	☐	☐
Watching this exhibit makes me feel more connected to nature.	☐	☐	☐	☐	☐
Everything I see in this exhibit fits there.	☐	☐	☐	☐	☐
I am not satisfied with this exhibit.	☐	☐	☐	☐	☐
This exhibit is a good place to relax.	☐	☐	☐	☐	☐

We will now head to the next exhibit but before you see the exhibit we'd just like to ask about your mood again.

5. Your mood

Please indicate how you are feeling, right now, by circling the most appropriate number on the two scales below.

(a)

Very sad										Very happy
-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5

(b)

Very calm										Very excited
-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5

Please let the researcher know that you've finished this section. You will now be shown to the next exhibit.

You should now have watched the exhibit for about five minutes. Below are a few more questions about how you feel and what you saw.

6. Your mood again

Please indicate how you are feeling, right now, by circling the most appropriate number on the two scales below.

(a)

Very sad										Very happy
-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5

(b)

Very calm										Very excited
-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5

7. What's in the exhibit?

a) In this next section are questions about what you saw in this exhibit.

Our Question	Your Answer
How many different types of fish do you think you saw in the exhibit?	_ _ _ _ _ _ _ _ _ types (species) of fish.
How many individual fish do you think are in the exhibit?	_ _ _ _ _ _ fish.
Which species of fish do you like best? (You can ask the researcher for their names)	
Which species of fish most catches your eye? (You can ask the researcher for their names)	
Did you notice any particular fish behaviours?	
Other than fish, was there anything else in the exhibit that caught your attention?	

b) In this exhibit, the "Biological diversity" is made up of (i) the number of different kinds of marine animals there are, and (ii) how many individuals of each different kind there are. Based on this, how much biodiversity do you think is in this tank, on a scale of 1 to 10? Please circle the most appropriate answer.

Extremely LOW biodiversity									Extremely HIGH biodiversity
1	2	3	4	5	6	7	8	9	10

c) How to you think the biodiversity of this exhibit compares to the *first* exhibit that you saw? Please tick the most appropriate answer.

	Much LOWER biodiversity			About the same biodiversity			Much HIGHER biodiversity
Compared to the first exhibit, I think this exhibit has...	☐	☐	☐	☐	☐	☐	☐

8. Your thoughts on the exhibit

We'd like to know a bit more about what you think of this exhibit and how it makes you feel. Please indicate how much you agree with each statement about this exhibit.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
There is much to discover in this exhibit.	☐	☐	☐	☐	☐
I feel peaceful when I am in front of this exhibit.	☐	☐	☐	☐	☐
This exhibit is unique.	☐	☐	☐	☐	☐
I feel happy when I am watching this exhibit.	☐	☐	☐	☐	☐
When I am at this exhibit I feel free from my daily routine.	☐	☐	☐	☐	☐
Watching this exhibit clears my head.	☐	☐	☐	☐	☐
Everything I see in this exhibit goes well together.	☐	☐	☐	☐	☐
I do not gain pleasure from this exhibit.	☐	☐	☐	☐	☐
There are many things in this exhibit that attract my attention effortlessly.	☐	☐	☐	☐	☐
I do not feel calm when I watch this exhibit.	☐	☐	☐	☐	☐
This exhibit is not novel.	☐	☐	☐	☐	☐
I like this exhibit.	☐	☐	☐	☐	☐
At this exhibit I can forget about my obligations.	☐	☐	☐	☐	☐
Watching this exhibit makes me feel more connected to nature.	☐	☐	☐	☐	☐
Everything I see in this exhibit fits there.	☐	☐	☐	☐	☐
I am not satisfied with this exhibit.	☐	☐	☐	☐	☐
This exhibit is a good place to relax.	☐	☐	☐	☐	☐

9. Your marine wildlife knowledge

(a) How much do you think you know about marine animals compared to the average person of your age and gender? Do you think you'd be better or worse than other people at naming fish from pictures of them? On the scale below rate how you think you compare to others?

I think my knowledge of marine wildlife is…

Well below average		Average		Well above average
☐	☐	☐	☐	☐

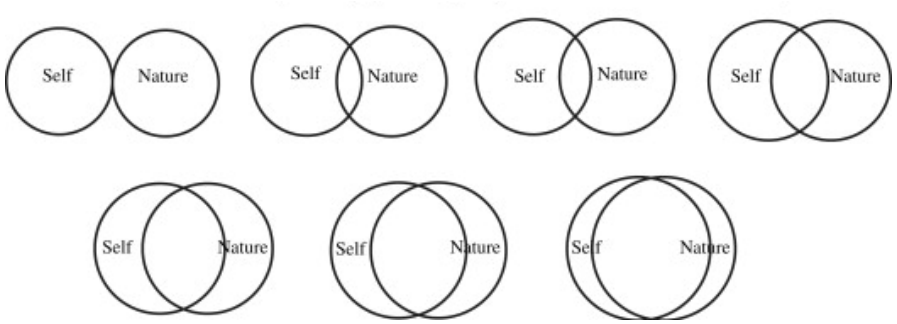
(b) On the table in front of you is a sheet with pictures of 10 marine species on it. Please attempt to name the species in the numbered boxes below. If you're not sure of a species then feel free to guess its name or leave the box empty.

Picture number	Species name	Picture number	Species name
1		6	
2		7	
3		8	
4		9	
5		10	

10. Your Values

We'd just like to ask a few questions about your values and how you see your relationship with nature.

(a) Please circle the picture that best describes how you see your relationship with the natural environment. How interconnected are you with nature?



(b) People around the world are generally concerned about environmental problems because of the consequences that result from harming nature. However, people differ in the consequences that concern them the most.

Please rate each of the following items from 1 (not important) to 7 (supreme importance) in response to the following question:

I am concerned about environmental problems because of the consequences for……

	Not important						Supreme importance
Plants	1	2	3	4	5	6	7
Me	1	2	3	4	5	6	7
People in my country	1	2	3	4	5	6	7
Marine life	1	2	3	4	5	6	7
My lifestyle	1	2	3	4	5	6	7
All people	1	2	3	4	5	6	7
Birds	1	2	3	4	5	6	7
My health	1	2	3	4	5	6	7
Children	1	2	3	4	5	6	7
Animals	1	2	3	4	5	6	7
My future	1	2	3	4	5	6	7
My children	1	2	3	4	5	6	7

11. Finally, a bit about yourself

To finish we would like to know a little about you and your visiting habits to our Aquarium.

1. How many times have you visited this Aquarium (including today)?	_ _ _ _ _ _ times

2. Overall, how often do you visit aquariums (this aquarium or any other)? Please circle the statement that most applies.

Weekly	More than once a month	Once a month
Once every 2 – 3 months	Once every 6 – 9 months	Once a year
Once in 2 – 5 years	Once every 5 years or more	This is my first visit to an aquarium

3. Are you a member of this Aquarium?	Yes	No
4. Do you have a Day Plus Pass ticket?	Yes	No
5. What is your gender? (please circle)	Male	Female

6. In what year were you born? _ _ _ _ _ _ _

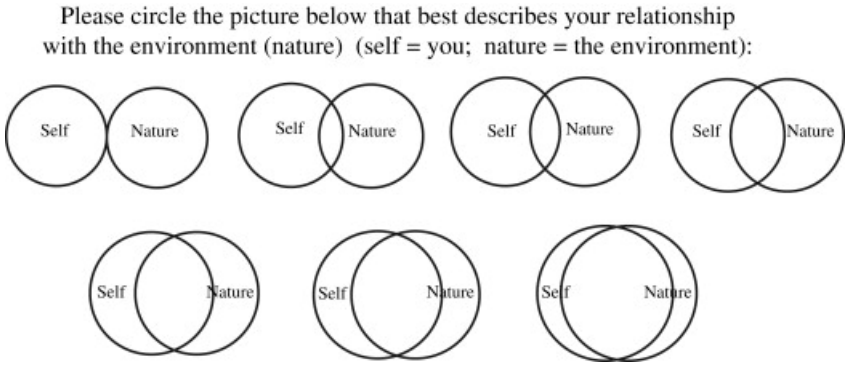
Thanks again for taking part - it's greatly appreciated.

Appendix J:

Additional Information: Participants' Relationship with Nature and Their Environmental Concerns (Study 6 only)

1.0 Measures

a) Please circle the picture that best describes how you see your relationship with the natural environment. How interconnected are you with nature?



b) People around the world are generally concerned about environmental problems because of the consequences that result from harming nature. However, people differ in the consequences that concern them the most.

Please rate each of the following items from 1 (Not important) to 7 (Supreme importance), in response to the following statement:

I am concerned about environmental problems because of the consequences for……

	Not important						Supreme importance
Plants	1	2	3	4	5	6	7
Me	1	2	3	4	5	6	7
People in my country	1	2	3	4	5	6	7
Marine life	1	2	3	4	5	6	7
My lifestyle	1	2	3	4	5	6	7
All people	1	2	3	4	5	6	7
Birds	1	2	3	4	5	6	7
My health	1	2	3	4	5	6	7
Children	1	2	3	4	5	6	7
Animals	1	2	3	4	5	6	7
My future	1	2	3	4	5	6	7
My children	1	2	3	4	5	6	7

Item (a) was the “Inclusion of Nature in Self” (INS) measure. It is a single item graphical scale (Schultz, 2001), designed to measure the extent to which an individual includes nature as part of their identity. This measure uses seven pairs of circles where one circle is labelled ‘Self’ and the other circle is labelled ‘Nature’. The circle pair with the least overlap (scored as 1) represents a person who sees his or herself as separate from nature, whereas the circles the most overlap (scored as 7) represents an individual who views him or herself as the same as nature.

Item (b), measured an individual's attitudes to "Environmental Concern" (Schultz, 2000). Participants were asked to rate 12 items that represented three different 'types' of concern: "Egoistic" (Me, My health, My lifestyle, My future), "Altruistic" (All people, Children, My children, People in my country), and "Biospheric" (Plants, Marine life, Animals, Birds).

2.0 Results

The overall INS score was 4.55, which was only just above the mid-point on the 7-point scale. This suggested that the participants did not strongly view nature as being part of their identity. Nevertheless, their scores for "Environmental Concern" were greatest for Biospheric (M = 5.74, SD = .777) and Altruistic (M = 5.57, SD = .90) items, and less for Egoistic items (M = 4.94, SD = 1.21). A one way ANOVA revealed no significant gender differences (all ps $> .4$). Paired samples t-tests found a significant difference between Altruistic vs. Egoistic concern, $t(59) = 5.35$, $p < .001$, and Biospheric vs. Egoistic concern $t(59) = 4.13$, $p < .001$. There was no significant difference between Biospheric vs. Altruistic concern $t(59) = 1.10$, $p = .276$).

Correlations between the INS and Environmental Concern found only two significant, positive correlations: INS and Biospheric concerns, $r(60)= .46$, $p < .001$; Altruistic and Egoistic concerns, $r(60) = .66$, $p < .001$. There was a marginal, negative relationship between INS and Egoistic concerns $r(60) = -.236$, $p = .070$.

3.0 Summary of findings and Discussion

Although participants did not appear to identify themselves as having a particularly strong relationship with nature on the INS scale, they nevertheless exhibited significantly greater concern for Biospheric and Altruistic factors than Egoistic factors.

Appendix K.

World Association of Zoos and Aquariums (WAZA):

Code of Ethics and Animal Welfare

The Code of Ethics and Animal Welfare was prepared on the basis of the 1999 Code of Ethics and the 2002 Code of Animal Welfare. It was adopted at the 58th Annual Conference of WAZA on 19 November 2003 in San José (Costa Rica).

Principles

- Assisting in achieving the conservation and survival of species must be the aim of all members of the profession. Any actions taken in relation to an individual animal, e.g. euthanasia or contraception, must be undertaken with this higher ideal of species survival in mind, but the welfare of the individual animal should not be compromised.
- Promote the interests of wildlife conservation, biodiversity and animal welfare to colleagues and to society at large.
- Co-operate with the wider conservation community including wildlife agencies, conservation organisations and research institutions to assist in maintaining global biodiversity.
- Co-operate with governments and other appropriate bodies to improve standards of animal welfare and ensure the welfare of all animals in our care.
- Encourage research and dissemination of achievements and results in appropriate publications and forums.
- Deal fairly with members in the dissemination of professional information and advice.
- Promote public education programmes and cultural recreational activities of zoos and aquariums.
- Work progressively towards achieving all professional guidelines established by the WAZA.

http://www.waza.org/en/site/conservation/animal-welfare-1439197763/code-of-ethics-and-animal-welfare. Downloaded 5 April 2016

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Do Preferences for Waterscapes Persist in Inclement Weather and Extend to Sub-aquatic Scenes?

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ABSTRACT *Water is often a feature of preferred landscapes. Three experimental studies explored possible boundary conditions and extensions of this finding. Study 1 examined the role of weather and found that landscape preferences were moderated by climatic conditions. While waterscape preferences were significantly higher under clement than inclement conditions, urban/built landscape preferences were unaffected. Studies 2a and 2b explored reactions to sub-aquatic compared to above the waterline views, using colour and monochrome images respectively. In both cases, reactions to sub-aquatic scenes were broadly similar to those of green space. Findings are discussed in terms of possible evolutionary, cultural and personal mechanisms.*

KEY WORDS: waterscapes, preferences, perceived restorativeness, weather, sub-aquatic environments

1. Introduction

1.1. Overview

It has long been recognised that people often prefer, or respond especially positively to, landscapes containing water elements such as rivers, lakes and the coast (e.g. Hubbard & Kimball, 1967; Kaplan & Kaplan, 1989; Ulrich, 1983; Zube, 1974). However, boundary conditions have also been observed. For instance, the amount of water in a scene (Schafer & Brush, 1977) as well as water type (Herzog, 1985), quality (Wilson *et al*., 1995) and clarity (Nasar & Minhui Li, 2004) have all been shown to moderate preferences for waterscapes. The current research builds on this line of enquiry in two ways.

First, we investigate whether weather might also moderate waterscape preferences. Experimental evidence of higher preferences for waterscapes is based largely on ratings of photographs and other visual stimuli where the background weather was clement

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(i.e. pleasant, sunny, blue skies, etc., e.g. Han, 2007; Ulrich, 1981). The issue of weather may be particularly important for waterscapes because clement weather is generally associated with warmer temperatures and waterscapes may be especially attractive under these conditions perhaps due to their cooling function, positive associations with holiday experiences or simply a greater presence of the colour blue (Palmer & Schloss, 2010). Under inclement conditions with cloudy overcast skies and rain, waterscapes may be less preferred than terrestrial landscapes due, for instance, to an increased probability that an individual might find themselves in a threatening or unpleasant situation (e.g. exposure to flooding; Ulrich, 1983, p. 104). That is, waterscapes may be more compatible with an individual's aims, and thus be preferred, under the kind of clement weather conditions used in the majority of previous research. Study 1 explores this issue.

Our second aim was to examine an aspect of waterscapes rarely explored in the landscape literature, namely sub-aquatic waterscapes. There are at least two reasons why the underwater world is of interest. First, many millions of individuals reveal a preference for them by learning to dive (PADI, 2011) and recreating them in the form of aquaria (Gusset & Dick, 2011). What we don't know, however, is how sub-aquatic waterscapes are rated compared to terrestrial and normal waterscape views. Second, simulated and virtual sub-aquatic landscapes (e.g. aquaria/images) have been used in a variety of medical and care settings to reduce stress (Edwards & Beck, 2002; Katcher *et al*., 1984; Schneider *et al*., 2003). However, again, we know little regarding relative preferences for these environments compared to more traditional scenes and landscapes. Study 2a is, as far as we are aware, the first study to compare preferences for above and below the surface waterscapes alongside terrestrial urban and green environments. Moreover, Study 2b showed a different set of participants the same images, but converted into monochrome grey scale to rule out potential colour effects which may arise from viewing a systematically different colour spectrum while looking at sub-aquatic scenes.

1.2. Preferences for Waterscapes

Evidence supporting the notion that people like and respond positively to waterscapes is extensive and longstanding. Consequently, rather than attempt to review this literature here, we focus on several key studies which illustrate the effect using different approaches or which controlled for important potential confounds. Preferences for waterscapes were already well documented in the 1970s. Schafer & Brush (1977), for example, concluded after assessing preferences using people's ratings of photographic images that "water in combination with forest vegetation... strongly enhances scenic quality" (p. 255). More recent studies using a similar approach and controlling for factors such as biome type, image openness and complexity (Han, 2007), and landscape composition and content (White *et al*., 2010) report similar effects. Indeed, such is the magnitude of the effect some studies comparing urban and natural environments chose to exclude images of waterscapes to avoid biasing conclusions in favour of natural scenes (e.g. Herzog *et al*., 2003; Williams & Cary, 2002). For reasons discussed below, it is noteworthy that while most recent photo rating studies use colour images, the conclusions of Schafer and Brush were based on ratings of black and white photographs.

Ulrich (1981) extended this work by measuring individuals' moods and physiological states before and after they were presented with collections of colour photographs of

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different types of environment. Rather than getting individuals to rate individual scenes in order to derive stated preferences, the key dependent variables were instead changes in states over time following exposure to different landscapes. Using this approach, and consistent with people's stated preferences, he showed that only the natural scenes with water led to significant reductions in negative emotions such as sadness and fear over the test period, when compared to viewing urban scenes. Natural scenes without water were not significantly different from urban scenes. Intriguingly, later work by the same research team (Ulrich *et al*., 1991) collapsed the analysis of reactions to natural videos with or without water, claiming that no differences were found during preliminary analysis. Notable differences of this latter study with his earlier work included a stress induction task (a video of workplace accidents) and the use of a video of a single natural landscape or waterscape, rather than a range of images of different landscapes.

Stated preferences for waterscapes and positive changes in mood following exposure to waterscapes have also been found outside of the laboratory. For example, among a large sample of Finnish residents, Korpela and colleagues (2010) demonstrated that local waterscapes such as beaches and harbours were among the most preferred places for experiencing restoration (e.g. greater feelings of calmness). Moreover, reviewing evidence across 10 separate studies, Barton & Pretty (2010) found that people tended to show greater elevations in positive mood and self-esteem following visits to natural environments with significant aquatic elements.

Finally, revealed preferences, that is, those that can be observed without asking people, show a similar pattern. For instance, houses prices are generally higher near aquatic areas in several countries including the US (Kildow, 2007), the Netherlands (Luttik, 2000) and the UK (at least for freshwater areas, UK NEA, 2011, table 22.13). Similarly, a study of hotels in Zurich, Switzerland found that rooms with views onto the lake commanded higher prices than similar rooms with views of woodlands (Lange & Schaeffer, 2001). In short, the balance of evidence from studies of stated preferences, revealed preferences and changes in mood, and in both laboratory and field settings suggests that waterscapes are particularly valued.

Despite widespread support for this conclusion moderating effects have been found. For instance, Schafer & Brush (1977) also noted that "if water occupies a proportionately large section of the scene, it detracts from the quality of that scene" (p. 255; see also White *et al*., 2010). Herzog (1985) also noted that not all waterscapes are equal. Specifically, a factor analysis of student preferences for 70 colour waterscape photographs suggested four key types: 'mountain waterscapes', 'swampy areas', 'rivers lakes and ponds' and 'large bodies of water' (chiefly the Great Lakes). Preferences were consistently highest for mountain waterscapes and consistently lowest for swampy areas.

Wilson and colleagues (1995) went a step further by systematically manipulating the content of the same waterscape images by adding or subtracting key features (e.g. replacing a seagull with a tyre) to investigate the effect of 'dirty water' on preferences. As predicted various forms of contamination significantly decreased waterscape preferences, potentially reflecting people's innate wariness of contaminated, non-potable water. Finally, Nasar & Minhui Li (2004) constructed four model waterscapes, systematically altering key visual cues. Of relevance here, the authors found higher preferences for waterscapes with black bottoms that provided substantial reflection than sand-bottomed models, with little reflection. However, it should be noted that the model ponds contained no flora or fauna and it seems plausible that people may have reacted more

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positively to a transparent pond containing aquatic plants or fish (see below). In short, although much of the landscape preference literature suggests that waterscapes may be particularly liked, a number of moderating features have been found. The aim of our first study was to explore a further potential moderator, namely weather.

1.3. The Weather

As noted above the majority of studies ask about preferences of landscapes in clement weather (e.g. Han, 2007; Ulrich, 1981; White *et al*., 2010). Kaltenborn & Bjerke (2002) are fairly typical in stating that "we sought to secure reliability by selecting pictures with roughly the same weather and light conditions... and which give a similar impression in types of colours and seasons, that is pictures from approximately mid-summer" (p. 4). Moreover, this bias towards clement weather is also present in studies that measure changes in restoration following exposure to (not necessarily aquatic) natural versus urban environments using photographs (e.g. Hartig & Staats, 2006), videos (e.g. Laumann *et al*., 2003) or field visits (Nisbett & Zelensky, 2011). Keeping the weather constant across conditions makes sense, and fine weather may be particularly important for field experiments. This may, however, have a differential impact on preferences for different landscapes.

Waterscapes, for instance, may be particularly preferred under clement conditions because they offer the opportunity to cool the observer down, both in terms of direct immersion and cooler temperatures near large bodies of waters. A study by Hipp & Ogunseitan (2010) adds some support to this suggestion. These authors found that trips to Californian beaches were perceived as more restorative, in terms of "being away", on sunnier than cloudier days and indeed millions of people around the world head for the coast in the hottest months of the year (Smith, 1993). Further, Herzog (1985) argues that it is 'calm water' that is perceived as more restorative, and calm water is more likely in fine weather (Herzog & Bosley, 1992).

By contrast, preferences for waterscapes may be more affected by poor weather than urban environments because they offer fewer opportunities for warmth and shelter. In a study of Zurich exercisers, for instance, Hug *et al*. (2009) found significantly more instances of exercise indoors than outdoors during the winter sampling period (average temperatures between 3 and 6°C) even though participants rated outdoor environments as more restorative and both locations the same in terms of health benefits and barriers. Zurich is a particularly interesting case study because, as the authors acknowledge, all participants in their sample had ready access to a river path and Lake Zurich is a central feature of the town with parks on either side.

Nevertheless, an alternative possibility exists, namely that preferences for waterscapes continue to exist even in poor weather conditions. Work by Brown & Daniel (1991; Hetherington *et al*., 1993) suggests, for instance, that rivers are perceived as most attractive when there is a moderate level of flow, that is, not too calm and not too fast. Since moderate flow levels are associated with higher rain fall or snow melt, as well as gradient, river width and so forth, their data suggest preferences for aquatic scenes may be quite robust to climatic conditions. Further, Zuckerman *et al*., (1993) found that stormy aquatic paintings such as Constable's 'Seascape with Clouds' are particularly attractive, at least for high sensation-seekers. As long as one is physically safe, it may be quite exhilarating and even restorative, to watch a storm at sea or a torrent of water

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in a downpour. The aim of the first study was to investigate these possibilities by asking people about their preferences for land and waterscapes displayed under both clement and inclement weather conditions.

1.4. Sub-aquatic Waterscapes

Our second and third studies focus on a very different aspect of waterscapes; what lies beneath the surface. We know that many people are interested in these sub-aquatic waterscapes because they are willing to pay to experience them in captivity (i.e. public and private aquaria) and in the wild, through diving, snorkelling and glass-bottom boats. In 2010, for instance, there were an estimated 700 million visits to aquaria worldwide (Gusset & Dick, 2011) and in the UK the Professional Association of Diving Instructors issued nearly a million diving certifications (PADI, 2011). We suggest these preferences emerge from intrinsic fascination and are thus potentially restorative (Packer & Bond, 2010).

According to Kaplan & Kaplan's (1989) attention restoration theory (ART), the restorative quality of natural environments derives from their ability to offer "soft fascination", which captures people's attention in an effortless 'bottom-up' rather than 'top-down' manner, allowing executive systems that regulate directed attention to rest (Kaplan, 1995; also Berman *et al*., 2008). Clearly, sub-aquatic environments have this potential, if visibility is good, there is high biodiversity and there are no immediate threats. Indeed a large aquarium is probably more likely to be able to guarantee these features than many dive sites. ART identifies three additional features of environments that can help the switch from voluntary (effortful, directed) attention to involuntary (effortless) attention and facilitate restoration, namely 'being away', 'extent' and 'compatibility'. Being away reflects the feeling that one is away from everyday, familiar and mundane settings and clearly this is true for sub-aquatic environments for most people. Second, extent refers to an environment that is coherent and structured rather than chaotic and disjointed. Again sub-aquatic eco-systems, especially in large aquarium exhibits and popular dive sites are likely to be coherent and structured environments. Compatibility refers to the notion that an environment fits with an individual's specific goals and clearly people who deliberately dive, snorkel, visit or build their own aquarium are deliberately engaging in goal congruent behaviour. Thus there seems good reason to think that sub-aquatic environments may be restorative and thus show high preference ratings (given the strong relationship between perceived restorativeness and preferences, e.g. Purcell *et al*., 2001).

A second reason why we think that preferences for sub-aquatic environments are worth exploring is their increasing use in medical and care settings. Edwards & Beck (2002), for instance, found that providing an aquarium in a dining room used by older people with Alzheimer's was associated with a significant increase in food consumption. This is important because a loss of appetite and weight is common among people with dementia. The authors claim that the aquarium had a calming effect which enabled individuals to relax and eat more. In a very different context, Schneider *et al*. (2003) presented a virtual reality sub-aquatic environment to women undergoing breast cancer treatment. The authors found some evidence of a positive drop in anxiety (although the sample size was small) and a significant drop in awareness of time passing during the unpleasant chemotherapy procedures. Finally, Katcher *et al*. (1984) found that participants who were instructed to contemplate an aquarium before dental surgery

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experienced greater relaxation and reduced anxiety than other conditions such as sitting quietly in a chair. In short, across several different settings, viewing or considering sub-aquatic landscapes had a calming restorative function in line with the above theorising concerning their potentially restorative properties. To date however, we know of no study which has attempted to compare preferences for, or the perceived restorativeness of, sub-aquatic scenes with other more traditional above the waterline scenes.

Of course, individual differences are possible. Many members of the population may find sub-aquatic landscapes claustrophobic or intimidating especially if they can't swim, visibility is poor or they, quite reasonably, fear currents or predators. For these individuals, or in these contexts, sub-aquatic waterscapes may be anything but restorative and preferences for them may be low. Certainly, in terms of evolutionary theories of landscape preferences (e.g. Appleton, 1975; Orians & Heerwagen, 1992) we are not ideally suited to sub-aquatic environments, being unable to swim well underwater or for long periods of time. Nevertheless, we do have several physiological adaptations which enable us to swim better than any other primate suggesting that we may have spent a significant proportion of our evolutionary history in and around the aquatic margins, perhaps due to the rich variety of food available (Hardy, 1960). Thus it seems possible that humans may have some residual preference for sub-aquatic waterscapes because attraction to these waterscapes once provided adaptive advantages.

Study 2a begins to address this issue by asking individuals to state their preferences for and perceived restorativeness of sub-aquatic scenes alongside more familiar urban, rural and aquatic landscapes. Given that familiarity with sub-aquatic scenes may be important, approximately half of our sample consisted of self-identified recreational 'divers'. Thus a subsidiary question was whether those with diving experience would show higher preferences for sub-aquatic scenes.

Finally, given that the sub-aquatic colour photographs used in Study 2a tended to have high levels of the colour blue in them, we conducted a third study, 2b, with the same images converted to a monochrome grey scale. As noted above, earlier work found similar landscape preferences using both black and white and colour photographs, so we were not expecting the patterns of the two studies to differ. Nonetheless, it was important to rule out the colour effect of sub-aquatic scenes since work by Palmer and Schloss (2010; Schloss & Palmer, 2011) suggests that blue is the most preferred colour, even when fully decontextualised, and thus preferences for aquatic environments, including sub-aquatic ones, may, in theory, reflect this more general colour preference. Of course the colour of water—as we perceive it—depends on many features including the colour of the sky, water calmness, depth, sediment load, the nature of the ground under the water and the presence of aquatic flora (e.g. weed or algal blooms). Thus, just because water is present, does not necessarily increase the amount of blue in a scene. Nonetheless, Study 2b ruled out any potential confound by only showing the images in black and white.

In sum, we explored the potential moderating effect of weather conditions on land and waterscape preferences in Study 1 and preferences for sub-aquatic waterscapes in Studies 2a (colour) and 2b (monochrome). Given a lack of relevant prior research, and potentially competing influences, we had no clear predictions as to whether relative preferences for waterscapes may be reduced in poor weather or would be relatively unaffected or how sub-aquatic waterscape preferences would fair relative to more traditional views.

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2. Study 1: Weather

2.1. Introduction

Study 1 explored the role of weather on preferences for different landscapes. In much past research, landscapes have been shown/visited 'at their best', that is, under clement conditions. The current study controls for this by presenting urban and rural landscapes and waterscapes under both clement and inclement conditions.

2.2. Method

2.2.1. Development of Photo Sets

The study used 72 colour photographs, 24 of each of three landscapes: urban/built scenes dominated by buildings and constructions (e.g. roads); rural/green scenes dominated by fields and woodlands; and 'natural' waterscapes containing rivers, lakes and the coast. Views reflected eye-level perspective and included similar scenic width and depth. Half of the images of each landscape were characterised by clement weather conditions whilst half were characterised by inclement conditions. Image content was controlled such that three of each landscape set contained people, three contained animals, three contained man-made objects (e.g. cars/boats) and three were scene only (Figure 1; see White *et al*., 2010).

2.2.2. Participants

Participants were 27 undergraduate students (23 females, M_{age} = 20.3 years) at a UK university who took part for course credit.

2.2.3. Design and procedure

All participants saw all images in a fully repeated measures design. On arriving at the testing labs participants were briefed and informed of the confidentiality of their answers and their right to withdraw. If happy to continue they were seated in front of a monitor (42 cm x 27 cm) roughly 60 cm away with the centre at eye-level. Participants read an introductory passage outlining the task, before conducting four practice trials. The photographs took up roughly 75% of the screen and were shown against a black background. Questions appeared below the image in sequence. Only after a response was made to the first question (via computer keyboard) was it replaced with the second. Image order was randomised for each participant. After the final rating participants were debriefed and thanked.

2.2.4. Measures

Preferences were measured using an item adapted from Herzog (1985): 'How much do you like this scene for whatever reason?' with responses on a scale from Not at all (1) to Extremely (10). Perceived restorative potential was measured using a single item adapted from Herzog *et al*. (1997; see also Felsten, 2009): 'Overall, to what extent do you think that this scene would be excellent for restoring your ability to concentrate or work effectively on a demanding project?' The response scale was from Not at all (1)

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Figure 1. Example scenes of different landscapes in different weather (Study 1).

to Extremely (10). Though significant, the correlation between the two items was moderate, $r = .43$, $p = .026$.[2]

2.3. Results and Discussion

Responses to all 24 images of each landscape type were collapsed (Figure 2). Results for each dependent variable were then examined using a 3 (Landscape: urban/rural/water) x 2 (Weather: clement/inclement) repeated measures ANOVA. Concerning preferences, there were significant main effects of environment $F(2, 52) = 135.86$, $p <$

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.001, η^2 = .71 and weather $F(1, 26) = 6.49$, $p = .017$, $\eta^2 = .02$. Consistent with previous research, waterscapes were most preferred followed by rural and urban landscapes (*Ms*, 7.44, 5.91, 3.72; *ps* < .001). Clement images were preferred to inclement ones (*M*s = 5.96 vs 5.42). Crucially for the potentially moderating effect of weather, there was also a significant interaction between landscape type and weather $F(2, 52) = 6.97$, $p = .002$, $\eta^2 = .01$ (Figure 2). Simple effects analyses found that preferences were significantly lower in poor than clement weather for both waterscapes $F(1, 26) = 13.31$, $p = .001$ and rural/green landscapes $F(1, 26) = 5.16$, $p = .032$, but not urban/built landscapes $F(1, 26) = .43$, $p = .52$. Moreover, contrast analyses suggested this drop in waterscape preferences across weather conditions was significantly greater than the drop for either rural/green landscapes $F(1, 26) = 12.80$, $p = .001$, and urban/built landscapes $F(1, 26) = 11.75$, $p = .002$. In other words, waterscapes were the most affected by weather and urban/built were not statistically affected at all.

In terms of perceived restorative potential, there were again significant main effects for landscape type $F(2, 52) = 82.25$, $p < .001$, $\eta^1 = .55$, and weather, $F(1, 26) = 23.23$, $p < .001$, $\eta^2 = .10$. As with preferences, waterscapes were seen as the most restorative followed by rural and urban landscapes (*Ms* 5.78, 5.07, 2.72; *ps* < .01) while clement images were rated as more restorative than inclement ones (*Ms* = 5.09 vs 3.97). Crucially, the interaction was again significant $F(2, 52) = 8.95$, $p < .001$, $\eta^2 = .01$ (Figure 2). This time simple effects analyses found that perceived restorativeness was significantly lower in poor than clement weather for waterscapes $F(1, 26) = 27.20$, $p < .001$, rural/green landscapes $F(1, 26) = 12.80$, $p = .001$, and urban/built landscapes $F(1, 26) = 10.79$, $p = .003$. Importantly though, and as with preferences, contrast analyses suggested the drop in the perceived restorativeness of waterscapes across weather types was significantly greater than the drop for either rural/green landscapes $F(1, 26) = 9.41$, $p = .005$ or urban/built landscapes $F(1, 26) = 18.28$, $p < .001$. Again, then, waterscapes were the most affected by weather.

In summary, Study 1 replicated earlier findings that waterscapes are preferred and perceived as more restorative than rural and urban landscapes without water in clement weather. Moreover, this rank order of preferences was replicated in inclement weather. Nonetheless, the significant interactions between landscape type and weather for preferences and perceived restorative potential suggested that waterscapes were the most negatively affected by poorer weather. That urban landscape preferences (though not

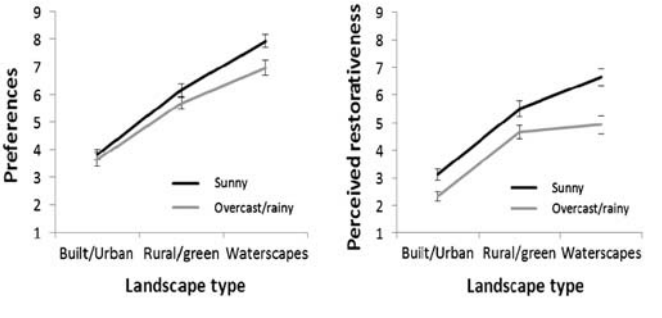

Figure 2. Means and standard errors for preferences and perceived restorativeness as a function of landscape type and weather (Study 1).

perceived restorativeness) were unaffected by weather is intriguing and supports the notion that these environments have the advantage of offering shelter in bad weather. Although findings from this single study are far from definitive, results suggest the need for greater consideration of climatic conditions in future research. Before returning to this issue in the general discussion, we now turn to our second theme, sub-aquatic waterscapes.

3. Study 2a: Sub-aquatic Waterscapes

The aim of Study 2a was to investigate preferences, perceived restorativeness of and affective responses to, sub-aquatic waterscapes in relation to the more widely investigated urban and rural landscapes and waterscapes seen from above the waterline.

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3.1. Development of Photo Sets

Participants were presented with 50 colour photographs, including 10 from each of the same three landscape categories as Study 1 (i.e. urban/rural/water). These landscape scenes showed clement weather (since for a study of sub-aquatic environments weather conditions are less relevant). Also, as with Study 1, each of the 10 images included the same number of images containing animals (2/10), people (2/10), man-made objects (e.g. cars, boats, 2/10) or were scene-only (4/10). Because sub-aquatic environments were the key interest they were over-represented with 20 images. These 20 images were selected by the second author, an expert in underwater environments, as representative of fauna and flora found in temperate seas, with many images around the UK coast (and thus commensurate with the above the waterline scenes, Figure 3). Sub-aquatic scenes also contained the same ratio of photographs including animals (4/20), people (i.e. divers, 4/20), man-made objects (e.g. pipelines/wrecks, 4/20) or were scene only (8/20).

3.2. Method

3.2.1. Participants

Participants (N = 77) were students at a UK university who participated for course credit (61 females, M_{age} = 21.5 years). Nearly half (N = 36) said they had been snorkelling, free or scuba diving.

3.2.2. Design and procedure

The procedure was similar to Study 1. The main differences were that participants now answered four questions about each photograph and after the final rating answered three further questions about diving experiences.

3.2.3. Measures

Although the perceived restorativeness question was the same as Study 1, the generic preference item was ‘How pleasant do you rate this scene?’, with responses ranging from Not at all (1) to Extremely (10). Following White *et al.* (2010), an additional

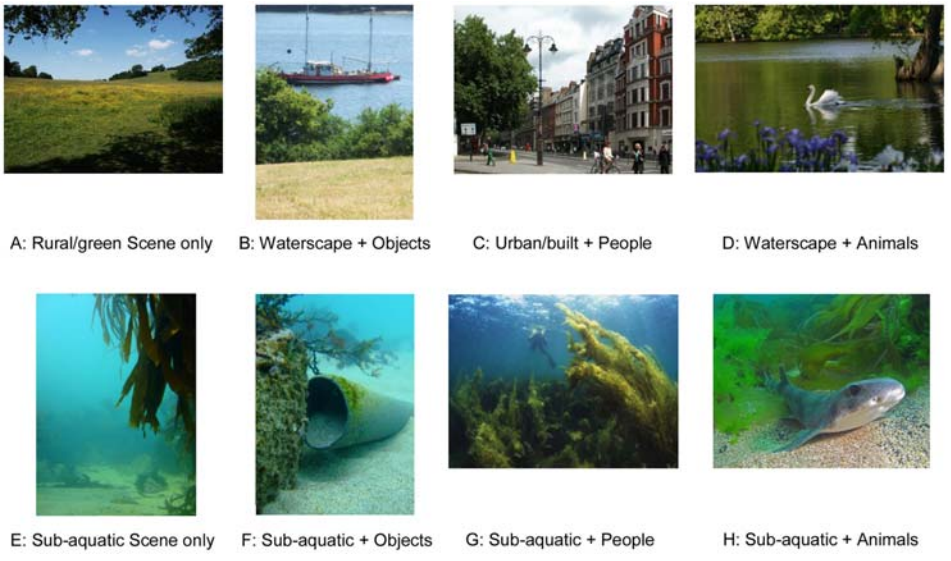

Figure 3. Example scenes of different land and waterscapes including sub-aquatic (Study 2).

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behavioural preference measure was added along with a measure of affective response. Specifically, participants were asked 'How willing would you be to hang this picture in your room?' with responses from Not at all (1) to Extremely (10) and 'How does this photo make you feel?' from Very Sad (1) to Very Happy (10).

At the end of the study participants were asked 'Have you ever snorkelled, free dived or scuba dived?' If they responded 'yes' they were asked 'What best describes the majority of your snorkelling, free diving or Scuba diving experience?' and 'What sort of snorkelling, free diving or Scuba diving do you prefer?' with response options for both questions being: mostly cool water/temperate; mostly warm water/tropical; mixture of both. Of those with diving/snorkelling experience, 58% said mostly tropical, 25% temperature and 17% a mixture of both. In terms of preferences the order was 72% tropical, 6% temperate and 22% both.

3.3. Results and discussion

Again responses to all images of each land/waterscape type were collapsed. Results were explored using a series of one-way repeated measure ANOVAs (Table 1). Landscapes were entered, based on a pre-screening of means, in the order from the lowest (urban/built) to the highest (waterscape) means. This enabled us to use repeated contrasts to compare the significance between adjacently ranked landscapes.

The main effect of landscape type was highly significant for aesthetic preferences, $F(3, 228) = 245.72$, $p < .001$, $\eta^2 = .76$, willingness to display $F(3, 228) = 210.85$, $p <. 001$, $\eta^2 = .74$, affect, $F(3, 228) = 205.52$, $p < .001$, $\eta^2 = .73$ and perceived restorativeness, $F(3, 228) = 198.49$, $p < .001$, $\eta^2 = .72$. Supporting Study 1 and most previous research, urban/built landscapes were rated significantly lower on all four

dimensions than rural/green landscapes (all *ps* < .001). Further, responses to waterscapes were more positive on all four dimensions than rural/green landscapes (all *ps* < .001). More importantly for present concerns, reactions to sub-aquatic waterscapes were, overall, highly similar to rural/green landscapes. Although respondents were marginally more willing to display sub-aquatic than rural landscapes in their rooms ($p = .053$), affective reactions were more positive to rural than sub-aquatic images ($p < .01$). There were no significant differences for either aesthetic preferences or perceived restorativeness between rural/green and sub-aquatic landscapes. For all variables, sub-aquatic scenes rated significantly higher than built/urban landscapes and significantly lower than normal waterscapes (Table 1).

Preliminary analysis as a function of sub-aquatic familiarity (i.e. divers/non-divers) revealed no differences in responses to any of the three normal landscape types. Of more interest was the possibility that responses to sub-aquatic waterscapes might be affected. To investigate this we conducted four independent samples *t*-tests comparing participants with vs without sub-aquatic experience. There were no significant differences between the two groups for preferences, display willingness or perceived restorativeness (all *ps* > .16). Nevertheless, divers/snorkellers ($M = 6.14$) did report more positive affective responses than non-divers ($M = 5.60$) to the sub-aquatic scenes $t(75) = 2.01$, $p = .048$. Further analysis suggested that preferences for and familiarity with different sub-aquatic environments (i.e. temperate vs tropical) among divers were unimportant.

The findings replicate the majority of earlier work showing greater preferences and perceived restorativeness of waterscapes over rural and urban landscapes without water. More importantly, reactions to the novel sub-aquatic waterscape images were most similar to rural/green landscapes and thus generally less positive than above the waterline waterscapes. Reactions to sub-aquatic images did not seem to be a function of familiarity because only affect was slightly higher for divers/snorkellers vs non-divers.

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Table 1. Means (*M*) and standard deviations (SD) for preferences, willingness to display, affective valence and perceived restorativeness as a function of landscape type and image colour (Studies 2a & 2b)

	Preferences		Display willingness		Affect		Restor-ativeness	
Landscape type	*M*	(SD)	*M*	(SD)	*M*	(SD)	*M*	(SD)
Study 2a: Colour images								
Urban/built	3.50[a]	(1.22)	2.36[a]	(1.03)	3.98[a]	(1.18)	2.95[a]	(1.18)
Sub-aquatic	6.15[b]	(1.44)	4.88[b]	(1.60)	5.85[b]	(1.18)	5.10[b]	(1.35)
Rural/green	6.41[b]	(1.33)	4.50[b]	(1.57)	6.22[c]	(1.17)	5.22[b]	(1.37)
Waterscape	7.84[c]	(1.04)	6.68[c]	(1.65)	7.44[d]	(1.03)	6.53[c]	(1.38)
Study 2b: Black & white								
Urban/built	3.82[a]	(1.31)	2.93[a]	(1.29)	4.13[a]	(1.09)	3.43[a]	(1.41)
Sub-aquatic	5.57[b]	(1.48)	4.62[b]	(1.84)	5.57[b]	(1.23)	4.96[b]	(1.46)
Rural/green	6.09[c]	(1.35)	4.53[b]	(1.43)	5.91[b]	(1.21)	5.27[b]	(1.23)
Waterscape	7.02[d]	(1.29)	5.62[c]	(1.59)	6.64[c]	(1.16)	6.10[c]	(1.24)

Notes: Both studies used identical images. Column means within the same study with different superscripts are significantly different ($p < .05$). All scales from 1–10; see text for anchors.

To check that these findings were not due to colour *per se* (Palmer & Schloss, 2010) we replicated the current study using monochrome grey scale images of the exact same scenes. If the amount of blue in the scenes was important we would expect preferences for both above and below the surface waterscapes to drop relative to the other two landscape types.

4. Study 2b: Monochrome Images

4.1. Method

Participants ($N = 32$) were recruited via a UK university participant pool and paid £4 to take part (19 females, $M_{age} = 26.81$ years). The pool includes university students, staff and members of the public. The design, procedure and materials were identical to Study 2a with the exception that all images were presented in monochrome grey scale.

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4.2. Results and Discussion

The analysis strategy was identical to Study 2a (Table 1). Again the main effect of landscape type was highly significant for preferences, $F(3, 93) = 57.49$, $p < .001$, $\eta^2 = .65$, willingness to display $F(3, 93) = 37.87$, $p < .001$, $\eta^2 = .55$, affect, $F(3, 93) = 50.68$, $p < .001$, $\eta^2 = .62$ and perceived restorativeness, $F(3, 93) = 43.01$, $p < .001$, $\eta^2 = .58$. Built/urban landscapes were again rated significantly lower on all four dimensions than rural/green ones (all $ps < .001$) and, in turn, waterscapes continued to result in significantly more positive responses to rural/green on all four dimensions (all $ps < .001$). Responses to sub-aquatic waterscapes were again most similar to rural/green landscapes with, this time, significantly greater aesthetic preferences for rural/green than sub-aquatic landscapes ($p < .05$). In short, the lack of colour had very little influence on the findings compared to Study 2a suggesting that these findings were not due to the particular array of colours in the photographs, but perhaps the conative meanings associated with the different land and waterscapes.

5. General Discussion

5.1. Summary of Main Findings

The present studies extended previous research into land and waterscape preferences by investigating different weather and adding sub-aquatic scenes. Study 1 investigated whether landscape preferences might be moderated by weather by presenting participants with colour photographs of waterscapes, rural/green landscapes and urban/built landscapes under both clement and inclement conditions. Replicating earlier work (for overviews see Hubbard & Kimball, 1967; Kaplan & Kaplan, 1989; Ulrich, 1983) waterscapes were the most preferred, and urban/built the least preferred landscape type under clement conditions. Although this order was maintained under inclement conditions, weather did significantly moderate preferences. Specifically, although waterscapes, and to some extent rural/green landscapes, were significantly less preferred in poor weather, preferences for urban/built landscapes were unaltered. A similar pattern of results emerged for perceived restorativeness although waterscapes were now similar to green space and the difference between urban environments under different weather

conditions was significant. Crucially, however, weather had a larger effect on reactions to waterscapes than the other two landscapes.

Study 2 investigated reactions to sub-aquatic landscapes, a novel consideration for landscape research but potentially important given popular interest in these environments (Gusset & Dick, 2011) and their use in medical and care settings (Edwards & Beck, 2002; Katcher *et al*., 1984; Schneider *et al*., 2003). Study 2a used colour images and Study 2b used monochrome images to control for the potentially confounding role of colour (Palmer & Schloss, 2010). Both studies found very similar results with responses to sub-aquatic landscapes being more positive than urban/built landscapes but less positive than above the surface waterscapes. Broadly speaking, sub-aquatic scenes were rated similarly to rural/green landscapes, with little difference as a function of sub-aquatic familiarity (i.e. snorkelling/diving experience). That sub-aquatic scenes were rated similarly to rural/green landscapes in terms of preferences (stated and willingness to hang the image up), affective responses and perceived restoration is especially intriguing in terms of underlying explanations (see below).

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5.2. Possible Explanations

Three basic findings emerged from the research: a) a generally positive response to waterscapes; b) a greater impact of weather conditions on responses to waterscapes than other landscapes; and c) responses to sub-aquatic environments that were very similar to rural/green landscapes. What could account for this collection of results? In attempting to answer this question we draw on Bourassa's (1990) distinction between biological, cultural and personal explanations for landscape preferences. Drawing on Vygotsky's theory of child development and existential psychiatry, Bourassa (1990) argued that preferences, including landscape preferences, are complex and can involve innate aspects reflecting underlying evolutionary mechanisms, culturally acquired aspects learnt through acculturation and personal aspects reflecting an individual's unique learning history.

In terms of biological/evolutionary perspectives, several authors have argued that landscape preferences reflect deep-seated responses to environments that aided the survival of our ancestors (Appleton, 1975; Kellert & Wilson, 1993; Orians & Heerwagen, 1992). Van den Berg *et al*. (2003), for instance, suggest that "environmental preference is determined by environmental properties that possess a potential functional significance for the perceiver" (p. 136). That is, a positive emotio-cognitive response which increases the probability of an approach, rather than avoidance, behaviour is an adaptive reaction to an environment which could aid our survival and chances of reproducing. Importantly, for present concerns, this theorising has also been applied to preferences for waterscapes, "perhaps part of the appeal of water is biologically based and largely independent of informational characteristics and learned associations" (Ulrich, 1983, p.105). Why aquatic environments in particular?

Renowned marine biologist Sir Alistair Hardy (1960) suggested that one reason may have been competition for food among early hominids: "my thesis is that a branch of... primitive ape-stock was forced by competition from life in the trees to life on the seashores and to hunt for food, shell-fish, sea urchins etc. in the shallow waters off the coast" (p. 642). He supports his thesis by observing that we are the only ape that can hold our breath and swim underwater and that we have a layer of subcutaneous fat, like

seals, that could help us retain body heat in cool waters. Moreover, he suggests the ability to stand upright may have arisen from our need to wade in the shallows in search of food where the water's buoyancy could help support the evolution of our upright posture.

Hardy's theory may help explain not just preferences for waterscapes in general but the findings from Studies 2a and 2b that preferences for sub-aquatic environments were at least as strong as rural/green terrestrial landscapes. If preferences for terrestrial green spaces such as savannah-like parklands reflect the amount of time we spent in these environments during our evolutionary history, the current findings seem to offer some tentative support for the notion that we may also have spent part of our evolutionary history in and around aquatic margins, perhaps swimming underwater, in order to catch fish and other seafood.

Evolutionary mechanisms may also help account for the moderating effect of weather. Many mammals seek aquatic environments in hot, sunny weather both to drink and bathe and it is possible this was shared by early hominids. Even in modern times coastal tourism is highest in the warmest months (Smith, 1993) and coastal visits are perceived as more restorative when it is sunny (Hipp & Ogunseitan, 2010). Clearly these suggestions are speculative and Hardy's theory has received both support (e.g. Ellis, 1993; Morgan, 1997) and criticism (e.g. Langdon, 1997; Pagel & Bodmer, 2003). One thing that is becoming increasingly apparent, however, is that the coastal margins are, as Hardy suggested, particularly rich in biodiversity and a variety of other ecosystem services (Martinez *et al*., 2007), which could have aided our ancestors' survival.

In terms of possible cultural accounts for our findings, Solomon (2010) argues that aquatic environments have been a major part of all ancient and modern societies. Not only were they important for freshwater and a direct source of food but as people began to settle into farming communities they needed to harness rivers, both for irrigation purposes and power (e.g. watermills). Thus, over millennia we may have learnt to value waterscapes based on their conative meanings, which perhaps we learn as children through rich cultural heritages. As Parkes & Horwitz (2009) put it, "water is arguably human society's principal natural resource and its distribution and abundance lies at the basis of human settlement" (p. 96). Consequently, this affiliation with aquatic environments has resulted in them being, "meaningful for everything from physiology to spirituality" (p. 96).

A cultural account could also, conceivably, help explain our findings that aquatic environments were particularly preferred under clement weather conditions. Specifically, the trend towards using aquatic environments to promote health in the UK only began in the second half of the eighteenth century with marine hospitals being established in Margate (1796) and Scarborough (1812), as the "invigorating effects of sea-air and bathing became generally recognized" (Fortescue Fox & Lloyd, 1938, p. 37). Before this 'recognition', the sea was perceived by many as a place of danger and to be avoided and only in the Victorian era did it become a 'healthy' destination to be enjoyed first by the wealthy, and later in the 1930s by the masses when paid holidays for workers were introduced. As Fortescue Fox & Lloyd (1938) point out these worker vacations to the coast have traditionally occurred during the summer months and they suggest this may be because this is the time of year when "nature is at her best, and human nature begins to rebel against confinement in the cities" (p. 38). The implication is that the cooling effect of the coast has innate intrinsic value, as suggested from a bio-

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logical/evolutionary perspective, but it is also possible that the "veritable summer exodus to the seaside" (p. 38) became a cultural phenomenon over time and people now have positive associations between clement weather conditions and aquatic environments. Intriguingly migration to the coast is now more substantial than merely a seasonal phenomenon. In 1990 30% of the world's population lived near the coast, today it is 41% and predicted to rise (Martinez *et al*., 2007). Cultural factors such as the growth in international trade and the associated need for industries to have access to shipping may be influencing these trends which in turn influence perceptions of waterscapes more generally.

In terms of the importance of personal/individual factors, there is a growing body of evidence suggesting that higher preferences for nature in adulthood are related to positive childhood experiences in natural environments (Louv, 2005; Muñoz, 2009; Ward Thomson *et al*., 2008; Wells & Lekies, 2006). That is, at least some of the variance in adult preferences may be due to individual learning histories. Importantly for current arguments, adults' memories of favourite natural settings while they were children are often of aquatic locations (Waite, 2009). This may be because they provide intrinsically enjoyable environments for children to play in (Pitt, 1989) and/or because they are associated with pleasant memories of positive experiences with parents and other family members. A recent survey by the UK heritage and environment charity, the National Trust, which owns and manages some 720 miles of the UK coast, found that people's favourite stretches of coastline were ones that their family had strong ties to or had visited for generations (Dyke, 2012). Waterscape preferences may thus have a component of family learning and history. It is also easy to imagine that good/bad individual experiences of aquatic and sub-aquatic landscapes, even as adults, could influence preferences. A drowning scare or jellyfish sting could conceivably lower an individual's preference for sub-aquatic scenes. Positive experiences of coral reef diving are likely to have the opposite effect.

Perhaps the main message is that, as with other preferences, we should be careful in looking for simple answers and explanations. Bourassa's (1990) tri-partite framework of biological, cultural and individual level mechanisms underpinning landscape preferences can, we believe, also be usefully applied to waterscapes. Other explanations, however, could also be important and the relative importance of different factors may also vary across individuals. Although we were not able to unpack the relative importance of these effects here, our findings may inspire future research to begin to address these questions.

5.3. Limitations and Further Research

One of the main limitations with the research presented here is that we used relatively small convenience samples of young adults. A key question is thus the extent to which our findings generalise across populations both in terms of age and geographical location. Encouragingly, results from two years of a nationally representative survey of leisure visits in the UK, seem to support our findings (Natural England, 2010, 2011). The survey interviewed over 90,000 individuals about their visits to urban parks, the countryside and the coast for leisure purposes with a subset asked how calming they found their last visit, how much they enjoyed it and how refreshed and revitalised they felt afterwards (all potential indicators of emotional restoration). For all three variables

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the percentage of people using the most positive response category replicated our pattern of findings: 'seaside/coastline' was rated most highly, followed by 'countryside' and then 'town/urban parks'. We recognise though that preferences for aquatic environments may be particularly strong in the UK, a developed island nation with a moderate climate and where nowhere is more than 73 miles from the coast (Depledge & Bird, 2009). Whether similar preferences exist for people in more landlocked countries is a question for future research.

Second, our studies used still photographic images and unique features of water such as movement and sound were lost. Although previous research suggests that preferences elicited this way are broadly similar to those elicited using other stimuli and settings (e.g. Stamps, 1990), we remain cautious. Studies by Ulrich *et al*. (1991) and van den Berg *et al*. (2003), for instance, both failed to find clear evidence of greater restoration following video exposure to aquatic vs non aquatic environments. Further work is needed to understand potential differences between still and moving images of waterscapes as well as their interaction with aquatic soundscapes (e.g. Huang, 2009; Yang & Kang, 2005).

Third, in our attempt to maintain consistency across environments, sub-aquatic scenes in Study 2 were of temperate waters, mostly off the UK coast, and included very few shots of sub-aquatic fauna (4/20) so that the presence of animals was standardised across landscape types. This may be important because these waters are generally less clear and have less diverse and colourful flora and fauna than other sub-aquatic environments such as coral reefs. It is possible therefore that clearer water with a greater array of biodiversity may actually be preferred to the sub-aquatic environments shown here. If true this would suggest the need for future work to consider different sub-aquatic environments much as previous work has considered different types of terrestrial environments (Han, 2007). For instance, further work could look at reactions to kelp forests, coral reefs, sandy seabeds, open water and so forth.

5.4. Conclusions

The present research supports the suggestion that waterscapes are a particularly valued landscape type. However, we also showed that preferences for waterscapes were more affected by weather conditions than those for terrestrial landscapes. The ecological validity of land and waterscape preference research would therefore benefit from studies that consider environments under a range of weather conditions. Our results also suggest that sub-aquatic scenes had similar preference and perceived restorative ratings to rural/green landscapes. Given the lower familiarity with sub-aquatic environments, for most people, the finding raises several issues about the biological, cultural and individual level influences on land and waterscape preferences generally. Considerable advances have been made in terms of examining landscape preferences across different terrestrial biomes. Perhaps the time is ripe to extend this line of work to waterscape types from both above and below the waterline perspectives.

Notes

1. Studies 1 and 2b were conducted by Gemma Jenkinson and Abigail Corcoran respectively as part of their undergraduate degree. Study 2a was conducted by Deborah Cracknell as part of her PhD funded by

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National Aquarium Ltd. All studies were supervised by Mathew White. We thank Lynne James for help with programming.

2. This study also contained three questions about how awe inspiring people thought the images were and came after the preference and perceived restorativeness items. Discussion of these items is beyond the scope of the current paper. Images for all studies can be obtained on request. As the primary aim of standardising image content across landscapes was to avoid potential confounds we do not present content data for any of the studies. Please contact the first author for further details.

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Marine Biota and Psychological Well-Being: A Preliminary Examination of Dose–Response Effects in an Aquarium Setting

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Abstract

Exposure to natural environments can have calming and stress-reducing effects on humans. Moreover, previous studies suggest that these benefits may be greater in areas with higher species richness. Our study took advantage of a "natural experiment" to examine people's behavioral, physiological, and psychological reactions to increases in levels of marine biota in a large aquarium exhibit during three stages of restocking: Unstocked, Partially stocked, and Fully stocked. We found that increased biota levels were associated with longer spontaneous viewing of the exhibit, greater reductions in heart rate, greater increases in self-reported mood, and higher interest. We suggest that higher biota levels, even in managed settings, may be associated with important well-being and health benefits, particularly for individuals not able to access the natural analogues of managed environments.

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restoration, aquatic environment, aquarium, health and well-being, biodiversity

Introduction

Overview

Psychological research suggests that individuals tend to prefer natural, rather than built, settings (Hartig, Evans, Jamner, David, & Gärling, 2003; Ulrich et al., 1991). These environmental preferences appear to be mediated by perceptions that nature provides elements of psychological well-being such as positive emotions, reduced stress, and cognitive fascination (Ulrich, 1984; van den Berg, Koole, & van der Wulp, 2003; also see reviews, Bowler, Buyung-Ali, Knight, & Pullin, 2010; Velarde, Fry, & Tveit, 2007). The current research aims to assess the well-being benefits (psychological and physiological) that people derive from different levels of biota (defined here as the plant and animal life of a particular region; "biota," n.d.), and thus add to the body of work attempting to understand potential dose–response relationships for natural ecosystems and human well-being (Millennium Ecosystem Assessment, 2005; UK National Ecosystem Assessment, 2011).

The opportunity for the current research arose due to a complete refurbishment and restocking of a large exhibit in the United Kingdom's National Marine Aquarium. As restocking was conducted in three stages, it provided a rare opportunity for a "natural experiment" (Medical Research Council, 2011) to compare people's responses with different levels of biota in precisely the same setting. Questions we sought to address included, how long people would stay in front of the exhibit as stocking level increased (reflecting intrinsic fascination), how would physiological markers of stress alter in relation to different levels of biota, and what emotional states people reported during different stages of restocking. Parts of the research required incidental visitor observation (e.g., length of stay), whereas other aspects required close monitoring of experimental participants (e.g., heart rate, mood) during exposure to the exhibit.

Previous studies suggest that greater actual or perceived species richness is associated with greater psychological well-being (Dallimer et al., 2012; Fuller, Irvine, Devine-Wright, Warren, & Gaston, 2007). The current study extends these findings in three key ways. First, we believe it is the first study to consider reactions to different levels of subaquatic, rather than terrestrial, biota by examining reactions to increases in marine life during a restocking event. There is currently a lack of research relating to the health and well-being benefits of aquatic environments (Sandifer, Sutton-Grier, & Ward,

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2015) and, although people may be less likely to visit subaquatic environments than terrestrial ones, the tens of thousands of people who learn to dive (PADI, 2015), visit public aquariums (Gusset & Dick, 2011), own their own aquaria, or watch underwater documentaries, is testament to their appeal (note aquariums and aquaria are both acceptable plurals of aquarium—we will refer to public "aquariums" and home "aquaria"). Moreover, precisely because most people will not regularly encounter these species and ecosystems, there is a need to understand what benefits they provide to ensure we understand the value they confer. Second, as the water in the exhibit needed to "settle" before any animals were introduced, it provided a "control" condition (i.e., water, but no living specimens) that enabled us to begin teasing apart the relative importance of the physic-chemical environment from the animals present within it. This is particularly important in the context of aquatic environments as recent work suggests that they may be especially good at providing psychological benefits such as feelings of calm and mental well-being, irrespective of issues of wildlife considerations (White, Alcock, Wheeler, & Depledge, 2013; White, Cracknell, Corcoran, Jenkinson, & Depledge, 2014; White, Pahl, Ashbullby, Herbert, & Depledge, 2013; White et al., 2010). Even research not specifically exploring preferences for aquatic environments but, for instance, exploring scenic preferences for different environment types, have found that water features strongly as a preferred environmental variable (e.g., Han, 2007; Kweon, Ulrich, Walker, & Tassinary, 2008; Purcell, Peron, & Berto, 2001).

Third, by examining people's reactions to different levels of restocking after both 5 and 10 min of exposure, we were also able to explore potential duration of dose–response effects. Recent field studies indicate that people may gain additional psychological benefits from longer self-selected visits to natural environments (e.g., White et al., 2013). The current, quasi-experimental study, therefore, is the first to examine psychophysiological responses to different "doses" of underwater marine life over different time periods.

Stress Recovery and Psychological Restoration From Nature Experiences

Many studies have investigated the links between environment type and/or composition, and people's psychological responses. This research found high correlations between preferences for natural environments and perceived restoration (e.g., Purcell et al., 2001; van den Berg et al., 2003). It is clear that human beings are drawn to, and may gain benefits from, natural environments. There are three main approaches that attempt to explain why this might be: the Biophilia Hypothesis, the Psychophysiological Stress Recovery Theory (PSRT), and Attention Restoration Theory (ART). Although all three

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approaches maintain that people find natural environments more restorative than urban or artificial settings, their mechanisms and motivations appear to differ. Biophilia is the "innately emotional affiliation of human beings to other living organisms" (Wilson, 1993, p. 31). It suggests that more than one million years of evolution has resulted in humans being genetically programmed to positively respond to natural environments that support success and survival. PSRT also proposes an evolutionary basis for the immediate and involuntary emotional and physiological responses to aspects of natural environments after stressful experiences. It suggests that humans have an unlearned predisposition to recognize and respond in a positive way to natural components (e.g., water, vegetation) and arrangements of these components, that aid survival and promote well-being (Hartig et al., 2003; Ulrich et al., 1991). It is proposed that, following a stressor, unthreatening natural settings provide a valuable "breather" from stress. This facilitates a more positive emotional state, decreases levels of physiological arousal, and recharges energy expended used to cope with the stressor (Ulrich, 1993; Ulrich et al., 1991). Finally, ART suggests that prolonged or intense periods of directed attention, the type of forced concentration that leads to mental fatigue, distraction, and irritability, can be alleviated by experiencing a restorative setting (Herzog, Maguire, & Nebel, 2003). According to Kaplan (1995), restorative settings have four key components: *fascination* (the environment holds one's attention effortlessly—particularly "soft" fascination—see Kaplan, 1995), *being away* (the environment is psychologically or physically removed from a person's daily routine), *extent* (the environment is rich and coherently connected), and *compatibility* (the environment is compatible with a person's expectations and inclinations). Although ART tends to be driven by the need to restore mental fatigue and PSRT is prompted by the mitigation of psychological stress (Berto, 2014), these two antecedents are not mutually exclusive. Stress-induced physiological arousal or negative affect can occur in the presence or absence of attentional fatigue, and vice versa (Hartig et al., 2003). There is also some evidence that the underlying processes for these two restorative theories are associated with different parts of the brain. Voluntary, directed attention has been linked to the right frontal cortex of the brain (Kastner, De Weerd, Desimone, & Ungerleider, 1998), whereas the involuntary reaction to psychophysiological stress has been located in the limbic system (Ulrich, 1983). Of these approaches, the PSRT aligns most closely with our research interests (i.e., exploring psychophysiological responses following a stressor, rather than cognitive recovery), and is therefore the main conceptual framework for the current study.

Although most research carried out on restorative environments focuses on the restorative benefits of real or simulated (e.g., photographs) natural

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ecosystems, compared with more urban settings, a smaller number of studies have explored alternative potentially restorative environments, such as botanical gardens, zoos, museums, and houses of worship (e.g., Ballantyne, Packer, & Hughes, 2008; Bennett & Swasey, 1996; Herzog, Ouellette, Rolens, & Koenigs, 2010; Kaplan, Bardwell, & Slakter, 1993; Packer & Bond, 2010; Pals, Steg, Siero, & van der Zee, 2009). Some of these weather-independent places may provide important access points to nature that would not be accessible ordinarily.

Aquariums and Health and Well-Being

Public aquariums worldwide welcome around 700 million visitors annually (Gusset & Dick, 2011), and smaller aquaria are present in homes, health care settings, and businesses. Although many people visit aquariums for entertainment or educational purposes (Packer & Ballantyne, 2002; Wyles et al., 2013), aquariums' potential to provide psychological benefits is considerable. Given the literature reviewed above, all three approaches (Biophilia, PSRT, and ART) may be, to some extent, relevant for aquarium contexts. Although not "natural" environments, public aquariums certainly contain "nature" and, as such, present opportunities to affiliate with living things (Biophilia). Aquariums potentially fulfill the four criteria of ART, and are thus capable of providing broader restorative experiences. They hold an array of animals of all shapes, sizes, and colors that may hold one's attention effortlessly (fascination), the setting is physically removed from a person's everyday life (being away); there are many different live exhibits, interactive displays, and educational panels to explore (extent); and, they are a place a person has chosen to visit (compatibility). Finally, and of relevance to PSRT, aquariums may trigger physiological, as well as psychological responses, that are indicative of calming and stress-reducing effects.

Anecdotal evidence and some data support the view that people gain relaxation and psychological well-being from large public aquariums (Falk, Heimlich, & Bronnenkant, 2008; Packer & Bond, 2010). In the home context, Kidd and Kidd (1999) found that 70% of aquaria owners described their fish as calming and stress reducing. Indeed, the assumption that fish tanks are often present in health care settings because of their potentially relaxing and calming properties has already prompted research in this area. Although findings from some studies only approached significance (e.g., Barker, Rasmussen, & Best, 2003; DeSchriver & Riddick, 1990) or were simply a testing ground for animal-assisted therapy in a clinical setting (Cole & Gawlinski, 1995), other studies produced significant results. For instance, Katcher, Segal, and Beck (1984) found that participants who were instructed

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to contemplate an aquarium before dental surgery, experienced greater relaxation and reduced anxiety than control conditions. Riddick (1985) added an aquarium to the home of seven non-institutionalized elderly people and found that the aquarium group experienced a significant decrease in diastolic blood pressure (DBP) compared with two other groups (a "visitor" and a "control" group—eight and seven participants each, respectively) with no fish tank to care for. Following a stressor task, significant decreases in blood pressure and/or heart rate were observed in participants who watched a tropical fish tank (Katcher, Friedman, Beck, & Lynch, 1983) or videotapes of fish, birds, or primates (Wells, 2005). Finally, Edwards and Beck (2002) observed beneficial changes in patients with Alzheimer's disease following the introduction of a fish tank in the activity/dining room. Individuals who tended to pace or wander spent more time sitting at the table watching the fish whereas those who were usually lethargic were more alert. Both responses resulted in a significant and important increase in food intake, a decrease in nutritional supplementation and weight gain for most residents. Thus, there is some indicative evidence for the benefits aquaria can provide but these mostly relate to small aquaria and health care settings: The effects of changes in a large public aquarium context have not been investigated.

The Role of Biodiversity, Species Richness, or Abundance

The contents of an aquarium may be of crucial importance if we are aiming to understand beneficial (or otherwise) effects of aquariums. There is a growing literature on psychological benefits of blue/aquatic environments, mostly derived from testing landscape scenery (via photographs or in situ). Thus, one question is whether the presence of water, before any marine life is added, provides benefits. Obviously, the presence of marine life is vital in public aquariums, but what does this add to the tank full of water? And, is it important how much marine wildlife there is, and how varied this is? To our knowledge, these questions have not yet been examined. There is, however, research in terrestrial contexts that has looked at the role of "biodiversity." This research has shown that greater well-being outcomes (e.g., Dallimer et al., 2012; Fuller et al., 2007; Luck, Davidson, Boxall, & Smallbone, 2011) and aesthetic preferences (e.g., Lindemann-Matthies & Bose, 2007; Lindemann-Matthies, Junge, & Matthies, 2010) can be positively associated with higher species richness (e.g., plants, birds). However, a recent systematic review of studies researching the health and well-being benefits of "biodiverse" environments (Lovell, Wheeler, Higgins, Irvine, & Depledge, 2014) concluded that much of the evidence was weak and equivocal and that further research was required.

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At this point, it is worth highlighting the confusion surrounding the term "diversity." According to Tuomisto (2010), "the term 'diversity' has been used in at least four conceptually different ways in the ecological literature, primarily because indices of diversity have been equated with diversity itself" (p. 853). These issues over terminology have made communicating about diversity appear excessively complicated (Tuomisto, 2010). In view of this confusion, and because our field study could not control for, or separately test the influence of, species richness or the abundance of individuals (causing what psychologists term a *confound*), we simply refer to increases in stocking level as increases in "biota" (defined earlier).

In sum, differences in aquarium content and composition may be very important in understanding the psychological effects of aquariums, but no research to date has investigated this question.

Current Research and Hypotheses

The current research extends earlier aquarium studies by using a substantially larger, public exhibit, and by exploring the additive or synergistic effects of adding marine life, over and above an aquatic environment per se. We examined psychophysiological reactions to the exhibit across three stages of restocking: "Unstocked"—seawater only and artificial decoration; "Partially stocked"—moderate levels of biota; and "Fully stocked"—approximately double the number of species and individuals (as the Partially stocked condition). Although a small number of studies have explored psychological responses to species richness (e.g., Dallimer et al., 2012), species abundance has less frequently been taken into consideration. Although our study also expanded on previous work by obtaining a precise measure of species abundance (as well as species richness), we had little control over restocking and, therefore, species richness and abundance were still confounded.

The study had two parts. Part A consisted of observing the amount of time a subsample of aquarium visitors spent looking at the exhibit at each restocking stage. As previous studies have demonstrated positive relationships between psychological well-being and (a) level of species richness and (b) length of self-selected visits to natural environments, we explored whether there was a relationship between stocking level and voluntary exposure time to the exhibit. Part B consisted of monitoring the physiological and psychological reactions of experimental participants seated in front of the exhibit after 5 and 10 min across the three conditions. Again, based on earlier research, we explored the relationship between indices of psychophysiological well-being (e.g., positive mood, heart rate) and the stocking level in the exhibit. Furthermore, by monitoring these indices at 5 and 10 min, we were

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able to see whether longer exposures conferred more benefits. Exposure times of 5 and 10 min were selected partly due to experimental time constraints and partly based on previous studies. Wells (2005) noted significant changes in physiological measure when using a 10 min video intervention. Katcher et al. (1983; Katcher et al., 1984) used longer interventions (≥20 min) but felt that maximal relaxation could be obtained in less time after noting that participants watching just water and plants in a previous study became bored and restless within 20 min. Other studies exploring reactions to restorative environments have found that physiological responses can occur within a few minutes (e.g., <4 min; Ulrich et al., 1991) and psychological changes can be immediate (e.g., Pretty, Peacock, Sellens & Griffin, 2005). Furthermore, from an adaptive evolutionary viewpoint, it would be expected that restoration should occur quite quickly (in minutes, rather than hours), depending on the stress response (Ulrich et al., 1991). These sudden changes also highlight the importance of employing a repeated-measures strategy (Hartig et al., 2003).

Based on previous research, we hypothesized the following:

Hypothesis 1 (Part A): Voluntary exposure time would reflect intrinsic fascination and would be positively correlated with the level of biota present within the exhibit.

As earlier studies suggest that psychological and physiological benefits may be gained from viewing aquaria, we hypothesized the following:

Hypothesis 2 (Part B): There would be a positive relationship between psychophysiological responses and viewing the exhibit when it contained marine life.

More specifically, we anticipated a decrease in heart rate and blood pressure (e.g., as per Katcher et al., 1983; Wells, 2005), an improvement in mood, and a decrease in arousal (e.g., as per Katcher et al., 1984), suggestive of greater relaxation and reduced stress. We also anticipated more positive responses to the evaluation statements. Moreover, we hypothesized that these benefits would be greater in the Fully stocked condition as previous work (e.g., Dallimer et al., 2012) has associated greater psychological well-being with higher species richness. As field studies have found a relationship between psychological benefits and length of self-selected visits to natural environments, we hypothesized the following:

Hypothesis 3 (Part B): Longer exposure time to the exhibit would improve psychophysiological responses.

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Overall, although facets of Biophilia (affiliation with living things) and ART (elements of fascination, being away, extent, and compatibility) are found in an aquarium environment and are relevant to this research, our hypotheses (i.e., psychophysiological responses to a stressor) are most applicable to PSRT.

Materials and Methods

Study Site and Experimental Conditions

The exhibit undergoing refurbishment was a 550,000-L aquarium exhibit (14.3 m length × 6.2 m width × 6 m height), viewed predominately through a single, huge acrylic window (14 m × 4.25 m). While drained of water, the exhibit was decorated with artificial seaweed (e.g., kelp—*Laminaria* spp.) and temperate corals (e.g., pink sea fans—*Eunicella verrucosa*) to recreate a local U.K. underwater habitat. The exhibit was then filled with seawater that was left to mature for 3 weeks before any marine life was added. Skylights above the tank allowed some natural light to penetrate the exhibit. The sheer size of the exhibit, together with the subtle changes in natural light and the gentle movement of the artificial seaweed (generated by hidden pumps), created a natural looking underwater scene that was pleasant, soothing, and immersive.

Each stage of the study was conducted on week days, during normal aquarium opening hours. In Condition 1 (Unstocked), normal visitors and participants in the experiment viewed the exhibit when it contained only seawater and artificial decoration. After Condition 1 was completed, the first fish and invertebrates were introduced to the exhibit. Although every effort was made to ensure that all visitors/participants in Condition 2 (Partially stocked) were presented with the same biota this was not possible. The practicalities of coordinating a field study in a working aquarium resulted in some fish being introduced to the exhibit throughout the time taken to collect all visitors/participants in Condition 2, although not while visitors/participants were actually present. Simpson's Index of Diversity (1-D) for the exhibit, therefore, increased from 0.615 to 0.808 as the number of fish species increased to 10 over a 3-day period (80 individual fish, for example, Orders: Gadiformes, Pleuronectiformes, and Rajiformes—see online appendix for full species list). Nevertheless, the majority of visitors/participants (>88%) viewed the exhibit when it contained approximately six species of fish (~60 individuals) and two species of crustaceans (14 individuals—Order: Decapoda). For these visitors/participants Simpson's Index of Diversity averaged 0.730.

Before the start of Condition 3 (Fully stocked, Figure 1), a further period of restocking was undertaken resulting in a total of 22 species: 19 fish species (138 individual fish) and 3 invertebrate species (13 individual crustaceans).

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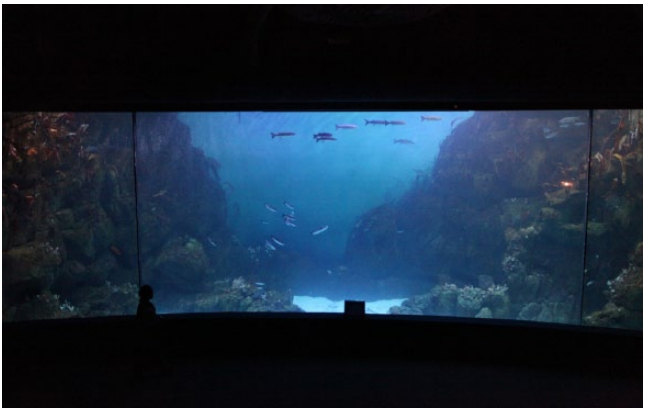

Figure 1. Condition 3—Fully stocked exhibit.

All visitors/participants in Condition 3 were exposed to the same level of biota (1-D = 0.881). Recalculation with Shannon Weiner's Diversity Index also indicated that the Fully stocked condition (H' = 2.51) was more diverse than the Partially stocked condition (H' = 1.93). Ethical approval for the study was provided by the University of Plymouth's Faculty of Science Ethics Committee.

Part A

Participants. Participants (visitors) were 112 randomly selected members of the public who were observed during a visit to the National Marine Aquarium. Observations were carried out during the three stages of refurbishment: Unstocked (n = 41), Partially stocked (n = 31), and Fully stocked (n = 40). Visitors were informed at the aquarium entrance that the exhibit was being refurbished.

Procedure and measures. A rectangular area of 84 m^2 (14 m × 6 m) in front of the exhibit was defined as the "target area." Observations were made by two trained researchers who were positioned unobtrusively at the back of the exhibit area. On commencement of a data collection session, the first adult visitor to enter the target area (either a lone visitor or one individual from a couple or group) was timed (in seconds) from the moment he or she entered the target area to the time he or she left it. The researchers then waited 1 min before selecting the next adult who entered the target area. Observations were

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carried out on a time schedule to reduce potential bias. Measurements were taken twice weekly, at varying times of the day. Numbers of observations differed across conditions due to visitor volume on sampling days.

Part B

Participants. Eighty-four students from a U.K. university elected to take part in the study for course credit (M age = 24 years, 64 females). Due to some "no shows" participant numbers differed slightly across conditions: Condition 1, n = 29; Condition 2, n = 26; Condition 3, n = 29. As this study was a "natural experiment," we were unable to randomly allocate participants to condition. Restocking took place over a 10-month period and, because participants were recruited for each condition at different time points, it is only quasi-experimental.

Procedure and measures. Participants made their own way to the aquarium and were collected from the entrance, in pairs, at an agreed time. As equipment and paperwork needed to be monitored and administered throughout the study, one researcher was allocated per participant. Participants were taken directly to the study area (without stopping to view any other exhibits on the way) and were seated in a curtained booth located in front of the exhibit but which obstructed the view of the exhibit. Participants were seated and briefed at the start of the study that we were interested in how their psychological and physiological measures changed in response to watching an aquarium exhibit; they were not informed about the different stocking levels at this point. We informed participants that mood, heart rate, and blood pressure would be taken before, after, and while watching the aquarium exhibit. Participants were informed of the confidentiality of their responses and their right to withdraw. If happy to proceed, participants signed a consent form. A heart rate monitor (Cateye PL-6000 with ear clip) and blood pressure monitor (Omron HEM705C) were attached to each participant.

Participants then sat quietly behind the curtain for 5 min, and blood pressure and heart rate were measured twice, after 2 min and after 5 min. In the 3-min interval, participants completed a series of anagrams ranging from very simple to impossible. We anticipated that this task would increase participants' stress arousal. However, as no significant effects on either blood pressure or heart rate were found between the two time periods, we collapsed both measures together to form a more robust estimate of baseline physiological states before the curtain was drawn and the exhibit revealed (i.e., Time 1: "Baseline").

Just after the second set of physiological measurements was taken, and before the curtain was withdrawn, two measures of psychological mood were taken: the Feeling Scale (Hardy & Rejeski, 1989) and the Felt Arousal Scale

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(adapted from Svebak & Murgatroyd, 1985). The Feeling Scale is a single-item 11-point bipolar scale (*very bad* to *very good*, −5 to +5), designed to measure affective valence. The Felt Arousal Scale uses a single-item 7-point scale (*low* to *high arousal*, 0 to +6). These measures recognize the fact that mood is related to two orthogonal dimensions (valence and arousal), so for instance, one can be in a positive mood with high arousal (excited) or low arousal (calm) or a negative mood with high arousal (angry) or low arousal (depressed). Combined, these scales have been validated in many studies examining the impact of exercise on mood at multiple time points and show reliable patterns of change over time (e.g., Ekkekakis, Hall, Van Landuyt, & Petruzzello, 2000). Once completed, the curtain was drawn back to reveal the exhibit in one of the three experimental conditions (Unstocked, Partially stocked, or Fully stocked), and participants were instructed to watch the exhibit until the curtain was drawn again.

After a period of 5 min, researchers discretely noted the participants' heart rate before asking them to complete the mood scales again (Time 2: "+5 min"). Blood pressure readings were not taken at this point so as not to disturb participants. Participants then watched the exhibit for a further 5 min after which the final heart rate and blood pressure readings were recorded. Mood scales were also completed for the last time (Time 3: "+10 min"). Finally, participants were asked to complete five evaluation statements: "I enjoyed watching the exhibit," "I feel better after watching this exhibit," "I would be happy to watch this exhibit again" (on a 7-point scale: *not at all* to *very much*, 0 to +6), "I found watching this exhibit" (*very boring* to *very interesting*, 0 to +6), and "I would be happy to watch this exhibit for another (5, 10, 15 or 20) minutes." At the end of the study the participants were debriefed and thanked for their time.

Analysis strategy

Part A. Preliminary analysis of visit duration found a large positive skew (1.89), reflecting the fact that although the majority (66%) of visitors spent less than 4 min at the exhibit, a few spent much longer, up to 20 min. Nevertheless, time was approximately lognormal, so was transformed to log base 10 to enable greater confidence in the outputs of the subsequent ANOVA. Planned repeated contrasts were also used to compare each subsequent stage of restocking.

Part B. For the psychophysiological part of the study, we began by examining participants' evaluations of their experiences after watching the exhibit for 10 min (with one-sample t tests used to compare responses with zero). We then

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examined the effects of watching the exhibit on blood pressure, heart rate, and mood. As blood pressure was only taken twice, we used paired-samples t tests for each condition separately to establish changes associated with watching an Unstocked, Partially, or Fully stocked exhibit for 10 min. To investigate the relative effects of the different stocking levels, we computed the change in blood pressure scores over time (from Baseline to +10 min) for each participant and analyzed these change scores using a one-way ANOVA, with level of stocking as the between-participant factor and planned contrasts if the main effect was significant. As heart rate and mood (valence and arousal) were measured at three time points we used one-way repeated-measures ANOVAs, with planned repeated contrasts, to explore the effects of each condition separately over time. Then, to explore the relative effects of the different conditions, we again derived difference scores by subtracting baseline scores from those at 5 and 10 min. These change scores were then analyzed using a series of 2 (Time: +5 min/+10 min) by 3 (Condition: Unstocked/Partially/Fully stocked) mixed factorial ANOVAs with repeated measures on Time and planned repeated contrasts (reflecting the predicted order of Stocking and Time). Change scores were used for several analyses because there was a pattern of non-equivalence across conditions at Baseline. In particular, participants who arrived at the aquarium in the Fully stocked condition had, by chance, higher average levels of (diastolic) blood pressure, significantly higher heart rate, and less positive mood (Table 1). Potential reasons for these differences are presented in the discussion and possibly reflect the studies' status as a "natural experiment."

Results

Part A

Time spent in front of the exhibit increased as the stocking level increased (Unstocked $M = 3.01$ min, $SD = 3.57$ min; Partially stocked $M = 4.08$ min, $SD = 3.66$ min; Fully stocked $M = 5.94$ min, $SD = 4.16$ min). Using the log base 10 transformation, we found, as predicted, that duration was greatest in the Fully stocked condition (log10 $M = 0.66$, $SD = 0.35$), followed by the Partially stocked condition (log10 $M = 0.48$, $SD = 0.35$), and then the Unstocked condition (log10 $M = 0.26$; $SD = 0.47$). ANOVA analysis (using log transformed scores) found a significant main effect of condition, $F(2, 109) = 10.15$, $p < .001$, $\eta_p^2 = .157$. Planned contrasts revealed that the time spent in front of the Fully and Partially stocked conditions was significantly greater than the Unstocked condition ($p < .001$ and $p = .022$, respectively). Furthermore, there was a marginally significant difference between the Partially and Fully

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Table 1. *M* (*SD*) for Post-Viewing Evaluation Statements, Blood Pressure and Heart Rate Readings, and Mood.

	Unstocked (*n* = 26)	Partially stocked (*n* = 29)	Fully stocked (*n* = 26)
	M (*SD*)	*M* (*SD*)	*M* (*SD*)
Evaluation statement			
1. I enjoyed watching this exhibit	3.14 (1.48)	4.58 (1.17)	5.00 (0.80)
2. I found this exhibit very boring–very interesting	4.14 (1.43)	5.38 (0.98)	6.00 (0.76)
3. I feel better after watching this exhibit	3.34 (1.68)	4.19 (1.23)	4.38 (1.05)
4. I would be happy to watch this exhibit again	3.10 (1.76)	4.46 (1.42)	5.24 (0.91)
5. I would be happy to watch this exhibit for another . . . 5, 10, 15, 20 min	7.41 (3.69)	11.35 (5.93)	11.38 (5.33)
Blood pressure (mm HG)[a]			
Systolic			
T1: Pre-exposure (Baseline)	115.71 (10.51)	114.21 (12.39)	114.50 (9.47)
T3: @10 min exposure	113.54 (9.73)	109.67 (15.20)	111.67 (8.06)
Diastolic			
T1: Pre-exposure (Baseline)	68.98 (6.28)	68.31 (9.05)	71.85 (8.30)
T3: @10 min exposure	67.50 (7.18)	65.79 (10.71)	70.89 (7.22)
Heart rate (bpm)[b]			
T1: Pre-exposure (Baseline)	74.61 (11.89)	76.62 (11.86)	81.59 (13.69)
T2: @5 min exposure	72.04 (10.93)	71.38 (10.56)	76.57 (11.79)
T3: @10 min exposure	72.43 (12.02)	71.08 (10.76)	75.61 (11.29)
Mood			
Valence			
T1: Pre-exposure (Baseline)	2.11 (1.77)	2.27 (1.64)	1.41 (1.88)
T2: @5 min exposure	2.29 (1.56)	2.96 (1.40)	2.24 (1.57)
T3: @10 min exposure	2.54 (1.53)	3.12 (1.21)	2.66 (1.72)
Arousal			
T1: Pre-exposure (Baseline)	2.86 (1.38)	2.77 (1.28)	2.66 (1.40)
T2: @5 min exposure	2.04 (1.37)	2.23 (1.31)	2.31 (1.39)
T3: @10 min exposure	1.50 (1.14)	1.85 (1.41)	1.97 (1.32)

Note. Evaluation statements values are the mean of reported scores on a 7-point scale (0 = *not at all*, 6 = *very much*—Statements 1, 3, and 4, 0 = *very boring*, 6 = *very interesting*—Statement 2). Valence values are the mean of reported scores on a single-item 11-point scale (−5 = *very bad*, +5 = *very good*). Arousal values are the mean of reported scores on a single-item 7-point scale (0 = *low arousal*, 6 = *high arousal*). *SD* = standard deviation.

[a]Excludes two outliers with changes >3 *SD*s from the mean.

[b]Excludes one outlier with changes >3 *SD*s from the mean.

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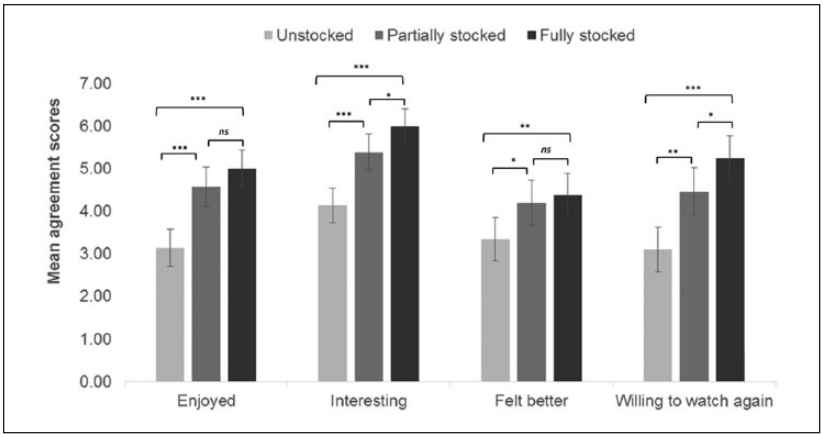

Figure 2. Mean agreement scores for evaluation statements.
Note. ns = not significant. Error bars: 95% confidence intervals.
*$p \leq .05$. **$p \leq .01$. ***$p \leq .001$.

stocked conditions ($p = .065$). In summary, and in support of Hypothesis 1, visitors stayed significantly longer in front of the exhibit with the highest stocking level suggesting that they found it more interesting.

Part B

Evaluation statements. Participants in all three conditions found 10 min in front of the exhibit was an enjoyable and interesting experience that made them feel better. Furthermore, participants stated that they were happy to continue watching the exhibit for another 7½ (Unstocked) or 11½ min (Partially and Fully stocked)—see Table 1 for test statistics. We compared participants' evaluations across the three conditions using one-way ANOVAs on each of the five statements (see Figure 2 for Evaluation Statements 1-4; the time estimates for Statement 5 are reported separately below). As predicted (Hypothesis 2), there was a significant increase in all five ratings. The planned repeated contrasts revealed that responses to all five evaluation statements were significantly more positive in the Partially versus Unstocked condition (enjoyed watching, $p < .001$; found interesting, $p < .001$; feel better, $p = .023$; happy to watch again, $p = .001$; and watch for an additional 3.94 min, $p = .005$). Means in the Fully stocked condition were also all higher than in the Partially stocked condition, but were only significantly higher for level of interest ($p = .041$) and willingness to watch the exhibit again ($p = .043$). In other words, people rated watching an Unstocked exhibit positively, Partial restocking

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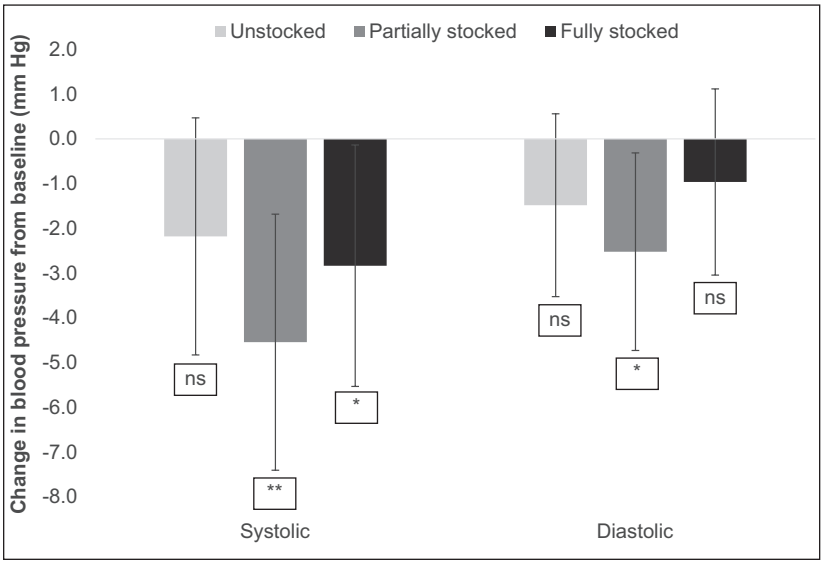

Figure 3. Change in systolic and diastolic blood pressure (mm Hg) from baseline at 10 min as a function of exhibit stocking level.
Note. ns = not significant. Error bars: 95% confidence intervals.
*$p \leq .05$. **$p \leq .01$. ***$p \leq .001$.

significantly improved these ratings, and Fully stocking the exhibit improved some of the ratings further.

Blood pressure. Two participants, one in the Unstocked and one in the Partially stocked condition, were excluded from blood pressure analysis due to erratic readings suggesting measurement error (changes >3 *SD*s from the mean). Analyses of the remaining participants found drops in both systolic blood pressure (SBP) and DBP in all three conditions (Table 1 and Figure 3) but only some of these were statistically significant. Specifically, SBP dropped significantly for the Partially, $t(23) = 2.96$, $p = .007$, and Fully stocked, $t(26) = 2.59$, $p = .016$, conditions, and DBP dropped significantly only in the Partially stocked condition, $t(23) = 2.27$, $p = .033$. The ANOVAs found no significant main effect of condition for either SBP, $F(2, 76) = 0.77$, $p = .467$, or DBP, $F(2, 76) = 0.54$, $p = .584$, and no significant repeated contrasts. In short, there was only partial support for Hypothesis 2 on this measure: Watching the exhibit, irrespective of condition, generally decreased blood pressure but the role of stocking level was unclear.

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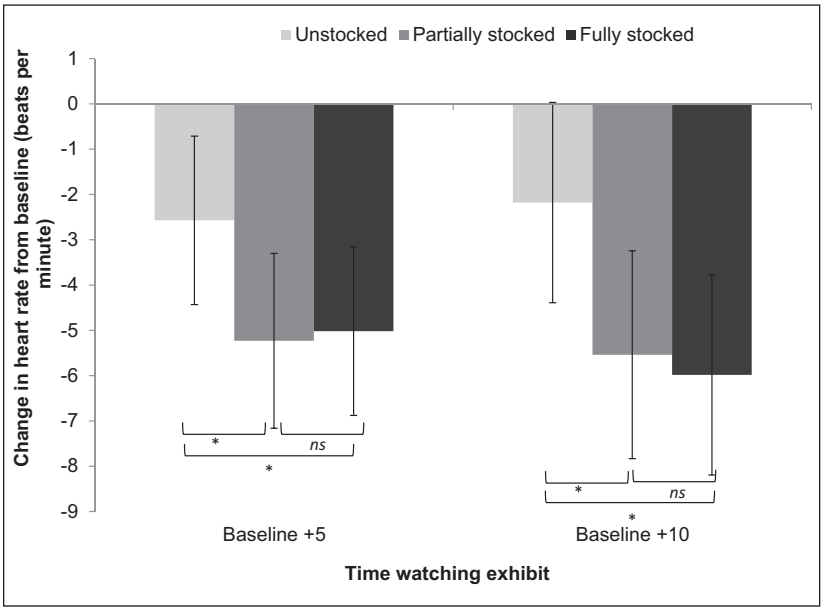

Figure 4. Change in heart rate (beats per minute) from baseline at 5 and 10 min as a function of exhibit stocking level.
Note. ns = not significant.
*$p \leq .05$. **$p \leq .01$. ***$p \leq .001$.

Heart rate. Data from one participant, in the Fully stocked condition, were excluded due to erratic readings (changes >3 *SD*s from the mean). The one-way ANOVAs for each condition separately revealed a similar basic pattern over time, with heart rate dropping substantially during the first 5 min followed by more modest changes over the next 5 min (Table 1). Specifically, there was a main effect of time in all three conditions. In each case, the planned repeated contrasts showed significant drops in heart rate over the first 5 min but no further significant change from 5 to 10 min, although the drop in the Fully stocked condition was somewhat greater than the other two conditions (Figure 4). The mixed factorial ANOVA found a significant effect of condition, $F(2, 79) = 3.38$, $p = .039$, $\eta_p^2 = .053$. The planned contrasts revealed that both the Partially and Fully stocked conditions resulted in significantly greater drops in heart rate than the Unstocked (control) condition (Partially, $p = .032$; Fully, $p = .024$). There was no significant effect of Time, $F(1, 79) = 0.50$, $p = .482$, $\eta_p^2 = .006$, or Time × Condition interaction, $F(2, 79) = 0.91$, $p = .405$, $\eta_p^2 = .023$. Nevertheless, the significant Intercept for

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Time, $F(1, 79) = 62.23$, $p < .001$, $\eta_p^2 = .441$, reflects the overall drop in heart rate compared with baseline. In short, as with blood pressure there is a tendency for heart rate to drop in all three conditions, drops in heart rate were significantly greater in the two conditions containing biota, supporting Hypothesis 2. Despite some indication of a duration dose–response effect, the majority of the effects took place in the first 5 min with only marginal gains subsequently, thus only partially supporting Hypothesis 3.

We noted that mean baseline heart rate was, by chance, higher in the Fully stocked condition than the other two. In part, this may have been due to generally poorer weather during the testing period, which (as well as potentially worsening the mood of participants) tends to make the aquarium more crowded and noisy. Given this possibility, we reran all our analyses controlling for visitor numbers on test days ($M_N = 421$, $min_N = 288$, $max_N = 656$) and found no significant main effect of attendance numbers or any interactions with attendance on any of the physiological or psychological variables. Nevertheless, attendance figures are per day, and thus we cannot be sure how participants were affected by ambient visitor numbers at the precise time of testing.

Mood. In general, valence increased over time (people felt more positive) and arousal fell (people became more relaxed)—see Table 1 and Figure 5. The one-way repeated-measures ANOVAs for each condition revealed that whereas valence improved considerably in both the Fully, $F(2, 56) = 24.80$, $p < .001$, $\eta_p^2 = .470$, and Partially stocked, $F(2, 50) = 8.97$, $p < .001$, $\eta_p^2 = .264$, conditions, the improvement in the Unstocked condition was not significant, $F(2, 54) = 1.52$, $p = .228$, $\eta_p^2 = .053$. Importantly, for the duration-related dose–response discussion, the planned repeated contrasts revealed that although valence became significantly more positive after 5 min in the Partially stocked condition, $F(1, 25) = 9.88$, $p = .004$, $\eta_p^2 = .283$, it did not further improve after 10 min, $F(1, 25) = 1.35$, $p = .256$, $\eta_p^2 = .051$. However, in the Fully stocked condition valence increased both from baseline to 5 min, $F(1, 28) = 17.31$, $p < .001$, $\eta_p^2 = .382$, and from 5 to 10 min, $F(1, 28) = 10.67$, $p = .003$, $\eta_p^2 = .276$. Given the non-significant main effect of time in the Unstocked condition, neither of the planned contrasts was significant. In other words, and in support of Hypotheses 2 and 3, there is a suggestion here of a double dose–response effect: Longer exposure to a greater stocking level produced the greatest improvement in valence.

Arousal decreased significantly in all three conditions: Fully stocked, $F(2, 56) = 5.40$, $p = .007$, $\eta_p^2 = .162$; Partially stocked, $F(2, 50) = 9.27$, $p < .001$, $\eta_p^2 = .270$; and Unstocked, $F(2, 54) = 17.44$, $p < .001$, $\eta_p^2 = .393$. However, the planned contrasts found that whereas the drops from baseline

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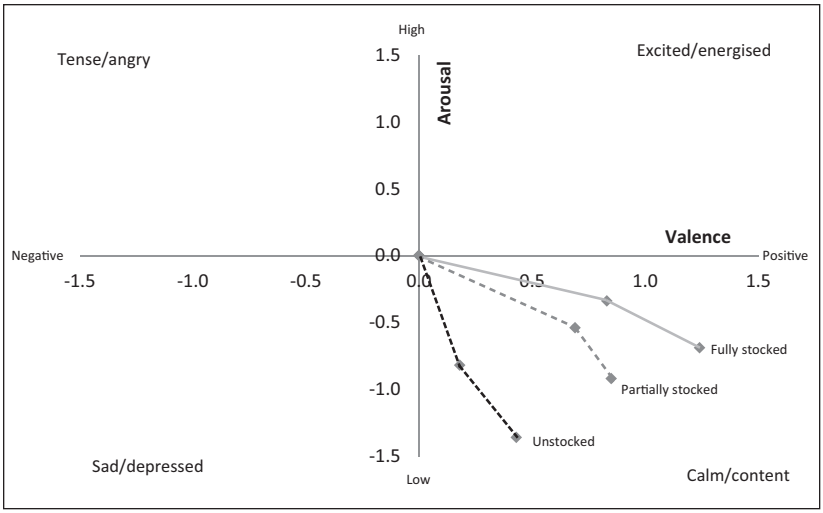

Figure 5. Psychological reaction to the three different levels of stocking presented in two-dimensional affective space.

to 5 min and from 5 to 10 min were associated with significant drops in arousal in the Unstocked, Baseline to 5 min: $F(1, 27) = 12.72$, $p = .001$, $\eta_p^2 = .320$; 5 to 10 min: $F(1, 27) = 9.45$, $p = .005$, $\eta_p^2 = .259$, and Partially stocked, Baseline to 5 min: $F(1, 25) = 7.70$, $p = .010$, $\eta_p^2 = .236$; 5 to 10 min: $F(1, 25) = 5.95$, $p = .022$, $\eta_p^2 = .192$ conditions, the drop in arousal in the Fully stocked condition was only significant from 5 to 10 min exposure, $F(1, 28) = 4.70$, $p = .039$, $\eta_p^2 = .144$, and not in the first 5 min, $F(1, 28) = 2.38$, $p = .134$, $\eta_p^2 = .078$. Referring to Figure 5 (differences from baseline), it seems that while watching the Fully stocked exhibit resulted in a greater increase in positive emotions than the Partially stocked exhibit, arousal was less affected. Contrary to our original Hypotheses (2 and 3), these findings suggest that watching the Fully stocked condition created a less calming but more energizing effect.

Regarding comparisons over time across condition, two mixed factorial ANOVAs (one each for valence and arousal) again found significant main effects of time, valence: $F(1, 80) = 10.33$, $p = .002$, $\eta_p^2 = .114$; arousal: $F(1, 80) = 19.75$, $p < .001$, $\eta_p^2 = .198$, only a marginally significant effect of condition for valence, $F(2, 80) = 2.66$, $p = .076$, $\eta_p^2 = .062$, and no effect for arousal, $F(2, 80) = 1.65$, $p = .198$, $\eta_p^2 = .040$. Neither of the interactions approached statistical significance, valence: $F(2, 80) = 0.803$, $p = .451$, $\eta_p^2 = .020$; arousal: $F(2, 80) = 0.383$, $p = .683$, $\eta_p^2 = .009$. Planned contrasts found that

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the only reliable difference for valence was between Unstocked and Fully stocked conditions ($p = .025$). There was no significant difference between conditions for arousal although there was a marginal effect between the Unstocked and Fully stocked conditions ($p = .075$). Again, then, it seems that there is some effect of biota with higher levels of restocking "tipping the balance" compared with the Unstocked exhibit.

Discussion

Summary of Findings

We had a unique opportunity to test a number of psychological and physiological responses to different levels of marine biota in a very large aquarium exhibit and to also examine the relative importance of the physical setting separate from the marine life contained within it. We were also able to examine people's reactions after both 5 and 10 min of exposure, enabling us to explore potential duration dose–response effects.

Visitor observations in Part A confirmed that, on average, visitors stayed longer in front of the exhibit when it contained the greatest level of marine life, supporting Hypothesis 1. If we assume that behavior reflects preferences this suggests that people gained more benefit from the exhibit when it was fully stocked. From a psychological perspective it might be that the greater levels of biota provided greater levels of interest and fascination and the opportunity to disengage from the mundane, all elements which have previously been shown to aid psychological restoration.

Evaluations of experimental participants who were closely monitored during their exposure to the exhibit in Part B supported these perspectives. Specifically, as stocking levels in the exhibit increased, participants' interest in the exhibit and willingness to watch it again significantly increased, indicating a dose–response relationship (supporting Hypothesis 2). Furthermore, it was also evident in both the observation and evaluation data that the exhibit alone, although unstocked and containing only seawater and artificial decoration, appeared to be sufficiently interesting to confer some benefits in line with previous studies showing the psychologically restorative effects of aquatic environments in general (e.g., White et al., 2013).

The physiological evidence in support of the dose–response effects of stocking level (Hypothesis 2) and exposure time (Hypothesis 3) was weaker. All three stages of exhibit restocking were associated with significant drops in blood pressure and heart rate, indicating that exposure in all conditions was calming and physiologically restorative. Note that these decreases were observed after a rest period, and so cannot be attributed simply to sitting quietly. Most of these gains

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occurred within the first 5 min, with only diminishing returns following a further 5 min of exposure. Nonetheless, the greatest drop in heart rate occurred in the Fully stocked condition and this drop was significantly different from the Unstocked condition. The mixed blood pressure results may result from the relative responses of SBP and DBP to a given situation: An increase in SBP characterizes a beta-adrenergic response linked to stressors involving active coping or defense whereas an increase in DBP represents an alpha-adrenergic response linked to stressors involving vigilance or passive coping (Hartig et al., 2003). Hence, although there was no effect of condition, potentially the decreases in SBP and DBP (some of which were significant) may reflect the overall benign and non-threatening setting.

Potential dose–response relationships were more evident in the mood data where people reported how they were currently feeling in terms of valence (positivity) and arousal. In general, as duration of exposure increased people became both more positive and calmer but as biota levels increased, people became more positive but relatively less calm. This latter finding is concordant with the notion that the greater levels of biota are associated with more interest and fascination. In fact, when viewed from this perspective, there might not be any reason to expect greater drops in blood pressure and heart rate from watching more versus less marine life as the former is more stimulating (e.g., see Katcher et al., 1983). Indeed, Pilotti, Klein, Golem, Piepenbrink, and Kaplan (2014) found a significant increase in participants' SBP following exposure to a nature video (but not an urban video) and suggest that changes in blood pressure may be related to pre-intervention (baseline) levels and participants' expectations.

The current data add to the still small body of literature, which suggests that individuals may gain psychological well-being from exposure to environments that contain relatively high levels of biota. Furthermore, these findings provide some support for all three previously mentioned hypotheses: The aquarium provided contact with nature (Biophilia) and fulfilled the criteria of ART, either fully for visitors who had chosen to visit the aquarium, or partially for participants for whom the aquarium still provided fascination and an escape from their daily routine. Overall, although participants tended to leave feeling happier and more relaxed (psychologically and physiologically) after viewing the exhibit, the unsuccessful stressor task (and our resultant inability to demonstrate a measurable effect on "elevated stress") would appear to lessen the relevance of this work to PSRT, compared with the two other theoretical models, Biophilia and ART. However, self-rating data from a study using unstressed university students found that everyday natural scenes (particularly those containing water) held the participants' attention and produced more positive emotional states than urban scenes lacking nature

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(Ulrich, 1981). Furthermore, the self-ratings in Ulrich (1981) were largely convergent with results of brain electrical activity (electroencephalography [EEG]) recordings in the alpha frequency range, suggesting that participants were more relaxed and wakeful when viewing natural scenes. Consistency between psychological and physiological measures in our study likewise justifies greater confidence in the findings and also suggests that findings are not a result of social desirability effects.

Although the current data pertain to a very large, and thus presumably immersive exhibit, our findings may inspire further research, which examines whether similar effects are found for smaller aquaria with generally smaller fish and lower stocking levels. This could be important for locations where reducing psychophysiological stress is a key objective; not only in traditional health care settings (e.g., dental waiting rooms) but in everyday places of stress such as office buildings. Our results suggest that an individual does not need to spend long in front of an exhibit (just 5 min) to derive significant benefits.

Limitations and Future Research

Key advantages of our research included a control condition (no biota present) and precise knowledge about the actual level of marine life at both stages (unlike most field studies). This enabled us to say what added advantage the presence of fauna had over and above the background environment.

The research also benefited from taking place in a working aquarium during normal opening hours. Although we could have conducted the research "out-of-hours" when peace and quiet could be assured, we felt it was important to examine the potential of the exhibit to promote well-being under normal conditions to enable generalization. However, this also presented challenges. We noted, for instance, that participants in the Fully stocked condition had, at baseline, generally higher heart rates and more negative moods than those in the other two conditions. Given these baseline differences, potentially due to poor weather and/or higher ambient visitor numbers, we also cannot rule out regression to the mean effects as a possible explanation for the particularly strong gains (e.g., in heart rate and valence) in the Fully stocked group. We also note that our stressor task (anagrams) did not sufficiently stress our participants: There was no significant increase in heart rate or blood pressure following the stressor task, and averaged readings (see Table 1 for means) fell within typically accepted "normal" rates for adults (i.e., resting heart rate: 60-100 bpm; blood pressure: <120/80 mm Hg—www.heart.org). The lack of stressor means that this study is therefore unlike other studies investigating stress reduction. Had the task been more effective at

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increasing stress arousal, it is possible that some of our findings may have been stronger. Replications of our findings are thus desirable.

A further limitation of our study was that, due to its opportunistic nature, species richness was naturally confounded with species abundance. As mentioned, this limits our ability to understand the relative impact of species richness versus abundance. As highlighted by Dallimer et al. (2012) who considered reactions to species richness only, "it is equally possible that the abundance of a given taxonomic group is more important or noticeable than the number of different species" (p. 51). However, such studies would be almost impossible in situ and would probably require more controlled laboratory studies. At best, we could at least be sure that participants were responding to current, known measures of species richness and abundance rather than estimates obtained during past surveys.

Finally, although we avoided collecting data during feeding times (when many species are particularly active) we also wonder how important certain types of behavior are in terms of the potential restorative effects for humans. Some species are relatively shy or have a limited behavior repertoire whereas others are more gregarious or exhibit intriguing behaviors, which may enhance the experience. Future work is therefore needed to explore whether there might be different levels of well-being associated with different types and/or combinations of underwater species.

Conclusion

In summary, the current work provides tentative support for previous, limited research that has suggested there are psychological and physiological benefits of watching aquaria. It extends earlier studies by exploring the potential influence of increasing biota levels on well-being measures recorded at several time points. The evidence that greater levels of stocking had positive effects on experience evaluations and mood extends findings from terrestrial studies that suggest dose–response relationships between biota levels and immediate psychological well-being. Further work is now needed to investigate different potential benefits across different aquarium types, sizes, and contexts. Just as research on plant array preferences may improve the design of green spaces for well-being, a greater understanding of aquarium biota and exhibit composition may maximize the restorative potential of aquaria in health care environments and other stressful settings such as the workplace.

Finally, the findings further highlight that restorative effects can be derived from artificial, as well as "real" nature experiences. Opportunities for engaging with nature, even in "managed" settings, may be key in helping urban populations connect with natural environments. Furthermore, as marine ecosystems

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can be adversely affected by visitors, the ability to connect people to marine environments by proxy, for example, through aquariums, could be extremely important. Aquariums may therefore be important for delivering psychological well-being, enhancing perceptions of the value of natural ecosystems, and ultimately encouraging support for conservation efforts in the wild.

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Authors' Note

The authors confirm that National Aquarium Limited (NAL) played no part in the study design, data collection, or analysis.

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Wallace J. Nichols is a marine biologist interested in ocean conservation, especially relating to sea turtles. He is also interested in the psychological benefits and cognitive effects of engaging with aquatic environments.

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