Government Office for Science

Foresight

Future of the Sea: Health and Wellbeing of Coastal Communities

Foresight – Future of the Sea Evidence Review

Foresight, Government Office for Science

Future of the Sea: Health and Wellbeing of Coastal Communities

Professor Michael Depledge, Dr Rebecca Lovell, Dr Benedict Wheeler, Dr Karyn Morrissey, Dr Mathew White, Professor Lora Fleming

August 2017

This review has been commissioned as part of the UK government's Foresight Future of the Sea project. The views expressed do not represent policy of any government or organisation

Contents

Executive Summary

Approximately 17 per cent of the UK population live in coastal communities; some are prosperous and commercially successful, others experiencing socio-economic decline. Regardless, evidence suggests growing risks for the health and wellbeing of coastal communities.

Communities along the coast are on the front line in facing climate change and marine pollution impacts, furthermore their economies are deeply embedded with coastal and other marine activities, making these communities particularly affected. Sea-level rise and extreme weather events, driven by climate change and ecosystem damage, expose coastal communities to flooding events now and in the future, damaging local economies, and threatening health and wellbeing. Continuing pollution of the sea has been underestimated as a threat to the health of coastal dwellers.

Coastal communities are also undergoing continuous socio-demographic upheaval, with highly transient and seasonal workforces, young people leaving and older people arriving. How well they thrive depends on factors such as social structures, employment opportunities, adequate health infrastructure and housing. Affluent coastal communities in which ‘second homes’ are especially common, but in which local people cannot afford housing or find good jobs, often struggle to support local infrastructure including health and social care.

Fortunately, marine settings provide many health-promoting opportunities for coastal dwellers including active, outdoor lifestyles and restorative mental health benefits. However, the health and wellbeing of coastal populations are especially vulnerable to the loss of these opportunities through, for example, adverse climate change impacts and chemical pollution.

Determining how each coastal community can become resilient in the face of socio-demographic change and the increasing number of extreme events and environmental threats is a key challenge. Evidence shows benefits to policies that offer a range of co-benefits to both the environment and health. The increasing use of marine planning and ‘natural capital’ methodologies may provide a basis for action. Any policy response is complicated by the fact that coastal communities’ diversity means that there is unlikely to be any ‘one size fits all’ policy response.

Ultimately, developing effective policies to ensure the future prosperity, sustainability and health of coastal communities relies on having accurate information upon which to make judgements about the extent to which particular risks should be addressed, and which health-promoting opportunities should be pursued. Currently, such information is inadequate or not available.

1. Coastal Communities

1.1 What are Coastal Communities?

There is no consistent, widely used definition of a 'coastal community'. The 'Coastal Communities' programme takes the position (adopted for the purposes of this paper) that a coastal community is a "coastal settlement within a … local authority area whose boundaries include [the] foreshore, including local authorities whose boundaries only include estuarine foreshore" (Coastal Communities Alliance 2015).

Coastal communities represent ca. 17 per cent of the UK population (Zsamboky et al. 2011). Although distributed around the entirety of the UK coasts, the majority of the coastal population live in 'developed coastal' communities; 10 of the 20 most populous cities in the UK are located on estuaries or the coastline. However, significant numbers live in 'undeveloped coastal' communities (small towns and villages) with clusters of settlements in specific geographic regions (e.g. South West England). Residents are also found in 'isolated coastal' communities (remote and sparsely populated); 18 per cent of Scotland's coastal population live in this type of community (James Hutton Institute n.d.).

The size and character (socially, economically and culturally) of coastal communities range from the large industrial and commercial centres such as Bristol, Portsmouth and Hull to small tourism-oriented resorts such as Bude and Whitby. The dominant coastal industries are similarly variable, but include fishing (including aquaculture), shipping and tourism. The specific characteristics of each type of coastal community are associated with, and contribute to, determining the health and wellbeing of residents and the risks they face.

1.2 Age Profile and Social Structure

More than 11 million Britons live in coastal areas. Coastal communities tend to have an older age profile than others across the UK. In a sample of 274 coastal communities (England and Wales), 20 per cent of the population were aged 65 years or over (compared with 16 per cent nationally) and were relatively more deprived than those elsewhere (2011 census – Office for National Statistics 2014; Marine Management Organisation 2016). Coastal local authorities are projected to be most affected by an increase in the proportion of the oldest population group over the next 10-year period (Office for National Statistics 2014). This will influence overall health and wellbeing of each community and the subsequent demands on social and health infrastructure.

Patterns of internal and inward migration also disproportionately affect coastal communities. The seaside is an aspirational destination for retirees, a phenomenon contributing to the rapidly aging profile of coastal populations in the UK and elsewhere. For example, 65 per cent of people aged 65 or over retiring from London moved to coastal local authorities (Pennington 2013). Concurrently, coastal communities are also experiencing outward migration of young people, and the inward migration of transient workers. The transient workforce has resulted in primary schools in some areas experiencing up to 30–40 per cent turnover of pupils within a school year (Lancaster City Council 2006). This flux has implications for the health and

wellbeing of residents, and for the planning, sustainability and delivery of social and health services.

Remoteness, lack of investment in infrastructure, high levels of socio-economic deprivation, seasonality of employment and limited labour markets also contribute to social exclusion and threaten wellbeing in coastal communities (Ward 2015).

1.3 Health Status

For the purposes of this report a definition of 'health and wellbeing' which recognises not only absence of ill health but also the ability to adapt and self-manage in the face of social, physical, emotional and environmental challenges was adopted (Huber et al. 2011).

Coastal populations are more likely to report poorer general health than those further inland; Figure 1 indicates that the unadjusted percentage of the population reporting bad or very bad health is greater at the coast. According to the Office for National Statistics (ONS), analysis of the 2011 census, six of the 10 medium/large built-up areas (population >20,000) with the highest shares of 16- to 64-year-old residents whose day-to-day activities were 'limited a lot' by disability, were coastal communities (e.g. Peterlee, Port Talbot, Skegness and Rhyl) (Office for National Statistics 2014). This pattern reflects the fact that coastal populations are more likely to be older and more socio-economically deprived.

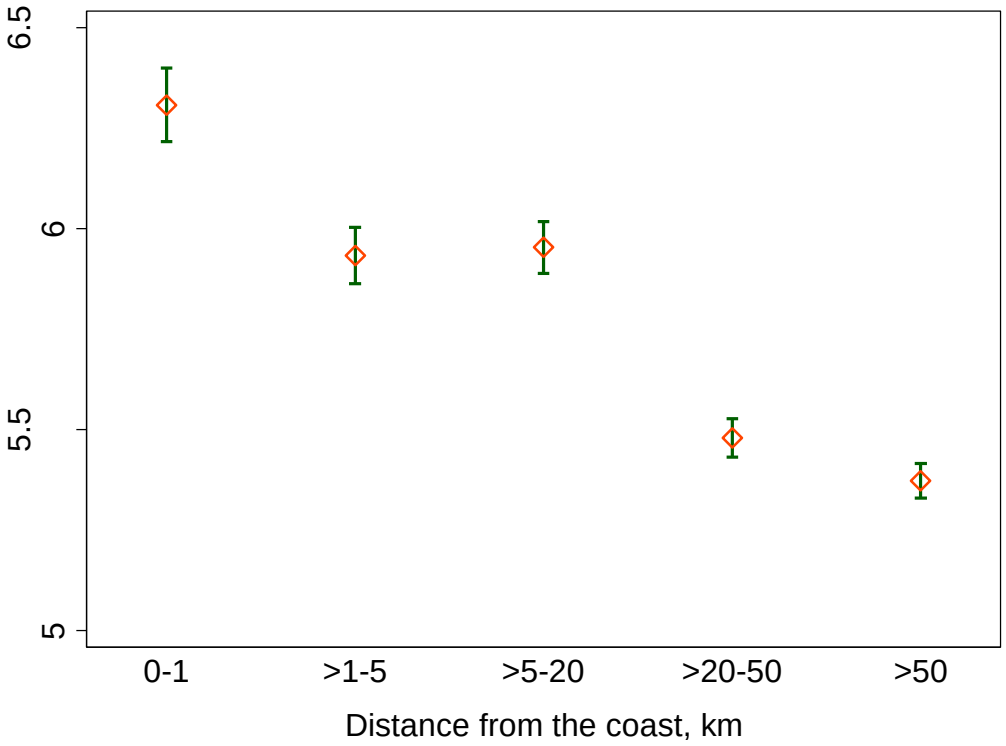

Figure 1. Unadjusted percentage of population reporting poor health in coastal and non-coastal communities

Source: 2011 Census: Means and 95% Confidence Intervals across 41,253 Lower layer Super Output Areas, GB 2011 – Office for National Statistics (2014)

However, after accounting for local age and socio-economic population profiles, overall coastal populations actually report better health than non-coastal populations (Wheeler et al. 2012). Consequently, while coastal populations have significant health needs, they are likely to be 'healthier' overall than inland populations which have similar age and socio-economic profiles. Gaps in self-reported health between relatively rich and poor coastal communities are smaller than the gaps between similar communities inland (Wheeler et al. 2012, 2015). These relationships are currently poorly explained and are subject to ongoing research.

The specific health issues of coastal dwellers are typically those faced by older populations (e.g. increased rates of morbidity and multi-morbidity, high demands on health services, and so on), or relate to lifestyle factors such as high levels of alcohol use. For example, in relation to the latter, in Brighton and Hove, rates of alcohol-related harm are higher than the national average (Cave 2010). Characteristics of coastal communities (potentially including physical isolation, low levels of employment, and constrained socio-cultural opportunities), have also been associated with high rates of poor self-esteem, poor mental health and harmful behaviours among young people (Cave 2010).

1.4 Housing

The availability, types and qualities of housing in coastal areas have major implications for the health and wellbeing of residents. In particular, there is concern over 'houses in multiple occupancy' (HMOs – often converted guest houses or hotels) and with high levels of occupancy of poor quality accommodation, such as caravans. HMOs provide a higher percentage of housing in coastal settings than other inland communities (apart from university towns), and are strongly associated with deprivation indicators such as housing benefit receipt (Smith 2012). Poor quality housing overall is linked with poor health, economic decline and increased concentrations of deprived populations (Cave 2010; Smith 2012). Caravan residents are less likely to be registered with a GP (Cave 2010). The highest shares of private sector renting (outside London), a housing category associated with poorer levels of wellbeing, are found in coastal communities (e.g. Brighton and Hove, Folkestone and Torquay) (Office for National Statistics 2014).

High levels of tourism put pressure on infrastructure, increasing house prices, pollution and, where tourism is highly seasonal (especially in communities with high levels of second-home ownership and homes with no usual residents), affect local service provision. Indeed, high rates of homes with no usual residents (e.g. second homes or holiday rental properties), as found in many coastal communities, exclude locals from the housing market, leading to long-term stress. The ONS reports that 6.1 per cent of household spaces in coastal communities were unoccupied by 'usual residents' (compared with 4.4 per cent for non-coastal England and Wales), with small coastal communities (population 10,000–20,000) having the highest shares of households with no permanent residents (e.g. ~50 per cent in Southwold and Salcombe). The problem is most prevalent within 1km of the coast (Figure 2).

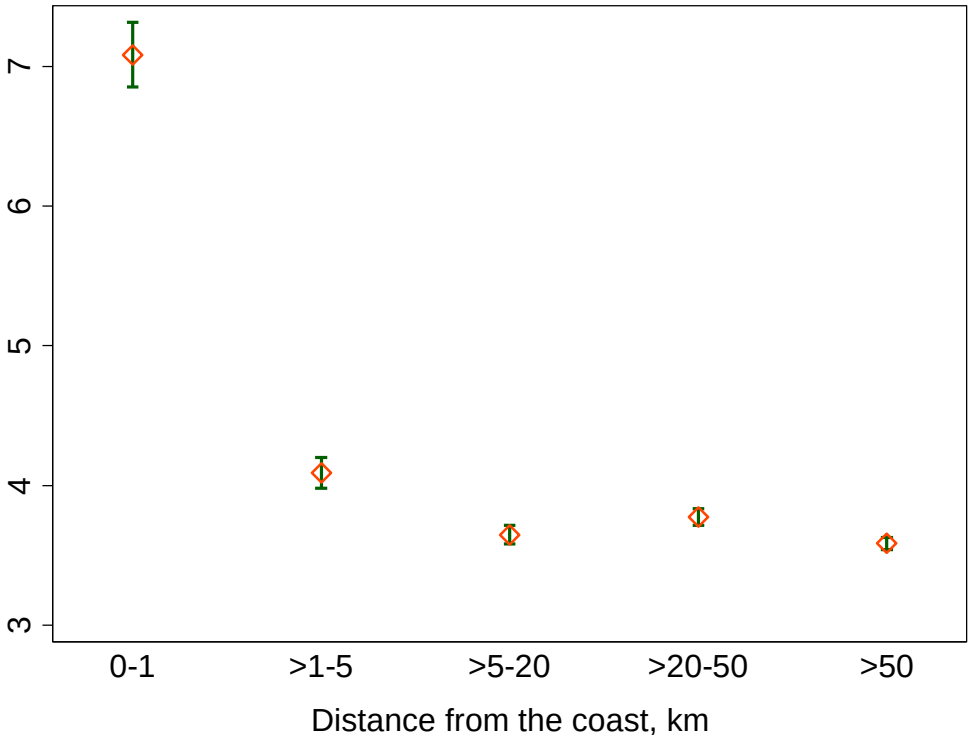

Figure 2. Percentage of homes with 'no usual residents' (primarily second/holiday homes) in coastal and non-coastal communities

Source: 2011 Census; Means and 95 per cent Confidence Intervals across 41,253 Lower layer Super Output Areas, GB 2011– Office for National Statistics (2014)

1.5 Economic Opportunity and Employment

Health and wellbeing of all types of communities are closely tied to economic activity and to the levels and quality of employment. The primary industries and commercial activities in many coastal areas – such as tourism, shipping, energy (including renewables), defence, and fishing – are highly dependent on the state of the local environment, further exacerbating vulnerability to change.

Tourism is of particular importance to coastal communities; employing over 250,000 people across 150 seaside resorts, with seaside tourism revenue estimated at £17 billion (DCLG 2016; Jones et al. 2011; Simpson 2013). However, in many coastal communities tourism plays only a minor role in local economies; in Barry and Greater Worthing, tourism accounts for just 1 and 2 per cent respectively of the total jobs (Simpson 2013). Associated economic and wellbeing benefits are particularly significant to more-remote communities. For example, in Wales in 2005, seaside tourism accounted for 42 per cent of domestic tourism spend, supporting nearly 100,000 jobs and contributing approximately £1.5 billion to Welsh GDP per year. Similarly, the value of tourism to communities in the Western Isles of Scotland is £49.9 million per year (Jones et al. 2011). While tourism clearly supports the viability of some coastal communities, tensions between the seasonal pressures of large numbers of tourists, the anti-social behaviours of some visitors, and the needs of local residents, can damage coastal community wellbeing (Cave, 2010).

In some coastal regions, the fishing industry (including aquaculture) provides up to 20 per cent of jobs (Marine Management Organisation 2013). Declines in the industry, shifts in populations and other pressures (such as the rise of second-home ownership) have threatened the social stability and wellbeing of those communities which are dependent on fishing (Box 1.)

Box 1. Health and hidden vulnerability in UK fishing-dependent communities

Turner and colleagues (2015) examined the social, economic and ecologic vulnerability of fishing communities in South West Cornwall and their impacts to health and wellbeing. They identified three categories of change the communities had faced since the 1960s:

Community, e.g.	**Fishery, e.g.**	**Individual/household, e.g.**
Increase in population and housing infrastructure	Changing fish stocks	Needing to adapt to shifts in fishing practices (e.g. time at sea, crew numbers)
Increase in retired population and loss of young people	Rising cost of fishing with lower income	Individuals leaving fishing or adapting to part time fishing
Increased cost of living	Difficulty finding crew	Changes in financial security, housing security and ability to provide for family
Decline in transport links	‘Demonisation’ of fishing industry	
	Harbour development focused on tourism rather than fishing industry	

Fishermen’s perceptions of the factors affecting their health included: work conditions, lifestyle, the economic and financial situation, and fisheries policies (Turner et al. 2017).

Other industries, such as marine services, dominate some communities. Oil and gas production is the highest value marine industry in England, and one of the largest contributors to gross domestic product. However, total UK oil and gas production peaked in 1999 and has since declined, threatening the stability and wellbeing of those communities dependent on the oil and gas production (Marine Management Organisation 2013). A key challenge will be the extent to which the associated skills base in these communities can be transferred to the marine renewables sector.

Patterns of employment vary around the country and according to coastal settlement size; however rates of employment are, on average, lower in coastal communities than elsewhere. The ONS found that (at the time of the 2011 census) in some coastal settlements, such as Jaywick, Lynemouth, Aberystwyth and Great Yarmouth, the unemployment rate among people aged 16–64 was between 14 and 19 per cent (compared to 7.4 per cent at the time of the census, nationally) (Office for National Statistics 2014). Overall, the coastal labour force tends to work in sectors that are relatively low skilled, highly seasonal, low-paid and service sector oriented. The poor mental health of younger coastal residents has been linked to difficulties in providing a stable workforce (Cave 2010).

1.6 Economic Policy in Coastal Communities

The 'plight' of UK coastal areas receiving substantial political and media attention has meant that marine-based activities are seen as important instruments for channelling national and supranational funding to these areas (Morrissey 2017). In Europe and the UK, fishing and aquaculture activities are a primary instrument for channelling national and supranational funding to deprived coastal populations (Surís-Regueiro et al. 2014; Morrissey 2015; Urquhart and Acott 2013). However, as noted previously, coastal communities occupy highly heterogeneous environments that include urban, rural and peripheral locations with a diversity of economic activities (Morrissey 2015). In response, the newly implemented European Maritime and Fisheries Fund under the revised Common Fisheries Policy (2009), has been designed as a financial instrument to aid in the sustainable development of EU coastal areas through fisheries, aquaculture and maritime activity. The fund aims to help fishermen in the transition to sustainable fishing, support coastal communities in diversifying their economies, and to finance projects that create new jobs and improve quality of life along European coasts.

Analysis of the performance of the marine sector in the UK pre-and post-2008 recession found that a number of subsectors, particularly the shipbuilding and repair and the pleasure-boat building industries, have grown substantially after the recession (Morrissey 2015). The marine sector is likely to be crucial for support for future growth and development in coastal communities.

Some research suggests that there is a risk that many potential growth sectors may not be based in coastal areas. There is potential for high-value-added activities associated with, for instance, marine renewable energy, blue biotechnology and marine technology to remain in urban hubs, with minimal increases in the labour force in coastal communities (Morrissey 2017). Poorer infrastructure, small labour pools, and greater distance to central markets could mean that larger companies will continue not to invest in coastal areas. This would prevent the development of local, small and medium enterprise-based supply chains in coastal settings.

2. Threats to the Health and Wellbeing of Coastal Communities

Key threats to health and wellbeing in coastal communities are summarised in Table 1 (synthesised from a number of sources including: Berdalet et al. 2016; Boxall et al. 2009; British Geological Survey 2012; Committee on Climate Change 2016; FAO/WHO 2011; Fleming et al. 2014; Hames and Vardoulakis 2012; Herr and Galland 2009; Intergovernmental Oceanographic Commission 2002; Leonard et al. 2015; Marine Management Organisation 2013; MacLeod et al. 2012; Moore et al. 2013; Mozaffarian and Rimm 2006; Occhipinti-Ambrogi 2007; Redshaw et al. 2013; Stanke 2012; UK National Ecosystem Assessment 2011).

Table 1. Key threats to health and wellbeing in coastal communities

Risk Category	Key Health/Wellbeing Outcome(s)	Potential Impact	Likelihood	Extent
Human activities in coastal ecosystems				
Human manipulation of the coasts (including urbanisation)	Exposure to pollutants Mental health	High	High	Global
Marine mining and extractive industries (oil, minerals, metals, etc.)	Injury Morbidity Mortality	Medium	Medium	Global/Regional
Shipping/ transport (including oil)	Injury Mental health Cancer*	Medium	Medium	Regional/Local
Fishing	Injury Morbidity Mortality	Medium	Medium	Regional/Local
Aquaculture	Morbidity* Contamination	Medium	Medium	Regional/Local
Marine energy renewables	Injury Morbidity Mortality	Low	Medium	Regional/Local
Marine biotechnology	Unknown	Low	Medium	Local
Environmental threats (including climate change)				
Ecosystem degradation	Long-term threat from new diseases Mental health	High	High	Global
Built infrastructure damage and destruction (e.g. sanitation, drinking water, housing, roads)	Loss of health sector capacity Accidents Infectious diseases Inequalities	High	High	Regional/ Local
Flooding	Drowning Morbidity Mental health Infectious/ allergic diseases Pollutant toxicity	High	High	Local
Storm surges	Drowning Morbidity Mortality	High	High	Local
Vector- and water-borne diseases	Infectious diseases (cholera, etc.)	High	High	Local
Marine current and wind changes (leading to increased harmful algal blooms, surges, changes in biodiversity; see below)	Morbidity Acute/chronic illness	High	Medium Increasing	Global/Local
Earthquakes and tsunamis	Morbidity Mortality Mental health	High	Low	Global/Regional/ Local

Risk Category	Key Health/Wellbeing Outcome(s)	Potential Impact	Likelihood	Extent
Invasive species	Envenomations (bites/stings)	Medium chronic	Medium Increasing	Regional/Local
Harmful algal blooms	Acute/chronic illness	Low but chronic	Low	Local
Ocean acidification	Unknown	Unknown	High	Global
Pollution of the coast and marine environment				
Microbial pollution	Infectious diseases (Hepatitis, Enterobacter, E.coli) Antimicrobial resistance (AMR)	High	High	Global/Local
Anthropogenic Chemical Pollution	Acute toxicity Chronic diseases	Medium	High	Global
Air pollution (sulphur dioxide and nitrogen oxides) from coastal shipping, industry	Respiratory and cardiovascular disease Morbidity Mortality	Medium	Medium	Local
Pharmaceutical pollution/AMR	Infectious disease AMR estrogenic analogue effects*	Medium	Low Rapidly increasing	Local
Nutrient pollution (including run off)	Methemoglobinemia Birth defects*	Low Chronic/ occasionally acute	Medium	Local/Global
Plastics	Depression Chemical toxicity Chronic diseases*	Low (potential effects unknown)	High Increasing	Local/Global
Socio-economic and cultural threats				
Demographic change in coastal zone	Inequalities Reduced wellbeing Chemical and Pathogen Pollution	High	High	Local
Destruction of traditional communities (e.g. fishing communities)	Addictions Mental health Inequalities Chronic disease	High	High	Local
Shifts in economies and industries	Mental health Chronic disease	Variable	High	Local/Global
Tourism and second-home ownership	Mental health Inequalities	Variable	Medium	Local
Peripherality and remoteness of coastal communities	Addictions Mental health Inequalities Chronic disease	Variable	Medium	Local
*** = suggested but not yet strong supporting evidence; categories of impact, likelihood and extent are the authors' syntheses of the literature (also see p.276 in Bowen et al. 2014)**				

2.1 Human Activities in Coastal Ecosystems

Human use and modification of the coastal zone is increasing relentlessly. Industrial and commercial activity (including fishing and aquaculture, maritime transportation, and energy production and storage), and both leisure activities and tourism (of which the extent, scale and implications to human health were reviewed in section 1) are resulting in environmental change in many areas (Jones et al. 2011) and are exacerbating existing threats to health and wellbeing.

One of the key human activities in coastal zones that threatens human health is ongoing urbanisation and development. Ten of the 20 most populous cities in the UK are located on estuaries or the coast, and the coast is a desirable location for future development. Ongoing coastal development increases the numbers of people and crucial built infrastructure exposed to the impacts of climate and environmental change (as discussed below) (Lee 2014). Many coastal villages, towns and cities are geographically isolated with poor infrastructure and connectivity. This reduces access to education, employment, and health and social services, as well as to other social opportunities, thereby potentially contributing to poor mental health and harmful behaviours, especially in younger residents (Cave 2010).

2.2 Threats from Physical Environmental Change

2.2.1 Climate Change

Climate change has already altered, and will continue to alter, weather patterns that can have adverse consequences (though not necessarily) for human health and wellbeing (Watts et al. 2015). As human activities are projected to accelerate greenhouse gas emissions, the dynamics of the climate will continue to shift, increasing the intensity and/or frequency of different extreme events resulting in (often quite rapid) changes in local environmental conditions. By 2080 climate change is predicted to have ‘severe’ damaging impacts, to the degree that it will pose a significant threat to the health and wellbeing of UK and global coastal communities (Committee on Climate Change 2017; Zsamboky et al. 2011; Marine Management Organisation 2013), due to:

- Sea-level rise of one metre (and potentially up to two metres)
- Increased frequency of winter storms
- Increased coastal flooding
- Increased temperatures
- Higher levels of winter precipitation, particularly along the northern and western coastlines
- Increased rates of coastal erosion and sediment reworking (resulting in reconfiguration, relocation and decline of coastal sedimentary processes).

The most vulnerable subgroups in society, which include coastal communities, continue to be disproportionately affected, as witnessed in severe storm and flooding events in the UK in recent years (Zsamboky et al. 2011). The most vulnerable coastal communities in the UK are likely to be in south Wales, north-west Scotland, Yorkshire, Lincolnshire, East Anglia and the Thames Estuary. This is due both to the physical threats, but also through damage to local economies, industry and infrastructure, and the limited capacity of the communities most at risk to respond (Zsamboky et al. 2011). Health and wellbeing threats from extreme events or

physical environmental changes are strongly influenced by the mitigation capacity of built and natural infrastructure (Hames and Vardoulakis 2012).

As well as posing a direct threat to health (e.g. though extreme acute events), the rise in sea levels and flooding and storm surges associated with climate change threaten built infrastructure, including ports, roads and rail lines, upon which individual and societal health and wellbeing depend. The storm surge of 1953, which raised sea levels by 5.6 metres (18.4 ft) above mean levels, resulted in the deaths of 326 people in England and Wales (and of a further 1800 people in the Netherlands and Belgium), with damage valued at approximately £1.2 billion (in 2016 values) (Met Office 2016). The 2017 Committee on Climate Change risk assessment identifies flooding and coastal change as one of the six immediate priority areas for climate change action. Key risks are associated with the vulnerability of specific categories of built infrastructure including residential homes, industrial buildings, hospitals and other care facilities (Committee on Climate Change 2017; Hames and Vardoulakis 2012). The Committee noted that there are likely to be considerable long-term health and wellbeing impacts of climate-change-related flood events, but that these are currently little understood and research is needed to assess and mitigate risks (Committee on Climate Change 2017).

2.2.2 Loss of 'Natural' Sea Defences

Overall, the environmental state of coastal habitats has declined since 1945, degrading ecosystem service[1] provision. This, in turn, reduces the resilience to climate change, and adversely affects coastal economies, employment, health and wellbeing (Jones et al. 2011).

The loss of intertidal habitats and coastal features (natural coastal or marine ecosystems, and 'green/blue infrastructure'), due to climate change, development and erosion, removes the natural 'buffering' of wave energy, thereby threatening the UK's coastal defences, with direct implications for human health and wellbeing. Most notably, experiencing flooding can have major short and long-term effects on mental health and wellbeing (Stanke et al. 2012). Good medical advice and social support can help protect against negative psychosocial impacts of flooding and may need to be made more widely available in the future (Public Health England 2014).

Policymakers should note the enormous value of coastal ecosystems in protecting coastal urban communities. A notable example was the fate of New York City and the surrounding area of Jamaica Bay when Hurricane Sandy hit in October 2012. Extensive storm damage and flooding resulted in 60 deaths in New York and New Jersey together with thousands of injuries, over $20 billion in property damage, and $10–30 billion in lost business. Degradation of coastal wetlands and poor urban planning exacerbated the impacts (Figure 3). Currently, extremely costly measures are being taken to restore the Jamaica Bay wetland to provide greater protection and resilience in the future (Lloyd 2014).

1 Ecosystem services are the benefits provided by ecosystems that contribute to making human life both possible and worth living.

Figure 3. Jamaica Bay, New York showing the vulnerability of the coastal community to sea-level rise, tidal surges and storms

2.2.3 Coastal Erosion

Coastal erosion (naturally occurring or due to anthropogenic activity) threatens the homes, livelihoods and wellbeing of some coastal communities (notably in the east of England). The British Geological Association estimated that across England and Wales, 113,000 residential properties, 9000 commercial properties and 5000 hectares of agricultural land are at risk of coastal erosion, with a total capital value of these assets of approximately £7.7 billion (British Geological Survey 2012). Sudden coastal erosion poses a particularly acute risk; while there are no officially collated numbers, events such as landslides associated with such erosion events can pose an immediate threat to life (Harley 2017).

2.2.4 Ecological Threats

Marine species often invade new areas following environmental change and such occurrences are increasing due to climate change (Occhipinti-Ambrogi 2007). Nutrient pollution from agriculture and sewage (and rising sea temperatures) may be increasing the frequency and extent of coastal harmful algal blooms (HABs), which in turn affect the marine food web and human health (Fleming et al. 2015). Marine microalgae can produce potent and persistent natural toxins that are harmful or even lethal to humans (Berdalet et al. 2016). Toxicity is usually associated with ingestion of contaminated seafood products (fish or shellfish), skin contact with contaminated water, or the inhalation of aerosolised toxins or noxious compounds. Blooms can lead to disruption in coastal economies (including aquaculture), and reduced seafood security.

2.3 Pollution of the Coast and Oceans

Public health is affected, both directly and indirectly, by physical, chemical and microbial pollution of the sea resulting from human activities. Contamination is greatest in coastal waters (Intergovernmental Oceanographic Commission 2002). Although major point sources are now regulated, diffuse pollution is a growing problem. Examples of marine pollutants that threaten human health include:

- **Industrial, domestic and medical chemicals**, including persistent pollutants (e.g. heavy metals and metalloids, pesticide residues, persistent organic chemicals, oil and dispersants, pharmaceuticals residues, radioisotopes, nanomaterials, plastics, etc. (Depledge et al. 2013b). The insidious long-term effects of the slow accumulation of low concentrations of environmental chemicals (especially from seafood) within food chains and the human body are of growing concern as they have been implicated in chronic disease processes that severely affect people's health. As populations age, pharmaceutical use will increase, resulting in greater amounts of pharmaceutically active compounds entering the sea via sewage systems and from agricultural use (Fleming et al. 2015; Redshaw et al. 2013).
- **Soil, silt, sediments and nutrient runoff** from land into the sea affect water quality and nutrient cycles. This has a range of consequences to human health including the disruption of coastal businesses, tourism and the livelihoods of the wider community.
- **Microbial pollution** (bacteria, viruses, fungi and parasites) from the discharge of human sewage and animal waste (particularly agricultural runoff). Pathogens can cause gastrointestinal, respiratory and dermatological diseases in humans through direct skin and aerosol contact and incidental ingestion during swimming, as well as through the food chain transfer (Depledge et al. 2013b; Leonard et al. 2015).
- **Antimicrobial-resistant pathogens** (such as methicillin-resistant *Staphylococcus aureus* – MRSA) can arise in the coastal environment. The broader significance of this phenomenon is currently being evaluated (Fleming et al. 2015; Leonard et al. 2015).
- **Air pollutants** (for example, from ships and power stations) include particulates, sulphur dioxide (SO_2) and nitrogen oxides (NO_x) that lead to illness and premature death (Marine Management Organisation 2013).
- **Underwater noise** from shipping and drilling, and **heat emissions** from power station cooling can damage fisheries with consequential impacts to coastal community wellbeing (Marine Management Organisation 2013).
- **Marine litter**, from multiple sources but particularly plastics, affects the utility of beaches and the sea, impacts the lives of local residents who are dependent on maritime industries such as tourism and fishing, and has been shown to be entering the food chain (Depledge et al. 2013a).

Of note, climate change is likely to redistribute contaminants and alter uptake, toxicity and degradation, affecting the distribution and availability of some commercially important marine species, influencing biodiversity and potentially altering the level of threat to humans from seafood contamination, microbial pathogens, algal toxins and invasive species (MacLeod et al. 2012).

3. Threats to the Health Benefits of Coastal Areas

Counter-balancing actual and potential threats to the health and wellbeing of coastal communities are a wide range of health-promoting opportunities. The UK coastline has been used in attempts to 'cure' specific health conditions for hundreds of years, culminating in the construction of several 'sea bathing hospitals' in the late 18th and early 19th centuries (Fortescue-Fox and Lloyd 1938). More recently, there has been growing appreciation that natural environments, including marine and coastal settings, are important contexts for public health promotion (Dahlgren and Whitehead 2007; Lang and Rayner 2012; Maxwell and Lovell 2017).

Although some coastal communities are among the most deprived in the country (DCLG 2016), relatively speaking, the health of coastal residents seems less affected by socio-economic disadvantages than similar communities inland (see section 1.3) (Wheeler et al. 2012). Explanations for this pattern relate to a range of physical, mental and social wellbeing benefits associated with coastal living. However, any loss of the current health-promoting potential of coastal environments will negatively impact on the health and wellbeing of coastal communities. Health practitioners and planning authorities should take steps to avoid, or at least mitigate, the loss of these health-promoting factors and opportunities. Table 2 summarises key health benefits which are or may be threatened by factors such as climate change, extreme events or socio-economic change (such as those noted in previous sections) (the table was synthesised from a number of sources including: Bell et al. 2015; Berry et al. 2011; Cherrie et al. 2015; Devine-Wright 2013; Lund 2013; Nesheim and Yaktine 2007; Reed et al. 2013; Urquhart and Acott 2013; Völker et al. 2013; Weichselbaum et al. 2013; Wheeler et al. 2012; White et al. 2013, 2014; Wood et al. 2016).

Table 2. Risks of losing health and wellbeing benefits associated with coastal areas

Risk category	Loss pathway	Key Health/Wellbeing Outcome(s) loss	Impact	Likelihood	Extent
Reduced nutritional potential of seafoods	Pollution, climate change (ocean acidification, HABs, extreme events)	(Micro)nutrients in seafood (e.g. protein, B-vitamins, selenium, iodine) and poly-unsaturated fatty acids are linked to brain and central nervous system development during infancy and childhood	Adverse, low-level, chronic effects	High already occurring (increasing)	Widespread
Reduced exposure (via visits or residence) to coastal areas	Pollution, climate change, extreme events, morphological change, socio-cultural change	Reduction in physical activity (linked to increased rates of overweight and non-communicable diseases), poorer mental health	Adverse low-level, chronic effects	High already occurring (increasing)	Widespread
Loss of social capital via coastal community fragmentation	Pollution, climate change, extreme events, morphological change, socio-cultural change	Strong social capital networks with individuals having well defined attachment to their environment, and with long-established cultural associations with particular practices such as fishing, are important factors in community wellbeing	Adverse, low-level chronic effects	High	Local
Inadequate planning to maximise health potential of coastal development	Climate change, extreme events, morphological change	Well-designed coastal cities have reduced risk of heat-related ill health and deaths (compared to similar locations inland) as ambient temperatures tend to be lower near water. Risks of flooding can also be reduced by planning	Acute, severe, and low-level chronic adverse effects	High	Widespread

4. Policy Implications and Opportunities

The health and wellbeing of the UK's highly diverse coastal communities face serious threats now and in the coming decades; the mixture of climate change and sea-level rise, pollution and continuing development pressures, and socio-demographic change of human populations is key. The often remote, peripheral and linear nature of the marine environment exacerbates these threats. There is, however, much that can be done through policy and other interventions to capitalise on numerous opportunities to gain health benefits from coastal environments, thereby promoting wellbeing and community resilience. Key are the inter-sectoral policies, with

co-beneficial outcomes (relating to both environmental and health outcomes, see examples given in Figure 4), which derive from a shared responsibility for the future of coastal communities.

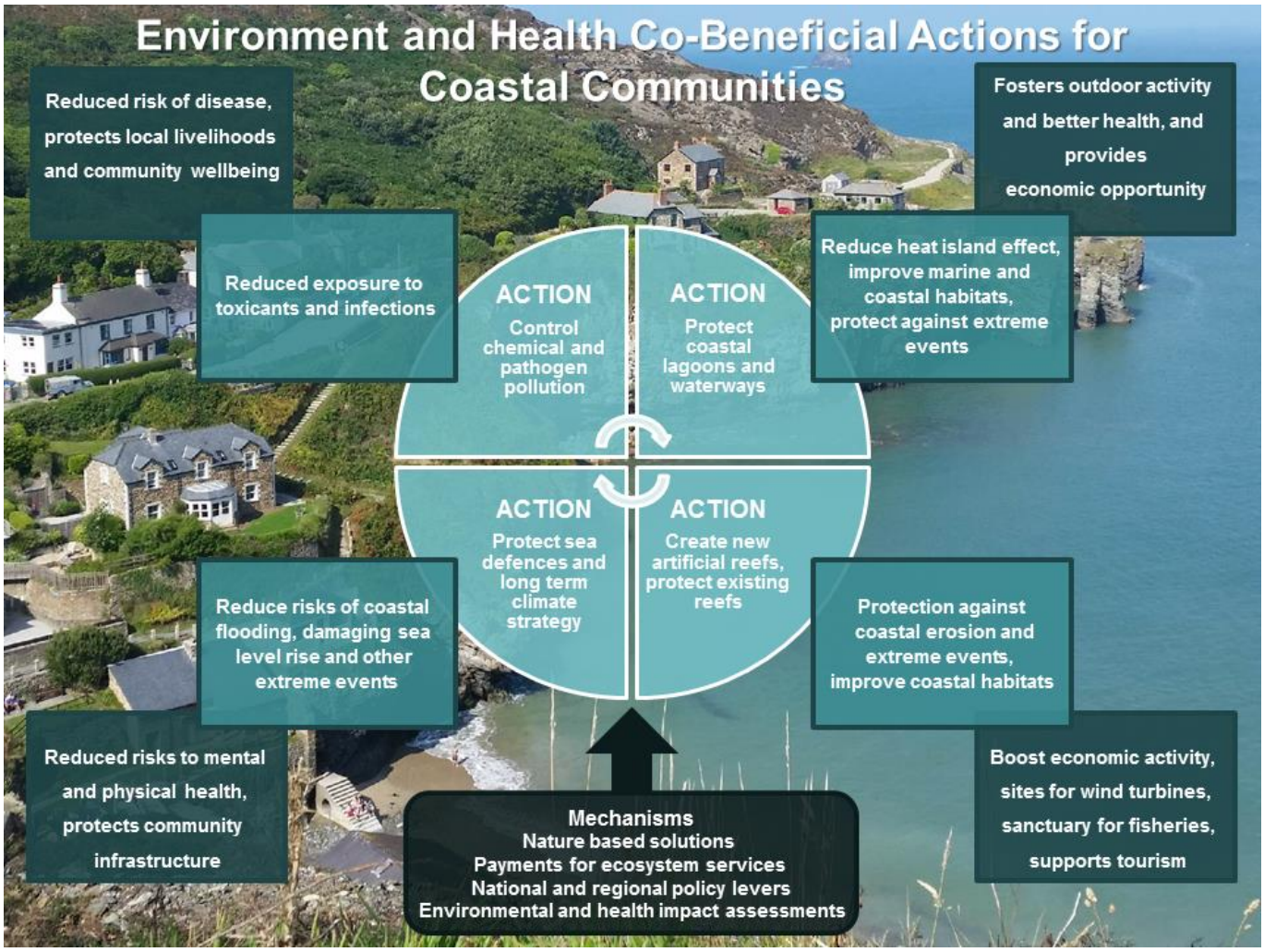

Figure 4. Potential environment and health co-beneficial actions for coastal communities

4.1 Evidence for Future Policy Strategy and Approaches

- There is clear evidence of **the diversity of coastal communities and their economic activity**. This suggests that future interventions should reflect this diversity, and recognise new economic opportunities for coastal communities, beyond 'traditional' forms of employment.
- Evidence suggests that **Marine Spatial Planning** can potentially provide a mechanism for the provision of economic growth in coastal zones in line with the development of healthy coastal communities (e.g. Papathanasopoulou et al. 2016) and the UN Sustainable Development Goals.

4.2 Urbanisation and Socio-demographic Change

- Evidence suggests that the **inappropriate development of coastal communities can damage local wellbeing and health and damage** marine and coastal ecosystems (Zsamboky et al. 2011).
- Evidence shows that **residential and commercial development** by the sea has an impact on health and wellbeing, and can affect resilience to climate-related future threats (European Marine Board 2013; Oven et al. 2012).

4.3 Economic and Industry

- Evidence shows that there are risks that **the development of new coastal industries do not necessarily flow downstream to benefit coastal communities** (Morrissey 2017).
- Evidence suggests that there is a need to be aware of and to carefully **balance the positive and negative societal impacts of coastal tourism** and other forms of industrial change to coastal communities.

4.4 Health Threats of Climate and Environmental Change

- The risks posed by **pollution, contamination of seafood, and the emergence of new chemicals** (nanomaterials, pharmaceutical residues, antibiotics) in coastal ecosystems requires thorough evaluation.
- Evidence shows that some policy options can have multiple benefits to both health and the environment, e.g. the emerging '**nature-based solutions**' such as multifunctional wetland restoration programmes or artificial reefs (Figure 4).

4.5 Knowledge

- A better understanding of (i) the combination/s of vulnerabilities faced by coastal communities and (ii) how to balance the risks and benefits of coastal residence would be beneficial. Rigorous analyses of **demographic and socio-economic trends** in the range of coastal communities around the UK would allow appropriate actions to be taken to meet specific health and wellbeing objectives. Development of scenarios, analysis of future trends and laying out a vision of what is a desirable future for coastal communities would provide insights into how coastal communities might change in the coming years.
- The integration of health and wellbeing outcomes into **natural capital** approaches could help clarify the full effects of economic activity (e.g. coastal tourism, fisheries including aquaculture, marine biotechnology), local development and marine management options on coastal communities.

References

Bell, S.L., Phoenix, C., Lovell, R. and Wheeler, B.W. (2015) Seeking Everyday Wellbeing: The Coast as a Therapeutic Landscape. *Social Science & Medicine* 142, 56–67.

Berdalet, E., Fleming, L.E., Gowen, R., Davidson, K. et al. (2016) Marine Harmful Algal Blooms, Human Health and Wellbeing: Challenges and Opportunities in the 21st Century. *Journal of the Marine Biological Association of the United Kingdom* 96 (1), 61–91.

Berry, D.J., Hesketh, K., Power, C. and Hyppoenen, E. (2011) Vitamin D Status has a Linear Association with Seasonal Infections and Lung Function in British Adults. *British Journal of Nutrition* 106 (9), 1433–1440.

Bowen, R., Depledge, M., Carlarne, C. and Flemming, L. (eds) (2014) *Oceans and Human Health: Implications for Society and Well-Being*. Chichester: Wiley-Blackwell.

Boxall, A.B.A., Hardy, A., Beulke, S., Boucard, T. et al. (2009). Impacts of Climate Change on Indirect Human Exposure to Pathogens and Chemicals from Agriculture. *Environmental Health Perspectives* 117 (4), 508–514.

British Geological Survey (2012) *Coastal Erosion*. UK Geohazard note. Nottingham: Natural Environment Research Council.

Cave, B. (2010) Health, Wellbeing and Regeneration in Coastal Resorts. In J.K. Walton and P. Browne (eds) *Coastal Regeneration in English Resorts*. Lincoln: Coastal Communities Alliance.

Cherrie, M.P.C., Wheeler, B., White, M.P., Sarran, C.E. and Osborne, N.J. (2015) Coastal Climate is Associated with Elevated Solar Irradiance and Higher 25(OH)D Level in Coastal Residents. *Environment International* 77, 76–84.

Coastal Communities Alliance (2015) Coastal Communities Teams. Coastal Communities Alliance website, http://www.coastalcommunities.co.uk/coastal-community-teams (accessed 2 August 2016).

Committee on Climate Change (2016) UK Climate Change Risk Assessment 2017 – Synthesis Report: Priorities for the Next Five Years. London: CCC.

Dahlgren, G. and Whitehead, M. (2007) A Framework for Assessing Health Systems from the Public's Perspective: The ALPS Approach. *International Journal of Health Services* 37 (2), 363–378.

DCLG – Department for Communities and Local Government (2016) Coastal Communities Fund Annual Progress Report, 2015. UK Government and Big Lottery Fund.

Depledge, M.H., Galgani, F., Panti, C., Caliani, I. et al. (2013a) Plastic Litter in the Sea. *Marine Environmental Research* 92, 279–281.

Depledge, M.H., Tyrrell, J., Fleming, L.E. and Holgate, S.T. (2013b) Are Marine Environmental Pollutants Influencing Global Patterns of Human Disease? *Marine Environmental Research* 83, 93–95.

Devine-Wright, P. (2013) Think Global, Act Local? The Relevance of Place Attachments and Place Identities in a Climate Changed World. *Global Environmental Change* 23 (1), 61–69.

European Environment Agency (2013) Late Lessons from Early Warnings: Science, Precaution, Innovation. Copenhagen: EEA

European Marine Board (2013) Linking Oceans and Human Health: A Strategic Research Priority for Europe. EMB Position Paper 19. Ostend, Belgium: European Marine Board.

European Marine Safety Agency (2015) Annual Overview of Marine Casualties and Incidents 2015. Lisbon, Portugal: EMSA.

FAO/WHO (2011) Report of the Joint FAO/WHO Expert Consultation on the Risks and Benefits of Fish Consumption. Rome, 25–29 January 2010. FAO Fisheries and Aquaculture Report 978. Rome: Food and Agriculture Organization.

Fleming, L., Depledge, M., McDonough, N., White, M. et al. (2015) *Oceans and Human Health, Environmental Science*. Oxford Research Encyclopedias.

Fleming, L., McDonough, M., Austen, N., Mee, M. et al. (2014) Oceans and Human Health: A Rising Tide of Challenges and Opportunities for Europe. *Marine Environment Research* 99:16–19.

Fortescue Fox, R. and Lloyd, W.B. (1938) Convalescence on the Coast. *The Lancet* 232, 37–39.

Hames D., and Vardoulakis, S. (2012) Climate Change Risk Assessment for the Health Sector. London: Department for Environment Food and Rural Affairs.

Herr, D. and Galland, G. (2009) The Ocean and Climate Change; Tools and Guidelines for Action. Gland, Switzerland: International Union for Conservation of Nature.

Huber, M., Knottnerus, J. A., Green, L., Horst, H.v.d. et al. (2011) How Should We Define Health? *BMJ* 343 (d4163).

Intergovernmental Oceanographic Commission (2002) The Final Design Plan for the HOTO Module of GOOS. Global Ocean Observing System Report 99. Paris: UNESCO.

James Hutton Institute (n.d.) Scotland's Coastal Assets. Aberdeen: JHI.

Jones, L., Angus, S., Cooper, A., Doody, P. et al. (2011) Coastal Margins. In The UK National Ecosystem Assessment: Technical Report. Cambridge: UNEP-WCMC.

Lancaster City Council (2006) Memorandum by Lancaster City Council (CT 04) Parliamentary Select Committee on Office of the Deputy Prime Minister: Housing, Local Government and the Regions Written Evidence.

Lang, T. and Rayner, G. (2012) Ecological Public Health: The 21st Century's Big Idea? *BMJ*, 345 (e5456).

Lee, V. (2014) Climate Change: Abandon Coastal Cities. Arup.

Leonard, A.F., Zhang, L., Balfour, A.J., Garside, R. and Gaze, W.H. (2015) Human Recreational Exposure to Antibiotic Resistant Bacteria in Coastal Bathing Waters. *Environment International* 82: 92–100.

Lloyd, E. (2014) Jamaica Bay Watershed Protection Plan (Update). New York City Department of Environmental Protection.

Lund, E.K. (2013) Health Benefits of Seafood; Is it Just the Fatty Acids? *Food Chemistry* 140 (3), 413–420.

MacLeod, C., Fallon, P.D., Evans, R. and Haygarth, P. (2012) Effects of Climate Change on the Mobilization of Diffuse Substances from Agricultural Systems. *Advances in Agronomy* 115, 41–77.

Marine Accident Investigation Board (2016) Safety Digest; Lessons from Marine Accident Reports 2/2016. Southampton, UK: MAIB.

Marine Management Organisation (2013) Strategic Scoping Report for Marine Planning in England. Newcastle upon Tyne, UK: MMO.

Marine Management Organisation (2016) Communities Report Card. Newcastle upon Tyne, UK: MMO.

Maxwell, S. and Lovell, R. (2017) Evidence Statement on the Links Between Natural Environments and Human Health. London: Department for Environment, Food and Rural Affairs.

Met Office (2016) 1953 East Coast Flood – 60 Years On. http://www.metoffice.gov.uk/news/in-depth/1953-east-coast-flood (accessed 20 December 2016).

Moore, M.N., Depledge, M.H., Fleming, L., Hess, P. et al. (2013) Oceans and Human Health (OHH): A European Perspective from the Marine Board of the European Science Foundation (Marine Board-ESF). *Microbial Ecology* 65 (4), 889–900.

Morrissey, K. (2014) Using Secondary Data to Examine Economic Trends in a Subset of Sectors in the English Marine Economy: 2003–2011. *Marine Policy* 50, 135–141.

Morrissey, K. (2015) An Inter and Intra-Regional Exploration of the Marine Sector Employment and Deprivation in England. *The Geographical Journal* 181 (3), 295–303.

Morrissey, K. (2017) Economics of the Marine Sector: Modelling Natural Resources. London: Rowman & Littlefield.

Mozaffarian, D. and Rimm, E. (2006) Fish Intake, Contaminants, and Human Health: Evaluating the Risks and the Benefits. *The Journal of the American Medical Association*, 296 (15), 1885–1899.

Nesheim, M.C. and Yaktine, A. (2007) *Seafood Choices: Balancing Benefits and Risks.* Committee on Nutrient Relationships in Seafood Selections to Balance Benefits and Risks. Institute of Medicine. Washington, DC: National Academies Press.

Occhipinti-Ambrogi, A. (2007) Global Change and Marine Communities: Alien Species and Climate Change. *Marine Pollution Bulletin* 55, 342–352.

Office for National Statistics (2014) Coastal Communities in England and Wales. 2011 Census. London: ONS.

Oven, K., Curtis, S., Reaney, S., Riva, M. et al. (2012) Climate Change and Human Health: Defining Future Hazard, Vulnerability and Risk for Infrastructure Systems Supporting Older People's Health Care in England. *Journal of Applied Geography* 33, 16–24

Papathanasopoulou, E., White, M.P., Hattam, C., Lannin, A. et al. (2016) Valuing the Health Benefits of Physical Activities in the Marine Environment and their Importance for Marine Spatial Planning. *Marine Policy* 63, 144–152.

Pennington, J. (2013) Moving On: Migration Trends in Older Life. London: Institute for Public Policy Research; Staines, UK: Hanover Housing Association.

Public Health England (2014) Flooding and Mental Health: Essential Information for Front-Line Responders. Extreme Events and Health Protection. London: Public Health England.

Redshaw, C.H., Stahl-Timmins, W., Fleming, L.E., Davidson, I., and Depledge, M.H. (2013) Potential Changes in Disease Patterns and Pharmaceutical Use in Response to Climate Change. *Journal of Toxicology and Environmental Health Part B: Critical Reviews* 16 (5), 285–320.

Reed, M., Courtney, P., Urquhart, J. and Ross, N. (2013) Beyond Fish as Commodities: Understanding the Socio-Cultural Role of Inshore Fisheries in England. *Marine Policy* 37, 62–68.

Simpson, M. (2013) Impacts of Climate Change on Tourism (and Marine Recreation). *Marine Climate Change Impacts Partnership: Science Review* 2013, 271–283.

Smith, D. (2012) The Social and Economic Consequences of Housing in Multiple Occupation (HMO) in UK Coastal Towns: Geographies of Segregation. *Transactions of the Institute of British Geographers* 37 (3), 461–467.

Stanke, C., Murray, V., Amlôt, R., Nurse, J. and Williams, R. (2012) The Effects of Flooding on Mental Health: Outcomes and Recommendations from a Review of the Literature. *PLoS Currents Disasters* 1; doi: 10.1371/4f9f1fa9c3cae

Surís-Regueiro, J.C., Garza-Gil, M.D. and Varela-Lafuente, M.M. (2014) Socio-Economic Quantification of Fishing in a European Urban Area: The Case of Vigo. *Marine Policy* 43, 347–358.

Turner, R. and Szaboova, L. (2017) Improving Access to Health and Wellbeing Support in UK Fishing Communities: Project Report. University of Exeter.

Turner, R., Abernethy, K., Woodhead, A. and Brown, K. (2015) Health and Hidden Vulnerability in UK Fishing-Dependent Communities. Workshop Summary Note (15 September). University of Exeter.

UK National Ecosystem Assessment (2011) The UK National Ecosystem Assessment: Technical Report. Cambridge: UNEP-WCMC.

UNU-IHDP (2015) Coastal Zones and Urbanization. Summary for Decision-Makers. Bonn, Germany: International Human Dimensions Programme on Global Environmental Change.

Urquhart, J. and Acott, T. (2013) Constructing 'The Stade': Fishers' and Non-Fishers' Identity and Place Attachment in Hastings, South-East England. *Marine Policy* 37, 45–54.

Völker, S., Baumeister, H., Claßen, T., Hornberg, C. and Kistemann, T. (2013) Evidence for the Temperature-Mitigating Capacity of Urban Blue Space – A Health Geographic Perspective. *Erdkunde* 67 (4), 355–371.

Ward, K.J. (2015) Geographies of Exclusion: Seaside Towns and Houses in Multiple Occupancy. *Journal of Rural Studies* 37, 96–107.

Watts, N., Adger, W.N., Agnolucci, P., Blackstock, J. et al. (2015) Health and Climate Change: Policy Responses to Protect Public Health. *The Lancet* 386 (10006), 1861–1914.

Weichselbaum, E., Coe, S., Buttriss, J. and Stanner, S. (2013) Fish in the Diet: A Review. *Nutrition Bulletin* 38 (2), 128–177.

Wheeler, B.W., Lovell, R., Higgins, S.L., White, M.P. et al. (2015) Beyond Greenspace: An Ecological Study of Population General Health and Indicators of Natural Environment Type and Quality. *International Journal of Health Geographics* 14 (1).

Wheeler, B., White, M.P., Stahl-Timmins, W. and Depledge, M.H. (2012) Does Living by the Coast Improve Health and Wellbeing? *Health & Place* 18, 1198–1201.

White, M.P., Alcock, I., Wheeler, B.W. and Depledge, M.H. (2013) Coastal Proximity and Health: A Fixed Effects Analysis of Longitudinal Panel Data. *Health & Place* 23, 97–103.

White, M.P., Wheeler, B.W., Herbert, S., Alcock, I. and Depledge, M.H. (2014) Coastal Proximity and Physical Activity: Is the Coast an Underappreciated Public Health Resource? *Preventive Medicine* 69,135–140.

Wood, S.L., Demougin, P.R., Higgins, S., Husk, K. et al. (2016) Exploring the Relationship between Childhood Obesity and Proximity to the Coast: A Rural/Urban Perspective. *Health & Place* 40, 126–136.

Zsamboky, M., Fernández-Bilbao, A., Smith, D., Knight, J. and Allan, A. (2011) *Impacts of Climate Change on Disadvantaged UK Coastal Communities*. York, UK: Joseph Rowntree Trust.

This publication available from www.gov.uk/go-science

Contacts us if you have any enquiries about this publication, including requests for alternative formats, at:

Government Office for Science
1 Victoria Street
London SW1H 0ET
Tel: 020 7215 5000
Email: contact@go-science.gsi.gov.uk