# CHAPTER 8.
# Assessment of Natural Resources Use for Sustainable Development - DPSIR Framework for Case Studies in Portsmouth and Thames Gateway, U.K.

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## List of acronyms and units

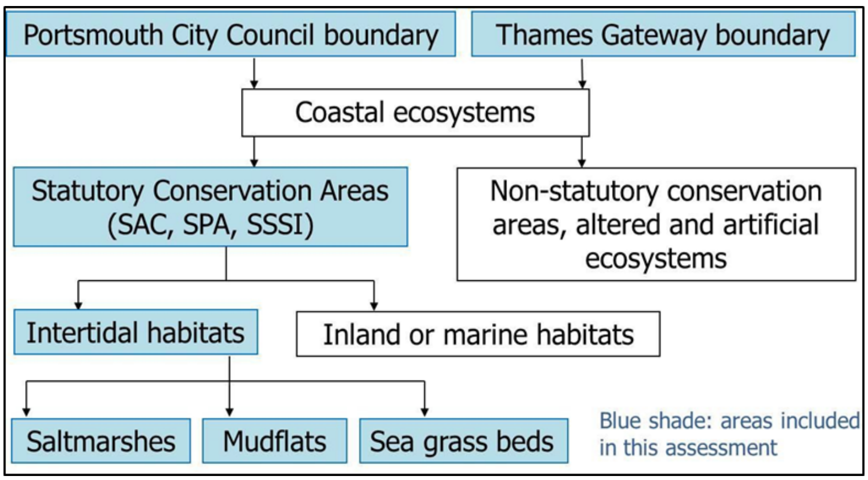
| | |
|---|---|
| **BAP** | UK Biodiversity Action Plan |
| **°C** | degrees Celsius |
| **c.** | circa |
| **CD** | Chart Datum |
| **DCLG** | Department of Communities and Local Government |
| **DPSIR** | Drivers-Pressure-State-Impacts-Response |
| **EU** | European Union |
| **EC** | European Commission |
| **ha** | hectares |
| **HRA** | Habitats Regulations Assessment |
| **Ie** | environmental impacts |
| **Is** | socioeconomic impacts |
| **IPCC** | Intergovernmental Panel for Climate Change |
| **IPPC** | Integrated Pollution Prevention and Control |
| **IS** | Index of Sustainability |
| **ISrank** | Ranking value based on the Index of Sustainability |
| **JNCC** | Joint Nature Conservation Committee |
| **LDD** | Local Development Documents |
| **LSOA** | Lower Layer Super Output Area |
| **PCC** | Portsmouth City Council |
| **PPS** | Planning Policy Statement |
| **RIS** | Relative Index of Sustainability |
| **RISrank** | Ranking value based on the Relative Index of Sustainability |
| **SAC** | Special Area of Conservation |
| **SPA** | Special Protection Area |
| **SECOA** | Solutions for Environmental Contrasts in Coastal Areas |
| **SIC** | UK Standard Industrial Classification of Economic Activities |
| **SSSI** | Site of Special Scientific Interest |
| **UK** | United Kingdom |

# 1. Introduction

Natural habitats in the areas of Portsmouth and Thames Gateway have been greatly modified during a long history of human occupation. As a result, only a small part of the original natural coastal habitats still remains, comprising mainly of intertidal flats and saltmarshes. Due to the importance of these intertidal habitats for biodiversity and supply of ecosystem services, they are now designated conservation areas of national and international importance. This study uses the DPSIR framework to assess the sustainability of the intertidal environments within the boundaries of Portsmouth City Council (PCC) and Thames Gateway, focusing on six statutory conservation areas (Figure 8.5 and Figure 8.6). These areas are protected by more than one designation: Ramsar Sites (wetland areas of international importance designated by the government under the terms of the Ramsar Convention); Special Protection Areas (SPAs are designated under the European Birds Directive to protect rare and vulnerable species of birds); Special Areas of Conservation (SACs are designated under the European Habitats Directive to protect important habitats and their wildlife) and Sites of Special Scientific Interest (SSSIs are recognised for their nationally important wildlife and/or geology and are legally protected under the Wildlife and Countryside Act of 1981 and the Countryside and Rights of Way Act of 2000). Some of these designated areas extend beyond the boundaries of the SECOA study sites, but the DPSIR assessment will concentrate only on the areas within the project's study sites (of which the areal extent is shown in Figure 8.5). As the designated areas overlap and some of the qualifying features are common to more than one designation, the extent of the SSSIs is used here to assess current conditions of legally protected intertidal habitats. The DPSIR analysis focuses on changes occurring within the last two decades and considers previous and long-term factors when they are relevant to the background condition of the study areas. Although this assessment is focused at the local level (i.e. within the study areas), national and international drivers and pressures with significant local influence are also considered.

This study uses the DPSIR framework to assess the sustainability of the intertidal environments within the boundaries of PCC and Thames Gateway, with focus on statutory conservation areas (Figure 8.1). Analysis based on the DPSIR framework can contribute to the protection and the sustainable use of the coastal and marine environment (Turner et al. 2010) by quantifying the main pressures and economic drivers causing a negative impact and identifying efficient and cost-effective policy options. The analysis will concentrate on internationally designated conservation areas to describe the state of the environment (environmental quality), quantify trends of changes (impacts), analyse the main pressures and drivers of change and, by the use of selected indicators, provide a relative comparison of the long term sustainability of these areas. Six statutory conservation areas are included in this study (Figure 8.5), two in Portsmouth (Portsmouth and Langstone harbours) and four in the Thames Gateway (Thames Estuaries and Marshes, Medway Estuaries and Marshes, Swale, and Benfleet and Southend Marshes). As c. 90% of Foulness lies outside the SECOA study area, it will not be considered in this assessment.

*Figure 8.1. In the UK the DPSIR analysis focuses on intertidal habitats within statutory conservation areas, as indicated by the blue shaded boxes.*




## 2. Materials and methodology

### 2.1. Sources and data

- For this study, data was compiled through literature search and by using various sources, most important are:
- DCLG (Department for Communities and Local Government) - Generalized Land Use Database of 2001 and 2005.
- Ordnance Survey MasterMap - data were reclassified to enable comparison with Generalised Land Use Database 2005.
- JNCC (Joint Nature Conservation Committee) – GIS layers of internationally designated conservation areas (SAC, SPA, Ramsar).
- Natural England – data and reports on the state of conservation of SSSI units.

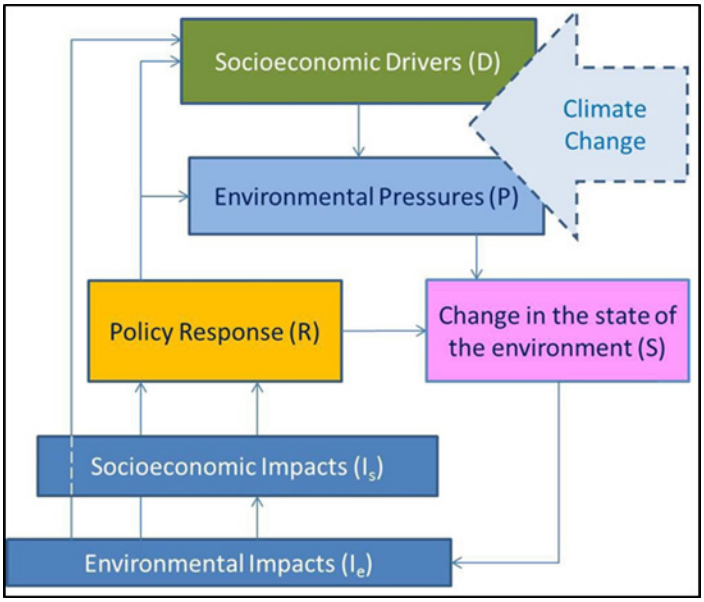
- Office for National Statistics - population growth for the period 2001 to 2009 based on the Mid-2009 Lower Layer Super Output Area (LSOA) and the number of firms (in 2003 and 2008) at Ward level as provided in the Annual Business Inquiry.
- Meteorological Office.

## 2.2. Methods

The DPSIR framework is used here to identify the socio-economic drivers that influence environmental pressures and lead to changes in the state of saltmarshes and mudflats in the two UK study areas. As part of the DPSIR analysis, the environmental and socio-economic impacts of the change in the state of the selected intertidal habitats are assessed, in conjunction with the effects of policy responses. The analysis focuses on changes occurring within the last decade and considers previous and long-term factors when they are relevant to the background condition of the study areas. Although this assessment is focused at the local level (i.e. within the study areas), forces (drivers and pressures) acting at larger spatial scales with significant local influence are also considered. The structure of the analysis is based on the DPSIR framework proposed by Turner et al. (1998), which was modified to fit the purpose of this assessment.

Figure 8.2 illustrates the conceptual framework of the DPSIR analysis applied to assess the sustainability of intertidal habitats within statutory conservation areas of Portsmouth and the Thames Gateway. The methodological approach started with the identification of the main drivers influencing the state of intertidal habitats and the resulting environmental pressures. Together with the main socioeconomic drivers (S), climate change impacts (especially sea-level rise) are included here due to the considerable pressure they pose on the long-term sustainability of intertidal habitats. The next step includes the assessment of the environmental pressures (P) caused by both socioeconomic drivers and climate change impacts and the resulting changes in the state of the environment (S). The main pressures were identified through a literature search based on assessments of the conservation of designated areas (i.e. reports from Natural England), official "state of the environment" reports (e.g. produced by the Environment Agency) and scientific publications. Changes in the state of the environment will invariably cause direct environmental impacts (Ie) and these, when significant, lead to socioeconomic impacts (Is). The realisation of Ie or Is (originated from Ie) calls for responses (R), usually in the form of policies aiming to lessen the S or reduce the D and P. It is also possible that Ie (sometimes by causing Is) can directly influence D without the implementation of formal policies.

*Figure 8.2. The DPSIR framework used in the assessment of sustainability of intertidal habitats within Portsmouth and Thames Gateway.*




Selected indicators are used here to quantify changes over time and estimate an index for the sustainable maintenance of legally protected intertidal habitats. The eight selected indicators reflect observed changes in relevant D, P, S and Ie. According to Cave et al. (2003), useful indicators must be: (a) relevant to the issue under consideration (i.e. conservation of intertidal habitats); (b) practical to measure at the required time and spatial scale; (c) fully and easily understood and (d) comparable between study sites. The selected indicators are described below and summarised in Table 8.1.

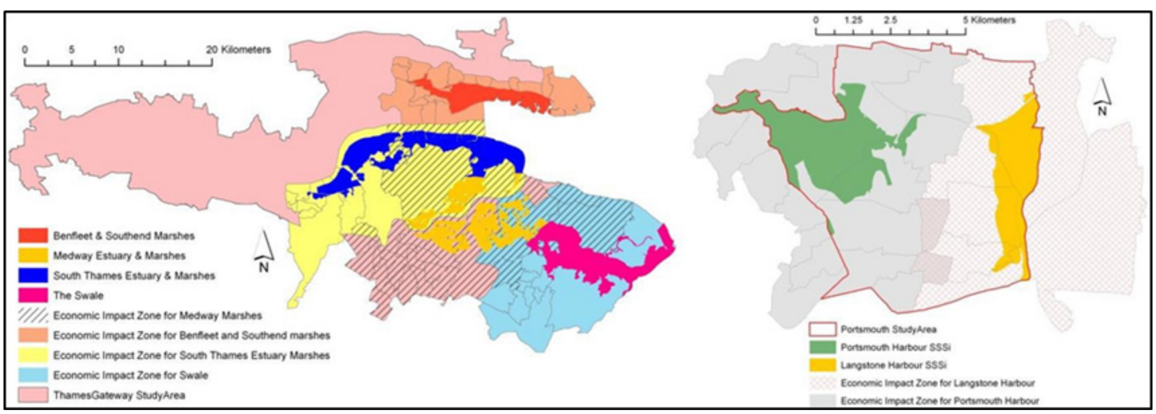
1. Population growth. It is assumed that population growth is a main driver leading to a number of interlinked environmental pressures. For example, population growth leads to coastal development, which results in land use change (e.g. increase in urban areas and reduction in natural habitats), demand for space (e.g. conflicts of use between development and nature conservation) and pressure on natural resources (waste production, water abstraction, deforestation, pollution, overfishing etc.). The population growth for each SSSI unit was estimated for the period 2001 to 2009 based on the Mid-2009 Lower Layer Super Output Area (LSOA) data provided by the Office for National Statistics[1]. The population within Wards bordering the SSSI was considered to have a

[1] http://www.statistics.gov.uk/statbase/Product.asp?vlnk=14357.

more direct impact over the conservation areas and was affected more directly by each SSSI unit. Therefore LSOA units belonging to the bordering Wards were included in the estimates of population growth.

2. Change in number of industries. This indicator reflects local economic changes, which in turn influence population mobility and determine the type and intensity of demand for natural resources (e.g. industrial discharges, traffic, water usage, demand for office space, land use change etc.). Data on the number of firms at two time points (2003 and 2008) are available for the study areas from the Annual Business Inquiry, Office of National Statistics at Ward level only. Areas of economic impact were defined based on the proximity of economic centres to the SSSI units. The number of industries within the Wards containing the areas of economic impact was then used to calculate the indicator. For the purposes of this study the designation of economic impact zones is both initial and experimental. Further research is required to assess if there is a distance decay effect in terms of impact. The selection process created overlapping geographies for 'economic impact zones' for the selected case study SSSIs in both Thames Gateway and Portsmouth (Figure 8.3). The change in the total number of firms and the number of firms in each broad economic sector (based on the UK Standard Industrial Classification of Economic Activities, SIC 2003) were calculated for each impact zone.

*Figure 8.3. Economic Impact zones of SSSI units in Thames Gateway (left) and Portsmouth (right).*




3. Land use change. Change in land use usually represents environmental pressures, which occur due to changes in socioeconomic interests. The increase in area of manmade (i.e. artificial) surfaces and the reduction in extent of natural environment illustrate changes in the state of the environment. Ordnance Survey MasterMap data were reclassified to

enable comparison with Generalised Land Use Database 2005[2] . Reclassification included assigning different features into two classes: natural or artificial (surfaces). 'Water' Polygons have been excluded from the analysis. Although the methodology is simplistic and limited by edge effects and a number of assumptions in order to fit features into the two classes, it provides a general indication of the shifting between natural and artificial areas.

4. Sea level rise. Rising sea levels can directly affect the long-term evolution of intertidal habitats, especially in areas bordered by fixed coastlines (i.e. urban areas or flood defences). It is known that, in natural conditions, saltmarshes can cope with sea level rise by inland migration and vertical accretion. However, the presence of coastal development prevents inland migration and vertical accretion is often limited by human-induced deficit in sediment supply. Therefore, sea level rise is the main driver of coastal squeeze, which is considered one of the main current pressures causing the decline of intertidal habitats. Here, the relative sea level rise estimated to occur in 50 years based on long-term sea level trends (estimated from local tide measurements by Woodworth et al. 2009) is used as an indicator of potential pressure. It is understood that saltmarshes are able to cope with fast rates of sea level rise if adequate sediment supply is available. Therefore, sea level rise is used here as a relative measure of potential pressure on the evolution of intertidal habitats confined by the presence of fixed coastlines.

5. Exposure to waves. Intertidal habitats such as saltmarshes and mudflats develop in sheltered environments where fine sediments are allowed to settle. The impact of storms and/or increased wave energy can cause erosion on the edges of saltmarshes. The level of exposure is determined qualitatively as follows: intertidal habitats along open coasts exposed to storm waves are assigned the highest value (=1); sheltered environments not exposed to waves are assigned the lowest value (=0); intermediate values are assigned based on the percentage of area which is more or less exposed to waves.

6. Loss of saltmarsh areas. Saltmarshes are important intertidal habitats that support biodiversity and provide essential ecosystem services, such as production of food for heterotrophs (animals and fungi). A major component of their biological productivity becomes available to the estuarine nutrient cycles when saltmarsh plant material dies and

[2] http://www.communities.gov.uk/publications/planningandbuilding/generalisedlanduse.

decays. The organic detritus and especially decomposition products then become available for uptake by living autotrophs and the cycle continues. A high proportion (the figure depends on the location) of the recipient autotrophs are unicellular algae inhabiting the mudflat surface, where they are grazed by small invertebrates (amongst others), that in turn provide food for, for example, fish and birds. Therefore, saltmarshes are of importance to carnivorous wetland birds, such as almost all the waders, since they indirectly feed such birds via the cycle described, even though feeding occurs largely on the mudflats. The value of mudflats to birds then is much associated with input from saltmarshes, which can be far distant. However, in terms of associating areas of habitat with bird numbers, it is the mudflats which are most closely linked, with saltmarshes providing to some extent roosting sites for birds during high tide. Therefore, there is an indirect relationship (not easily quantifiable) between saltmarsh area and bird numbers. Reduction in the area of saltmarshes occurs as a response to natural processes (e.g. erosion, inundation, climatic variability) and human activities (e.g. land reclamation, pollution, introduction of exotic species, dredging). Data on saltmarsh losses are restricted to specific periods in time and the best available options that allow relative comparison between the SSSI in the two study areas are used here (Table 8.1).

*Table 8.1. Summary of indicators used to estimate the relative index of sustainability.*

| Indicator | Measure | Period | Weight |
|---|---|---|---|
| Population growth | % increase in population | 2001 to 2009 | 3 |
| Change in number of industries | % increase in number of firms | 2003 and 2008 | 1 |
| Land use change | % increase in artificial areas | 2005 and 2011 | 2 |
| Relative rise in sea level | Rise in sea level (cm) observed in 50 years based on long-term trends | Variable (within 20$^{th}$ century) | 2 |
| Exposure to waves | Values range from 0 (very sheltered) to 1 (open coasts directly exposed to the approach of storm waves). | Current exposure to wave climate) | 1 |
| Loss of saltmarsh area | % loss in saltmarsh area | 1971 and 1984 (Portsmouth); 1973 and 1988 (Thames Gateway) | 2 |
| Bird count | % decline in total bird count | 1992/93 to 2008/09 | 1 |
| State of conservation of SSSI units | % of SSSI areas in unfavourable condition (i.e. destroyed, unfavourable declining and unfavourable no change) | 2008 to 2010 (as in last assessment) | 1 |

7. Bird count. One of the reasons for statutory protection of the intertidal habitats assessed here is the support to bird populations of national and/or international importance. Although there are various proxies that can be used to measure how important certain areas are to birds, the most common quantifiable parameter is the total number of birds of all species counted during the year for a specific site. For estimating wetland bird numbers, large sites such as the Thames estuary are divided into sectors, of a size able to be covered by an observer over one 3-hour counting period, once per month through the year. Counts are synchronised so that a large site is counted by several observers in their different sectors at the same time, to avoid double counting. They are normally conducted at high tide, when birds are concentrated at roosts. Counts are made of each occurring species, the annual total is a summation of the individual counts per month. There are many factors that influence the number of birds in one specific location, especially when considering migratory birds. Bird numbers are also influenced by weather conditions, food supply, conditions at remote summer/winter grounds (or en route to such) and bird movement between adjacent locations of similar habitat. Bird numbers might vary trend-wise through consecutive years due to changes to environment, which makes bird counts very useful as proxies for environmental change, particularly since good data are available for 20-50 years depending on the site. However, much caution needs to be used before concluding that bird count increases/decreases are directly linked to changes in environmental quality at specific locations. Wetland birds especially waders need somewhere to roost at high tide. Waders generally cannot sit on the water in the same way as ducks, so the site must not be inundated, and should not be covered by tall vegetation. During neap tides the upper tidal areas of mudflat are often used, during which time the birds may continue feeding. During spring tides they might use saltmarsh, but if the vegetation is well-grown and tall this habitat may not be preferred. Waders then often use agricultural land landward of the sea defences, often the grazing marsh, which is especially extensive along the Kent shore of the Thames estuary. Changes to land use can then be significant if tall vegetation as crops comes to dominate potential high tide roosts. To add further complexity, most waders are present at UK coastal wetlands during the winter, breeding at much more northerly locations in the summer. Therefore, wintering populations in the UK also depend on the environmental conditions elsewhere.

8. State of conservation of designated SSSI according to Natural England assessment. Natural England is the organisation responsible for managing the statutory conservation areas. Assessments are conducted regularly to evaluate the environmental conditions that support the criteria set for the maintenance of designations. The assessment considers aspects related to environmental quality, biodiversity, existing pressures, implemented management measures and observed trends, which gives an indication of the overall state of conservation. Natural England classifies each SSSI sub-unit into five classes: destroyed, unfavourable declining, unfavourable no change, unfavourable recovering, favourable. An area is considered in favourable condition when the special habitats and features are in a healthy state and are being conserved for the future by appropriate management. An area in recovering condition means that all necessary management measures are in place to address the reasons for unfavourable condition; if these measures are sustained, the site will become favourable over time.

A relative weight was assigned to each indicator (Table 8.1) based on their importance to the maintenance of the conservation conditions of the intertidal habitats. The weights were determined based on expert judgement and literature review on the potential effects of relevant activities or factors. However, a number of tests were conducted to assess the sensitivity of the method to the exclusion of indicators and their relative weight. The measures used to quantify indicators' values reflect the potential for a negative impact. Thus, highest values indicate increased pressure levels.

### 2.3. Defining the study area

Both Portsmouth and Thames Gateway study sites are located in southern England (Figure 8.4a). The Thames Gateway (Figure 8.4b) extends 70 km eastwards along the Thames estuary from the London Docklands (about 10 km east of central London) to Southend in Essex and Sheerness in Kent. The Thames Gateway administrative area (Figure 8.4b) covers c. 111,247 ha and has a population of c.1.45 million people. Population density in the Thames Gateway is spatially variable and tends to be higher in the boroughs of Greater London and lower eastwards. Portsmouth (Figure 8.4c) is a coastal city which developed mostly on the Portsea Island, approximately 112 km southwest of London. Portsmouth City Council (PCC) has an administrative area of 6,019 ha, of which 4,028 ha (66.9%) is land and 1,991 ha (33.1%) comprise the Portsmouth (1,431 ha) and Langstone (537 ha) harbours. Portsmouth estimated population is c. 197,900 inhabitants, resulting in a population density c. 49 inhabitants/ha (or c. 4,947/km$^2$), the highest in the country outside inner London. Portsmouth is an important centre of the South Hampshire sub-region providing employment, leisure, shopping, culture and higher education. Particularly strong sectors include tourism, education, leisure and retail, marine manufacturing and information and communications technology. However, Portsmouth shows high unemployment rates and high numbers of commuters into the city of London.

*Figure 8.4. The study areas: Portsmouth and Thames Gateway.*

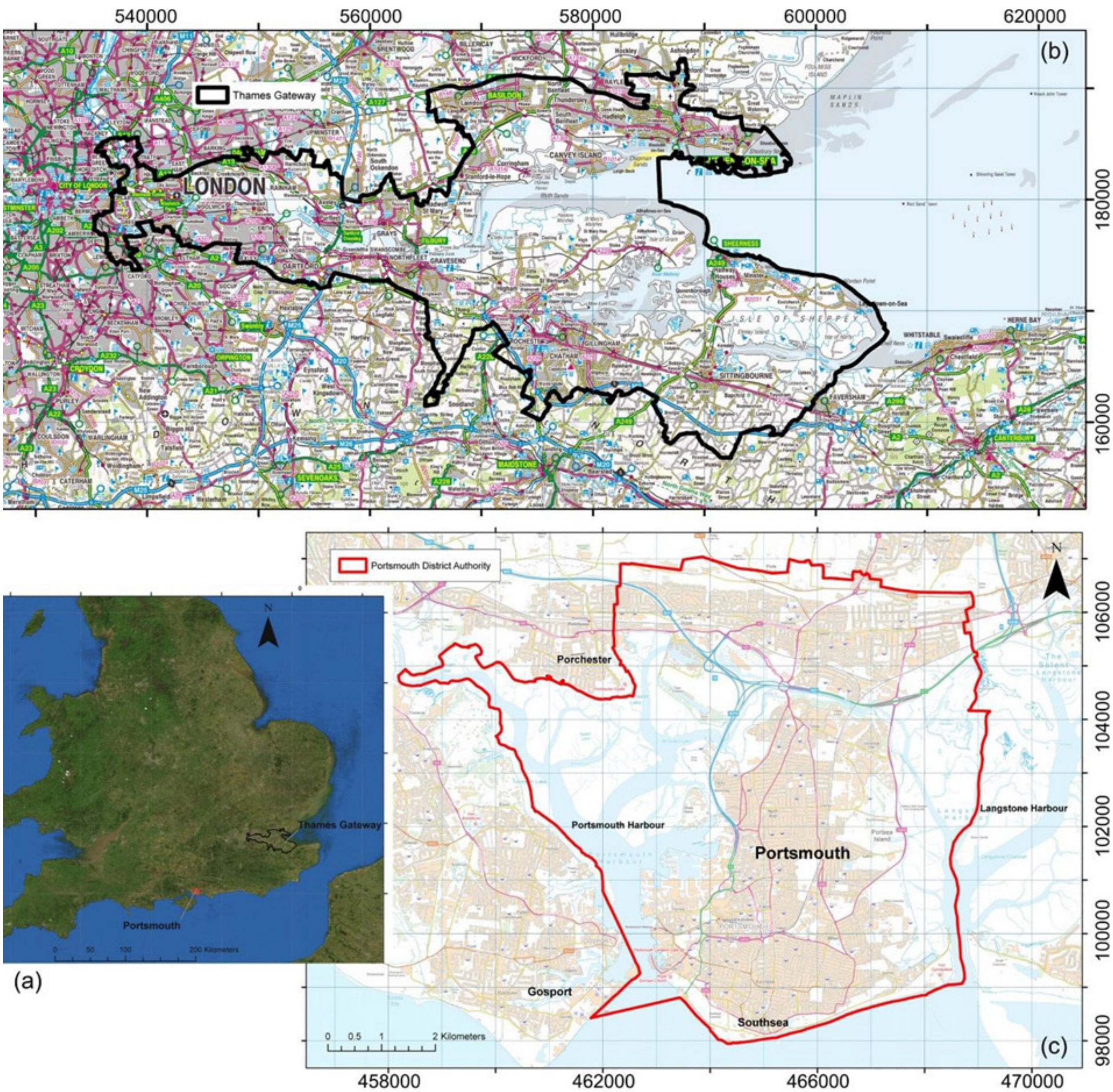
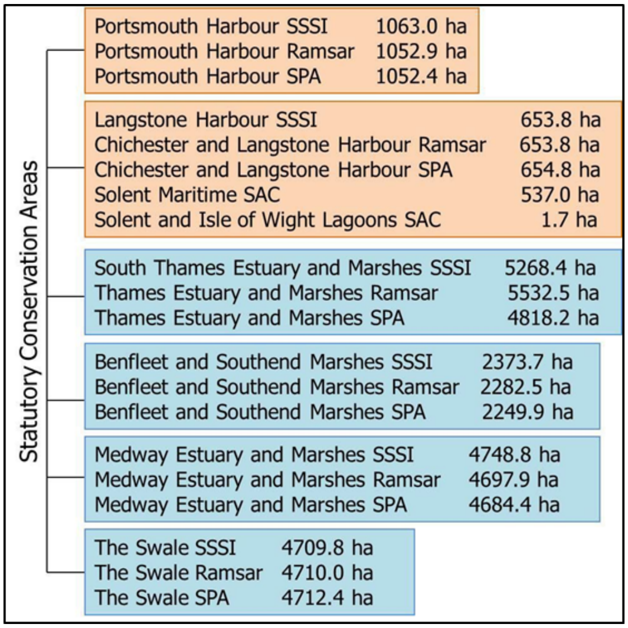


*Figure 8.5. Names and extent of designated conservation areas within Portsmouth (pink) and Thames Gateway (blue). Note that some of the designated areas extend beyond the boundaries of the study site.*




The topography of both areas is mainly flat and low-lying dominated by water features; the river Thames and its tributaries in the Thames Gateway and Portsmouth and Langstone harbours in Portsmouth (Figure 8.5). Based on the Generalised Land Use Database of 2001 (DCLG 2006), the Thames Gateway land use is distributed as follows: greenspace 60.6% (including 20% of agricultural land); water 12.5% (mainly the Thames); domestic buildings 3.3%; gardens 10.4%; non-domestic buildings 2.3%; roads 5.5%; rail 0.5%; paths 0.3%; other 4.8%. Portsmouth is an intensely built up area with c. 58% of the area comprising artificial surfaces (e.g. urban and industrial areas), 19% is wetland and 11% comprises water bodies. Southern England is subjected to continental weather influences that can bring cold spells in winter and hot, humid weather in summer, although the climate is still equable in comparison with adjacent mainland Europe. Weather patterns in Southern England tend to be more settled than in other parts of the UK. The region has a temperate marine climate, with mean annual temperatures around 11°C. January is the coldest and wettest month with average minimum temperatures of 1.4°C and average monthly rainfall of 79 mm, while July is the warmest and driest month with average maximum temperatures of 21.3°C and less than 50 mm of total rainfall. Areas in the Thames Gateway closer to London tend to be warmer than in Portsmouth. Based on the UK Climate Projections's (UKCP09) central estimate for a medium-emission scenario (equivalent to A1B of the IPCC Special Report on Emission Scenarios), in the southeast of England climate change is expected to result in hotter drier summers, warmer wetter winters, higher sea levels and an increase in extreme events such as heat waves, droughts and floods.

Intertidal environments comprise some of the most important and sensitive natural habitats in the study areas, most of which are designated conservation areas of international importance. Marshlands have been historically exploited to supply natural resources (e.g. fish, shell-fish, and wildfowl) and have been intensely altered by human intervention (e.g. extraction of salt; sheep grazing; land reclamation for agriculture and urban development). Therefore, the extent of intertidal environments has greatly reduced through time. Although statutory protection has greatly reduced direct negative impact over intertidal environments, these habitats are increasingly threatened by coastal squeeze. Within the PCC administrative area, both Portsmouth and Langstone Harbours are designated conservation areas with the first being intensely modified by human activity, while Langstone Harbour shows better preserved natural characteristics. Five statutory conservation areas dominated by coastal wetlands occur in the Thames Gateway: Thames Estuaries and Marshes, Medway Estuaries and Marshes, Swale (about 72% of the total area), Benfleet and Southend Marshes, and Foulness (only 11% of the total area). The six designated conservation areas included in this assessment are listed in Figure 8.5 (Foulness is excluded as it lies mainly outside the Thames Gateway boundary). Designations tend to overlap (Figure 8.5) and some areas extend beyond the boundaries of the SECOA study sites. The reasons for the SSSI designations included in this assessment are described in Appendix A. Table 8.2 indicates the relative composition of habitats within the Ramsar designated areas (i.e. including areas outside the SECOA study sites).

*Table 8.2. Habitat types of the six Ramsar sites within the two study areas.*

| | % of total area | | | | | |
|---|---|---|---|---|---|---|
| | Benfleet & Southend Marshes | Medway Estuary & Marshes | Thames Estuary & Marshes | The Swale | Portsmouth Harbour | Chichester & Langstone Harbours |
| Tidal flats | 85.10 | 58.30 | 49.60 | 38.00 | 59.30 | 46.00 |
| Salt marshes | 6.70 | 16.80 | 1.30 | 5.80 | 14.00 | 21.40 |
| Estuarine waters | - | - | - | - | 21.20 | 14.10 |
| Seasonally flooded agricultural land | - | 13.80 | 38.60 | 47.70 | - | - |
| Saline/brackish lakes | | - | 4.20 | - | - | 0.30 |
| Brackish/saline lagoons | 0.05 | 0.20 | - | - | 0.30 | - |
| Marine beds (seagrass beds) | 5.03 | - | - | - | 4.80 | 1.70 |
| Freshwater lakes/marshes | 2.80 | 0.40 | 0.70 | - | - | 1.30 |
| Saline/brackish marshes | - | - | 3.20 | - | - | 0.30 |
| Sand/shingle shores | - | 0.02 | 0.80 | 1.00 | 0.10 | 0.80 |
| Other | 0.05 | 10.50 | 1.60 | 7.50 | 0.30 | 14.10 |
| Total area (ha) | 2,251 | 4,697 | 5,589 | 6,515 | 1,249 | 5,810 |

Source: Joint Nature Conservation Committee (http://www.jncc.gov.uk/page-1390).

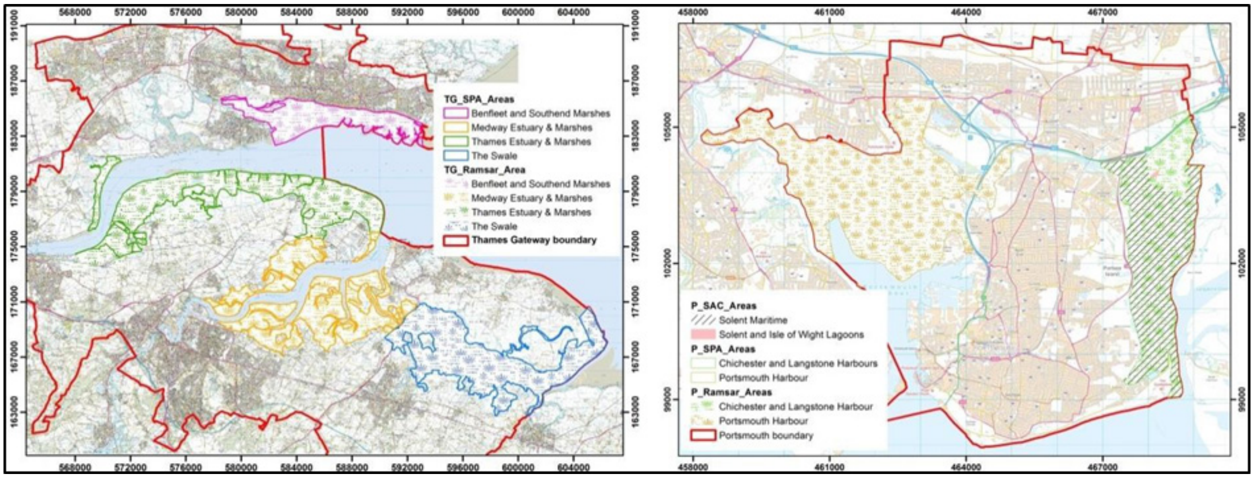
# 3. Natural resources and their exploitation

Here a brief description of the conditions and uses of natural resources in England, with focus on legally protected conservation areas, is provided. The overview of the current state and past trends in a broader context is useful as a comparative background for the DPSIR analysis conducted for the areas of Portsmouth and Thames Gateway.

## 3.1. State and impact

The six coastal margin habitats (Sand Dunes, Machair, Saltmarsh, Shingle, Sea Cliffs and Coastal Lagoons) comprise 0.6% of the UK's land area and provide a total value of ecosystem services estimated at £48 billion (adjusted to 2003 values), equivalent to 3.46% of Global National Income (Jones et al. 2011). Although the relative importance varies depending on location, tourism, leisure and coastal defence are the most economically important ecosystem services provided by coastal habitats (Jones et al. 2011). While the habitats within the case study areas are varied and represent the range that occur in southern England, those not completely modified into urban or agricultural areas are predominantly coastal. The majority of the natural coastal/estuarine habitats in the two study areas are intertidal mudflats and saltmarshes of national and international importance, which are designated conservation areas (Figure 8.6). The designated conservation areas are: Ramsar Sites(wetland areas of international importance designated by the government under the terms of the Ramsar Convention); Special Protection Areas (SPAs are designated under the European Birds Directive to protect rare and vulnerable species of birds); Special Areas of Conservation (SACs are designated under the European Habitats Directive to protect important habitats and their wildlife) and Sites of Special Scientific Interest (SSSIs are recognised for their nationally important wildlife and/or geology). The European designated conservation areas (SPAs and SACs) are protected by law under the EU Habitats and Bird directives, while SSSIs are legally protected under the Wildlife and Countryside Act of 1981 and the Countryside and Rights of Way Act of 2000. The areas of the SPA, SAC, Ramsar and SSSI sites often overlap and some of the qualifying features are common to more than one designation. Therefore, here the conditions of SSSIs are used to illustrate past trends and current conditions of protected natural environments.

*Figure 8.6. Statutory conservation areas within the Thames Gateway (left) and Portsmouth (right) included in this assessment overlap. Areas shown are also designated SSSIs.*




As result of a 10-year project aiming to reverse the trend of environmental degradation in England, at the end of December 2010, the Secretary for the Environment announced that 96% of the SSSIs were in favourable or recovering conditions (Table 8.3). In comparison, only 57% of the SSSIs were in the same condition as in 2003 (Natural England 2011). Although there has been a considerable increase in the percentage of recovering areas, there has been a reduction in the area of SSSIs in favourable conditions (Table 8.3). According to Natural England (2011), this is partly due to the use of different monitoring standards and partly due to a decline in the population of certain species, even though the actual condition of the habitat has remained favourable. This is the case at a number of intertidal sites where migratory wildfowl are appearing in fewer numbers. Table 8.3 also shows the conditions of SSSI areas in the counties where the study sites are found. Greater London is the only one with less than 95% of the areas meeting the target (i.e. showing favourable or recovering condition). Greater London is by far the most urbanised of the four counties in Table 8.3 and shows the lower percentage of SSSI in favourable condition. Similarly, Essex and Kent are the least urbanised and show the largest percentage of SSSI areas in favourable condition.

*Table 8.3. Percentage of SSSI areas classified based on their state of conservation.*

| Condition | England Sep 2003 | England Dec 2010 | Hampshire* | Greater* London | Essex* | Kent* |
|---|---|---|---|---|---|---|
| Favourable | 44.6 | 37.2 | 30.4 | 26.7 | 57.5 | 66 |
| Unfavourable recovering | 13.7 | 59.3 | 66.6 | 60.7 | 40.5 | 31.6 |
| Unfavourable no change | 25.2 | 2.3 | 1.3 | 4.8 | 1 | 1.3 |
| Unfavourable declining | 16.3 | 1.2 | 1.7 | 7.4 | 1.0 | 1.1 |
| Destroyed | 0.2 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 |
| Meeting target | 58.3 | 96.5 | 97 | 87.4 | 98 | 97.6 |

**As in the latest assessment (last compiled by Natural England on 01 May 2011).*

About 254,000 ha of coastal priority habitats under the UK Biodiversity Action Plan (BAP)[3] are within SSSIs, comprising 96% of total coastal habitats in England (Natural England 2011). SSSI coastal habitats meeting the target increased from 76% in 2003 to 98% in 2010 (Natural England 2011). Table 8.3 shows the conditions of SSSI in the districts located (partially or totally) within the SECOA study areas and the conditions of the SSSI units included in the DPSIR analysis (i.e. dominantly comprised by intertidal habitats). Within SECOA districts, only 65% of Greater London SSSIs are in favourable conditions or recovering (Table 8.4), contrasting with 87% of the SSSIs meeting the target overall in Greater London county (Table 8.3). However, the largest percentage of SSSIs in favourable conditions are found within SECOA districts (Table 8.4) when comparing with the overall figures for the respective counties (Table 8.3), including Greater London. This might indicate that either conservation areas within SECOA districts are subjected to lesser pressures than elsewhere in the respective counties or management responses are more effective. Comparing the SSSIs within the SECOA districts with the ones included in the DPSIR analysis (Table 8.4), a higher percentage of SSSIs in favourable conditions is found in the latter. However, this does not always result in a higher percentage of SSSIs meeting the target (e.g. Essex). Amongst the SSSIs included in the DPSIR analysis, Essex shows the largest percentage classified as unfavourable declining (7.7%).

[3] http://jncc.defra.gov.uk/page-5705.

According to the Habitats Directive (Article 1), the conservation status of a habitat or species can be considered to be favourable when:

- The area of habitat is stable or increasing within its natural range;
- The structure and functions of the habitat necessary for its long-term maintenance continue to exist;
- The population of a species is maintaining itself as viable on a long-term basis
- The natural range of a species is stable; and
- There is sufficient habitat to maintain the species population on a long-term basis.

The trends of impacts and main pressures/drivers impacting on the conditions listed above are discussed next in a broader context to establish the background for the DPSIR analysis.

*Table 8.4. Percentage of SSSI areas classified based on their state of conservation in the districts located within the SECOA study areas.*

| Condition | Portsmouth | | Greater London | | Essex | | Kent | |
|---|---|---|---|---|---|---|---|---|
| | a | b | a | b | a | b | a | b |
| Favourable | 37.83 | 39.86 | 42.97 | 0 | 77.02 | 78.06 | 69.23 | 68.94 |
| Unfavourable recovering | 62.00 | 59.97 | 22.21 | 0 | 20.76 | 14.21 | 28.41 | 29.12 |
| Unfavourable no change | 0 | 0 | 1.72 | 0 | 0.67 | 0 | 1.67 | 1.24 |
| Unfavourable declining | 0.02 | 0.02 | 30.78 | 0 | 1.55 | 7.73 | 0.58 | 0.57 |
| Destroyed | 0.15 | 0 | 2.33 | 0 | 0.01 | 0 | 0.12 | 0.14 |
| Meeting target | 99.83 | 99.82 | 65.17 | 0 | 97.77 | 92.27 | 97.64 | 98.06 |

a - in districts within SECOA boundaries; b - considering only the SSSI included in the DPSIR analysis.

England's biodiversity and the area of natural and semi-natural environments have declined significantly in the last 50 years, but selected indicators have shown positive overall trends in the last decade (JNCC 2008; Berry et al. 2011). The 2008 report on progress of the UK BAP (JNCC 2008) indicates that 40 species are considered to be increasing compared with 42 and 26 in 2005 and 2002, respectively. Eight of the 40 species have been removed from the UK BAP list because their improvement has met the set targets. Although the rate of decline is slowing for most species, eight (5% of the priority species) have been lost since the BAP publication in 1994. The 2008 report (JNCC 2008) shows a less favourable trend for habitats, with 19 considered to be declining (against 17 in 2005), of which six have been declining at faster rates (three in 2005). The increase in declining habitats is attributed to improved data availability, as these habitats were classified as having 'unknown' trend in 2005.

It is estimated that coastal margin habitats in the UK have reduced in 10% in the last 60 years, mainly due to development and coastal squeeze. However, habitat loss of certain habitats (i.e. saltmarshes) is considerably higher in some areas (i.e. southeast England). The six habitats assessed as declining accelerating by the UK BAP report are coastal or marine: mudflats, saltmarsh, coastal vegetated shingle, maritime cliff and slopes, sheltered muddy gravels and sublittoral sands and gravels.

Wetlands cover c. 4% of England and because they support a high number of internationally important species, c. 47% of England's wetlands are legally protected under SSSI designation (Berry et al. 2011). About 21% of SSSI wetlands are considered to be in favourable conditions and 48% are considered to be recovering. Areas of saltmarshes have reduced considerably in the 20th century, with only a small proportion of the original habitats left. Targets set for maintaining or enhancing habitats are mostly behind the schedule set by the UK BAP in 2006, with some targets (e.g. saltmarsh habitat recreation) showing no progress (JNCC 2008).

*Figure 8.7. Importance of broad habitats for delivering ecosystem services and trends since 1990 (modified from UKNEA 2011).*

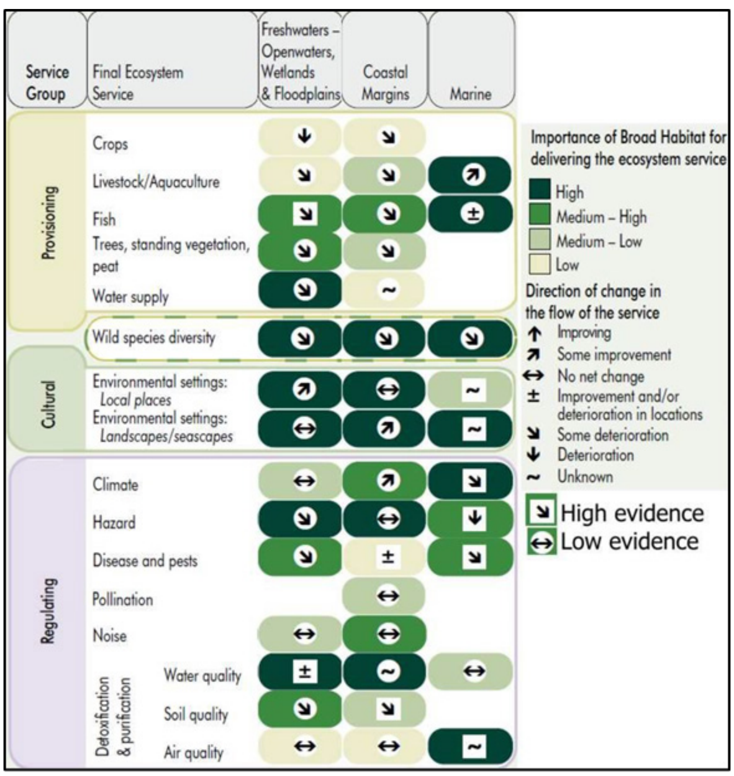


Figure 8.7 illustrates the importance of selected broad habitat types for delivering ecosystem services and the respective trends in the UK since 1990. The habitat types shown in Figure 8.7 are relevant to the DPSIR analysis presented later in this report and the trends indicate whether impacts have intensified or lessen in the period. It is evident that these habitats have medium to high importance to most of the ecosystem services listed, but the majority has shown a decline in the services flux, with only one or two showing some improvement in each habitat. However, there is low confidence in most of the trends. Besides contributing with high biodiversity, coastal margins are of great cultural and touristic importance in the UK, receiving over 250 million visits per year, of which about one-third are to natural habitats (UKNEA 2011). Degradation of coastal habitats and expansion of urban areas has negatively impacted ecosystem services related to climate regulation, hazards (flood regulation), soil and water quality and noise. In more recent times, reductions in the intensity of land management for agriculture and increased efforts in controlling diffuse and point sources or pollution have helped slowing the decline in many species used as indicators of ecosystem quality. However, these indicators are based on counts of well-monitored plant and animal species, while little is known about changes in microorganism assemblages in soils and water, which are essential to sustaining production (UKNEA 2011).

### 3.2. Drivers and pressures

A worldwide assessment (Millennium Environment Assessment 2005) has indicated that the key direct drivers of changes in the state of coastal zones are related to changes in land use and climate, while the indirect drivers include population growth, economic globalisation and changes in consumer preferences and diets (all leading to changes in land use and/or pollution). The UK National Ecosystem Assessment (UKNEA 2011) concluded that the primary drivers of change in UK ecosystem services in the last 60 years were: land cover change from natural habitats to farmland; exploitation of natural resources, especially marine fish; air and water pollution (especially nitrogen, sulphur and phosphorus); and to a lesser extent climate change and invasive species (including plant pests and animal diseases). Clearly most of the identified primary drivers are directly linked to population growth and urbanisation and are also related to globalisation and change in consumer preferences.

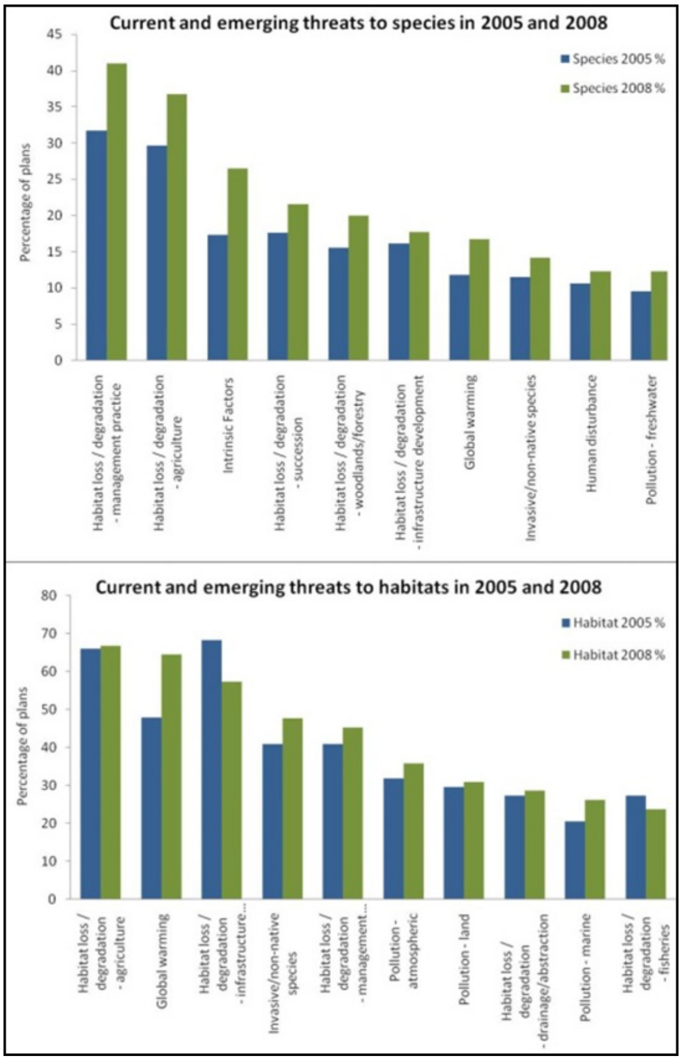
The UK population has grown from ca. 50 million in 1950 to c. 62 million today, about 24% in 60 years, and as incomes have also increased, the demand for ecosystem services has never been greater (UKNEA 2011). During the post-war reconstruction phase in England, agricultural production expanded rapidly with farmed land increasing by 40% from 1940 to 1980 (UKNEA 2011). This occurred at the expense of large areas of semi-natural habitat, which were converted into arable land. The increase in fertiliser use, particularly nitrogen and phosphorus, has impacted aquatic ecosystems through runoff (UKNEA 2011). The loss of natural habitats and water pollution contributed to a long-term trend of declining biodiversity that only recently has started to reverse.

Similarly to the intensification of agriculture, growth of other sectors (energy, industry, housing and transport) also caused significant impacts on ecosystems by atmospheric pollution (e.g. nitrogen and sulphur), loss of habitats through urbanisation and disruption of flood regimes in river basins and coastal wetlands by water abstraction and engineering works. Despite being one of the world's most densely populated countries, most of England's land is classified as Arable and Horticultural and Improved Grasslands (Berry et al. 2011). Only c. 14% of the country comprises of urban areas (according to the Generalised Land Use Database 2005), which have increased in the last two decades. Between 1991 and 2006, 152,400 ha of new development have been built, dominantly (75%) on brownfield sites and only 0.4% on undeveloped green belt land (Natural England 2010).

In more detail, Turner et al. (2010) identify as the main direct drivers and pressures on coastal and marine ecosystem services: land use change (coastal urbanisation and deforestation leading to loss of natural habitat); climate change (including sea level rise); pollution and contamination; mining; poor management of fisheries (overfishing or destructive practices); invasive species and engineering works. A number of studies have listed the main drivers and pressures affecting coastal zones over large spatial areas (i.e. globally and regionally). However, it is likely that the main influencing factors will change and/or have different levels of importance when the assessment is conducted at national and local scales. Additionally, the time scale and period of assessment can greatly affect the measured trends and environmental changes, as both drivers and responses can vary significantly.

Figure 8.8 shows the main threats to priority species and habitats in 2005 and 2008 in England (JNCC 2008). Priority species and habitats are listed in the UK BAP as being the most threatened and requiring conservation action. Habitat loss is clearly the main threat to both species and habitats as it results from land use change caused by different drivers (e.g. agriculture and infrastructure development). Other threats affecting both species and habitats are global warming, invasive species and pollution. However, the pressure from habitat loss seems to have increased more over priority species than habitats, while pollution and global warming are perceived to be a greater threat to habitats than species (Figure 8.8). The relative importance of the threats between 2005 and 2008 has changed more for habitats than for species, especially due to increasing pressure of global warming and marine pollution and less pressure from habitat loss due to infrastructure development and fisheries.

*Figure 8.8. Most important threats to priority species and habitats in the U.K. (Source: JNCC 2008).*




In the last 20 years, it is estimated that sea-level rise caused a 4.5% reduction in the area of saltmarshes in the UK, which is expected to accelerate in the future mainly due to coastal squeeze (Jones et al. 2011). Other climate change related impacts relate to changes in temperature (which can affect shifts in coastal species), rainfall distribution (affecting habitats dependent on water table) and storminess (increasing sediment mobilisation and rates of coastal erosion).

Adequate sediment supply is essential for the development of saltmarshes. Human intervention such as coastal protection works, building of ports, dredging and land reclamation have altered sediment budgets and pathways along most coastlines, usually resulting in sediment deficit and coastal erosion. Steepening of intertidal environments has been observed in the UK by low waterline migrating landward faster than high waterline (Hansom 2010), which has been used as an indicator of sediment loss (Jones et al. 2011). Air pollution from nitrogen and sulphur affects soil and vegetation of coastal habitats, especially in southeast England due to location of pollution sources. Atmospheric concentrations of sulphur dioxide in urban areas have decreased significantly since 1950s due to the reduction in the use of coal for domestic heating. Pollution from nitrogen oxides and dioxides increased between 1940 and 1990 due to the intensification of agriculture but has reduced since. As a result, eutrophication has reduced and water quality has improved. Although not included as one of the main threats shown in Figure 8.8, tourism patterns have been a major driver of coastal change (Jones et al. 2011). In mid-20th century, resort tourism dominated and high visitor pressure was concentrated at relatively few beach locations (Walton 2000). In the 1970s, the pattern changed to day trips and dispersed visitor pressure to areas a few hour's drive from major urban areas (Williams and Shaw 2009). More recent changes in tourism pressure resulted from the expansion of low-cost airlines (increasing international travel) and growing interest in outdoor-oriented attractions (e.g. eco-tourism, specialist sports). Both have contributed to a dispersion of pressure from tourism and collapse of coastal resorts in England. However, the deep economic recession experienced since 2009 caused a revival of internal tourism and more traditional seaside resorts. Current trends indicate a continuous increase in day-visits and short-stays and a slight decrease in long-stays at the coast (Williams and Shaw 2009).

Table 8.5 lists the main pressures affecting coastal wetlands in England and their trends at different time scales. Some pressures observed in the $20^{th}$ century have accelerated in the second half of the century but have decreased or ceased to exist (e.g. land reclamation) in recent times due to the positive effect of policy responses. This is particularly noticeable in the control of water pollution, eutrophication, land reclamation and introduction of invasive species. However, pressures linked to climate change tend to accelerate in the future.

*Table 8.5. Main pressures affecting coastal wetlands in England and their trends at different time scales.*

| Pressures | Long-term (20th century or longer) | Medium-term (since 1950s) | Recent (last 20 years) | Future (21st century) |
|---|---|---|---|---|
| Sea level rise | + | + | + | ++ |
| Increase in wave energy | + | + | + | ++ |
| Land reclamation | + | ++ | - | - |
| Coastal urbanisation | + | ++ | + | - |
| Change in sediment supply | + | ++ | ++ | ++ |
| Coastal engineering | ++ | ++ | ++ | ++/+ |
| Dredging | ++ | ++ | ++ | + |
| Water pollution | ++ | ++ | + | - |
| Invasive species | ++ | ++ | + | +/- |
| Tourism/recreation | + | ++ | + | ++/+ |
| - decreasing; + increasing; ++ increasing/accelerating | | | | |

## 3.3. Responses

The Convention on Biological Diversity[4] has triggered a number of policies and laws aiming to protect species and habitats in Europe and in England. Two main European initiatives have significantly influenced efforts towards conservation of biodiversity in England: the European Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (known as the Habitats Directive) and the Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (which is the amended version of the original Directive 79/409/EEC, known as the Birds Directive). The Habitats Directive was implemented to protect the most seriously threatened habitats and species in Europe. To do so, member states are required to establish Special Areas of Conservation (SACs) based on the presence of habitats and/or species of importance to Europe. The Birds Directive requires member states to establish Special Protection Areas (SPAs) to ensure protection for all wild bird species naturally occurring in the European Union. In England, in addition to the European designated conservation areas, the Planning Policy Statement 9: Biodiversity and Geological Conservation (ODPM 2005a) and Circular 06/2005 (ODPM 2005b) requires that Ramsar sites (designated under the Convention on Wetlands of International Importance 1971)

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[4] http://www.cbd.int/.

are treated as if they were officially designated European sites for the purposes of assessing potential detrimental effects caused by development proposals.

The transposition of the Habitats Directive into the UK law was provided by the Conservation (Natural Habitats, &c.) Regulations 1994 (known as the Habitats Regulations). The Habitats Regulations was amended by the Conservation (Natural Habitats &c) (Amendment) Regulations 2007, as a result of the European Court of Justice Ruling of October 2005. The Ruling found that the Habitats Regulations had failed to correctly implement the intention of the Habitats Directive in that it only required the application of Habitats Regulations Assessment (HRA) to projects, as opposed to plans and programmes. The HRA aims to assess the potential effects of land use plans on the conservation of statutory European designated sites (e.g. SPAs and SACs). Where negative effects are identified, the precautionary principle should apply and alternative actions and/or mitigation measures should be considered. As a last option, if it is impossible to prevent or mitigate the adverse effect, planners and developers must demonstrate, under the conditions of Regulation 85(C) of the Habitats Regulations, that there are Imperative Reasons of Overriding Public Interest (IROPI) to continue with the proposal. Since the amended Habitats Regulations 2007, HRA must be applied to all Local Development Documents (LDD) in England and Wales. LDD are statutory documents (as part of the Planning and Compulsory Purchase Act 2004) that describe the strategy and policies of each local planning authority for development and use of land within their administrative area. At present, local governments in England are developing their Core Strategy (one of the LDD) setting out their priorities and objectives for up to 2027.

SSSIs are legally protected under the Wildlife and Countryside Act 1981, as amended by the Countryside and Rights of Way Act 2000 and the Natural Environment and Rural Communities Act 2006. Another important step towards biodiversity preservation resulted from the publication of the UK Biodiversity Action Plan (BAP) in 1994, which by 1999 included 391 priority species and 45 priority habitats.

One of the United Nations Millennium Development Goals[5] included reducing biodiversity loss considerably by 2010 (Target 7b). England's Biodiversity Strategy (published in 2002) established the mechanisms for achieving the Millennium Goal and the BAP.

European Environmental Directives place a duty on each EU Member State to implement policies to protect and improve the environment and the health of its citizens. The EU Sixth

[5] http://www.undp.org/mdg/goal7.shtml.

Environment Action Programme of the European Community 2002-2012[6] includes thematic strategies to address environmental issues with focus on: waste prevention and recycling; the marine environment; soil; pesticides; natural resources; the urban environment; and air pollution. Besides the already mentioned Habitats and Birds directives, other strategies established by the Environment Action Programme influencing environmental policies in England include: Directive 96/61/EC[7] on integrated pollution prevention and control (IPPC) and the Directive 2000/60/EC[8] , known as the Water Framework Directive (WFD). The IPPC requires Member States to introduce regulations to control pollution from a range of industrial activities, from energy production to waste management. The transposition of the IPPC Directive into the national legislation came with the publication of the Pollution Prevention and Control Act 1999[9] (Lawrence and Isted 2008). The act establishes that emissions to air, land and water from potentially more polluting installations are regulated by the EA, while activities less potentially pollutant are regulated by local authorities. Currently, the Environmental Permitting (England and Wales) Regulations 2010[10] establishes the conditions for licensing operations involving air, water and soil waste/pollution production. The WFD came into force in 2000 and became part of UK law in December 2003. The WFD aims to provide means to protect and enhance the quality of groundwater, rivers, lakes, estuaries, coastal waters (up to one mile offshore from low-water) and dependant ecosystems. In England, the EA aims to implement the WFD by:

- improving inland and coastal waters through better land management (especially by reducing diffuse pollution in urban and rural areas);
- promoting sustainable use and better management of water as a natural resource;
- enhancing habitats for wildlife dependent on water environments.
- assessing the impact of human activity on the water bodies within the 11 River Basin Districts in England and Wales;
- monitoring the status of water bodies against the set objectives;
- preparing the River Basin Management Plans; and
    - taking the lead in drawing up and carrying out the Programme of Measures.

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6 http://ec.europa.eu/environment/newprg/strategies_en.htm.

7 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31996L0061:en:HTML.

8 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2000:327:0001:0072:EN:PDF.

9 http://www.legislation.gov.uk/ukpga/1999/24/contents.

10 http://www.legislation.gov.uk/uksi/2010/675/part/2/made.

# 4. DPSIR analysis

## 4.1. DPSIR Analysis For Assessing The Sustainability Of Saltmarshes And Mudflats In Designated Conservation Areas Of Portsmouth And Thames Gateway

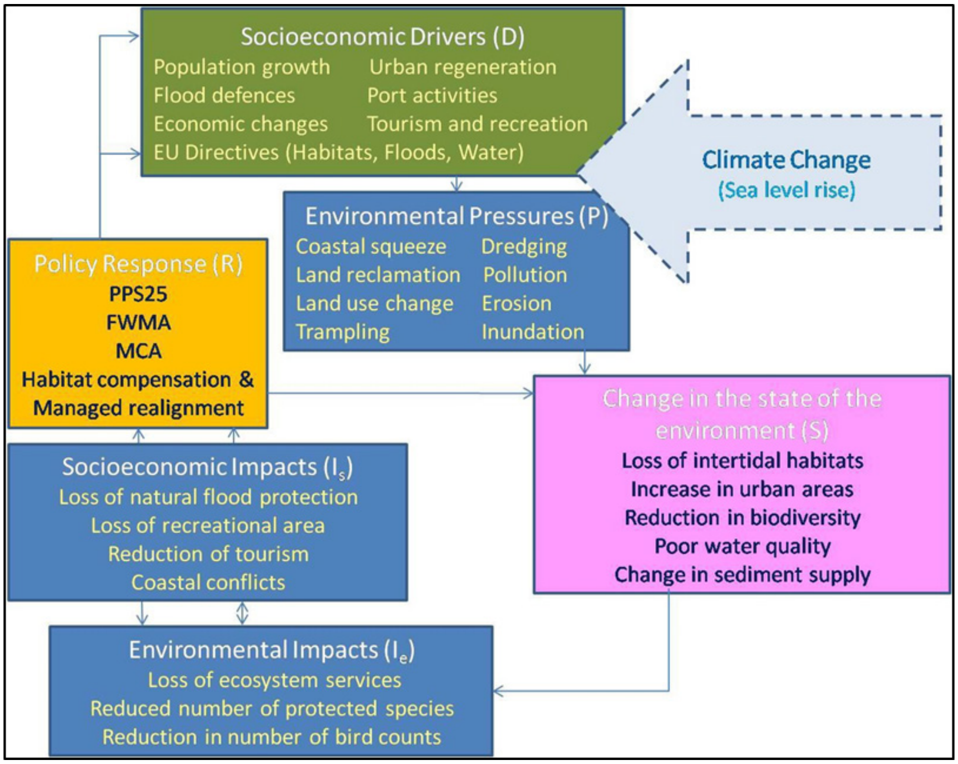
Figure 8.9 illustrates the conceptual framework of the DPSIR analysis applied to assess the sustainability of intertidal habitats within statutory conservation areas of Portsmouth and the Thames Gateway. Although different in many aspects, both Portsmouth and Thames Gate share the same D-P-S-I-R factors relevant to the conservation of intertidal habitats at the scale in which the analysis is conducted here (SSSI units). For example, the list of operations types that are likely to damage the special interest at each SSSI produced by Natural England differs mainly in the occurrence of only one of the 28 listed operations (see Appendix B). It is expected, however, that the level of potential impact will be variable between the SSSI areas. Only when analysis is conducted at a very local level (i.e. SSSI subunits) do important differences occur on the types of pressures and level of impact. Therefore, a general description of main D-P-S-I-R interactions is applicable to both areas.

Considering that the EU Habitats and Bird Directives have triggered the statutory conservation of important intertidal habitats (which is the focus of this analysis), they are listed here as a main driver positively influencing the state of conservation, but (negatively) increasing conflicts of use. All other listed drivers are somehow interlinked and tend to conflict with conservation aims. Sea level rise is an important driver for the long-term evolution of intertidal habitats. The combination of sea level rise and the presence of coastal development and flood defences lead to one of the main pressures to the sustainability of intertidal habitats. In natural environments where adequate sediment supply exists, intertidal habitats can accrete vertically and migrate inland as a result of sea level rise. However, where the coastline is fixed by the presence of flood defences or urban development, intertidal habitats cannot migrate inland and lose area due to increased inundation from rising sea levels (this process is known as coastal squeeze). Coastal squeeze is one of the main pressures affecting intertidal habitats in Portsmouth and the Thames Gateway. As a result of coastal development, land use change and land reclamation lead to a reduction in the extent of intertidal habitats and increase in developed areas. Water pollution from domestic, industrial and agricultural sources negatively affects the ecological functioning of intertidal habitats, often reducing biodiversity. According to Natural England (2011), the habitats within Portsmouth and Langstone Harbours are highly sensitive to inorganic fertilisers and pesticides and their use should be avoided even in surrounding areas.

Although eutrophication may still be a chronic problem in some areas, organic and inorganic pollution has been significantly reduced in the last few decades as a result of environmental policies (e.g. EU Nitrates and Water Framework Directives). Erosion of saltmarshes and mudflats due to the effect of dredging, boat waking and/or storms can have considerable impact on the state of conservation of these habitats. In some of the SSSIs (e.g. Langstone Harbour), the impact of recreational activities is also of concern.

To better understand the relationships within and between groups of factors in the generalised DPSIR framework (Figure 8.9), a more detailed analysis is required for the main influencing factors, such as coastal squeeze (Figure 8.10). Population growth leads to an increase in developed areas that ultimately requires a change in land use from the substitution of natural to urban environments. In many cases, land reclamation takes place to create agricultural or urban areas in locations previously occupied by intertidal environments. In Portsmouth and the Thames Gateway the coast is dominated by low-lying flood-prone land, where long-term rising sea levels aggravate the risk of coastal flooding, leading to the construction of flood defences. As a consequence, the coastline, once dynamic and constantly changing to accommodate the variability of natural processes, becomes fixed by the presence of urban development and/or flood defences. One direct effect of increase in developed land is the loss of recreational areas. The combined effect of land use change and coastal squeeze cause a reduction in the area of intertidal habitats, the ecosystem services they provide and their overall quality, including the biodiversity they support. One of the ecosystem services offered by intertidal habitats is natural flood protection to inland environments (including developed areas). Therefore, reduction in intertidal habitats will result in less natural flood protection. The status of legally protected conservation areas is directly related to the maintenance of biodiversity. Reduction of biodiversity might affect the conditions required for the award of designations and result in declining conservation status, which can ultimately lead to losing statutory protection. Poor or declining conditions of conservation affect tourism and recreation linked to bird watching and nature conservation. As responses to the impacts shown in Figure 8.10, a number of policies have been implemented. The Planning Policy Statements (PPS) are mechanisms used by the national Government to incorporate into the planning system a range of requirements set out in international and national legislations. PPS9 (published in 2005) sets out planning policies on protection of biodiversity and geological conservation and PPS25 (published in 2006, revised in 2010) concerns with development and flood risk.

*Figure 8.9. DPSIR Framework for the sustainability of intertidal habitats in designated conservation areas in Portsmouth and the Thames Gateway.*




An example of the current drivers and pressures can be given by the Portsmouth Core Strategy[11], which plans for 12,800 new homes; 301,875 m$^2$ employment floor space; 50,000 m$^2$ retail floor space; and the necessary associated facilities, services and critical infrastructure for the period 2006 to 2027. Portsmouth is already densely urbanised with a deficit of green spaces. Therefore, new development is targeted to occupy previously developed land. However, areas identified for new developments are at high or very high risk of flooding, increasing the pressure for enhanced flood protection. As Portsmouth is surrounded by designated conservation areas, flood protection can only be built or upgraded if it is demonstrated not causing detrimental impact. Associated with the pressure of new development within Portsmouth area, there is the planned economic growth for the South Hampshire region, which is likely to increase the pressure from recreation and leisure, commuters' population, demand for services and natural resources (e.g. transport, sewers, waste management, water consumption). The main drivers affecting the conservation on natural habitats in Portsmouth are: air pollution, recreational

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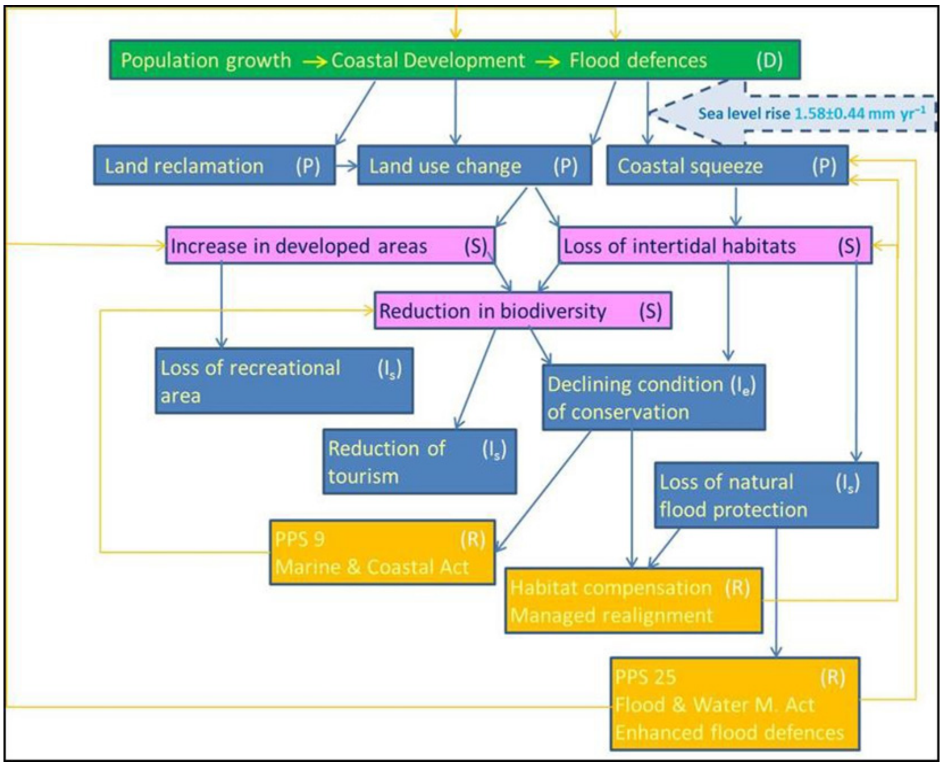
11 http://www.portsmouth.gov.uk/living/7923.html.

pressure, flood risk, coastal squeeze, habitats degradation, light pollution, urbanisation, water abstraction/consumption and waste water pollution (UE Associates Ltd 2011). However, the Habitat Regulation Assessment (HRA) has concluded that water abstraction and waste water pollution are unlikely to cause any adverse effect on the integrity of statutory conservation sites and mitigation measures can effectively reduce the negative impact from the other pressures (UE Associates Ltd 2011). However, climate change is likely to aggravate coastal squeeze and the conflicts between flood risk management and conservation of intertidal habitats.

*Figure 8.10. Detailed DPSIR framework for the impact of population growth and coastal squeeze on intertidal habitats. Sea level rise rate shown applies to Portsmouth areas.*

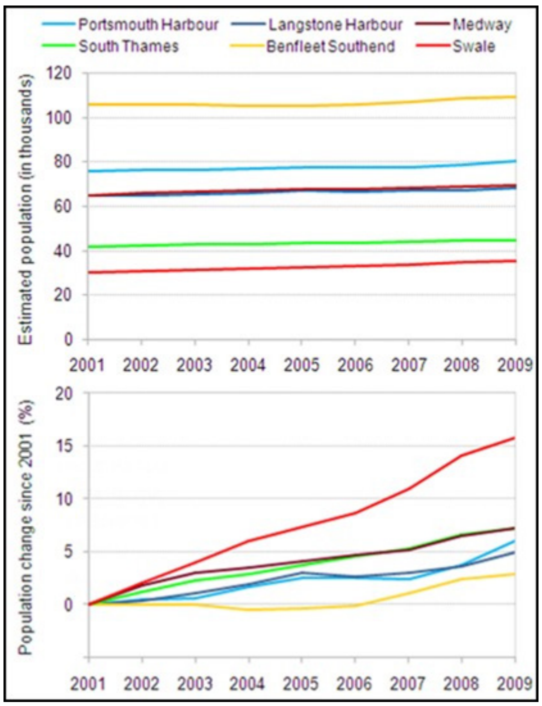



## 4.2. Sustainability of natural resources in the study areas

Taking into account that: the DPSIR analysis here focuses on statutory conservation areas; most pressures show evidence of alleviating; and management measures are generally in place to maintain and/or improve the current state of conservation, all six SSSI areas are considered to have sustainable use. (see annex for index). The limitations include (amongst others):

- quantification of indicators is based on variable time spans;
- some indicators reflect a direct pressure or impact (e.g. loss of saltmarsh areas), others cause indirect impact (e.g. change in number of industries) that is not easily quantifiable;
- the index is sensitive to the weights attributed to each indicator;
- same weights were used here for all areas, although it is likely that the importance of pressures/impacts are spatially variable; and
- the final ranking is likely to change if different time-spans, formulas or indicators are used.

*Figure 8.11. Population changes in the areas adjacent to the SSSI.*




*Indicators and trends*

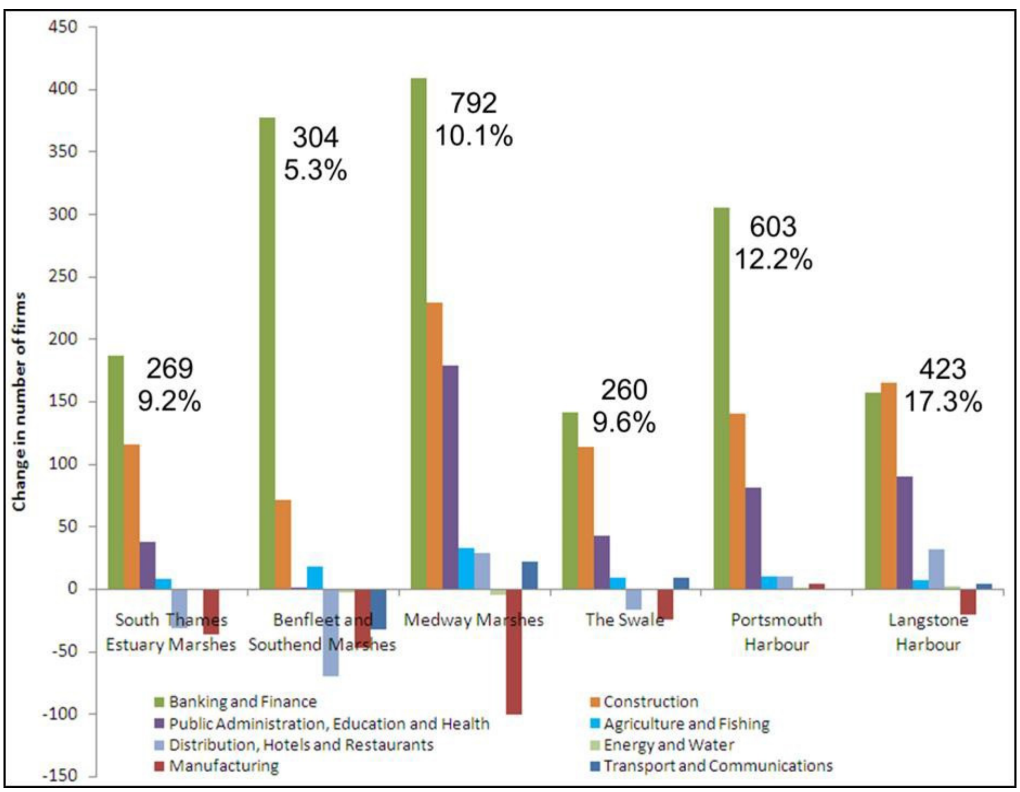
A brief description of the data and trends used to quantify the indicators for each of the six designated conservation areas is provided below.

**Population growth**. All areas have shown an increase in population between 2001 and 2009 (Figure 8.11) ranging from 2.9% (in Benfleet and Southend Marshes) to 15.7% (in Swale). Benfleet and Southend Marshes show the largest population of all areas but the lowest population growth (Figure 8.11). Benfleet's population was stationary and even decreased between 2003 and 2006, but has increased since. Swale, on the other hand, has the smallest population but the highest growth in the period (Figure 8.11), which is due mainly to a new housing development in Iwade.

Although Portsmouth Harbour has larger population in surrounding Wards, it shows a pattern of population growth similar to Langstone Harbour.

**Change in number of industries**. All areas showed an increase in the number of firms between 2003 and 2008, with relative increases varying from 5.2% to 17.3% (Figure 8.12). Langstone and Portsmouth Harbours experienced the largest relative increase in the number of firms of the six economic impact areas, with Medway Marshes showing the largest increase in the Thames Gateway (Figure 8.12). The increase in absolute number of firms, however, varies from 269 in the South Thames Estuary to 792 in the Medway Estuary. Portsmouth Harbour experienced a larger change in number of firms than Langstone Harbour, but relative growth was larger in the Langstone Harbour economic impact area. Banking and Financing represented the largest increase in most areas, except in the Langstone Harbour, where change in number of construction firms was highest (Figure 8.12). Besides Banking and Finance, most new firms were in Construction and Public Administration, Health and Education, with the sectors of Manufacturing and Distribution, Hotel and Restaurants representing the largest reduction in the number of firms.

*Figure 8.12. Change in the number of firms by sector (SIC 2003) within the impact economic area of the six SSSI. The total increase in number of firms from 2003 to 2008 and the percentage in relation to the total number of firms in 2003 is indicated.*



**Land use change.** Between 2005 and 2009 a relatively small (0.18% to 1.25%) switch from natural to artificial surfaces has occurred in the six areas. As expected, due to the already intense urbanisation, Portsmouth's areas have shown the smallest change (0.18% in Langstone Harbour and 0.26% in Portsmouth Harbour). Swale has shown the highest increase in artificial surfaces (1.25%), which are related to the new housing development in Iwade. The second largest increase in artificial area was observed in Benfleet and Southend Marshes (0.84%).

**Sea-level rise.** Rising sea levels and isostatic land subsidence result in the study areas being subjected to one of the highest rates of relative sea level-rise in the country. Here, (worst-case) long-term rates of sea level rise estimated by Woodworth et al. (2009) for stations in the study areas (Table 8.6) are used to estimate the rise in sea levels expected in 50 years (the usual life-time of coastal defences). Highest rates of sea-level rise are found for Sheerness and Tilbury, along the Thames. The impact of rising sea levels on the evolution of saltmarshes depends highly on sediment availability and the presence of coastal defences. However, the magnitude of rates can be used as a relative comparison of the pressure on intertidal habitats.

*Table 8.6. Estimated rise in relative sea level in 50 years based on long-term trends.*

| Conservation Area | Station | Trend[a] | 50 yr rise in sea level (cm) |
|---|---|---|---|
| Portsmouth Harbour<br>Langstone Harbour | Portsmouth | 2.02 mm yr$^{-1}$ | 10.1 |
| Benfleet and Southend Marshes | Southend | 1.50 mm yr$^{-1}$ | 7.5 |
| South Thames Estuary | Tilbury<br>Sheerness | 3.03 mm yr$^{-1}$<br>2.45 mm yr$^{-1}$ | 13.7[b] |
| Medway Estuary<br>Swale | Sheerness | 2.45 mm yr$^{-1}$ | 12.2 |

*[a]the highest rate as estimated by Woodworth et al. (2009); [b]Calculated by the average of the trends for Tilbury (located west of the area) and Sheerness (located east of the area).*

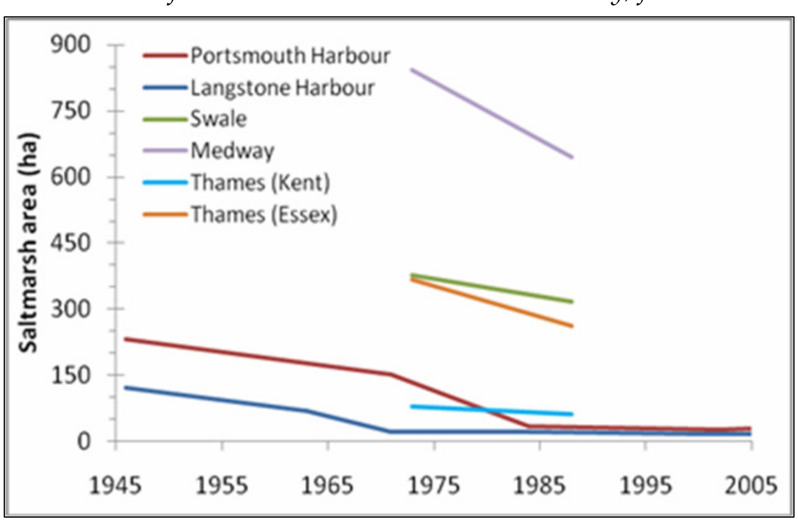
**Exposure to waves**. Intertidal habitats such as saltmarshes and mudflats develop in sheltered environments where fine sediments are allowed to settle. The impact of storms and/or increased wave energy can cause erosion on the edges of saltmarshes. Wave impact is considered to be the main mechanism causing saltmarsh loss in the Thames estuary (Thames Estuary Partnership 2005). The level of exposure is determined qualitatively as follows: intertidal habitats along open coasts exposed to storm waves are assigned the highest value (=1); sheltered environments not exposed to waves are assigned the lowest value (=0); intermediate values are assigned based on the percentage of area which is more or less exposed to waves. Both Portsmouth and Langstone harbours are sheltered from swell waves due to the protective effect of the Isle of Wight and from wind waves due to interaction with tidal currents at the narrow harbour entrances and local refraction at the ebb shoals (SCOPAC 2004). Modelling studies calculate that the mean wave height at the entrance of Portsmouth Harbour is 0.48 m (HR Wallingford 1995) and the maximum significant wave height is 0.8 m, increasing to 1.04 m for a 1 in 200 year recurrence (Halcrow Maritime 2000). Inside the harbour, ship-generated waves are normally less than 0.40 m high (SCOPAC 2004), but may cause erosion in intertidal habitats due to the intense vessel traffic. At the entrance of Langstone Harbour, significant wave height is estimated to be 2.1 m, increasing to 2.58 m for a 1 in 100 year recurrence (SCOPAC 2004). According to wave data collected at a water depth of 10.2 m CD off the coast of Hayling Island (50°43.9936'N; 00°57.5557'W) between 2003 and 2010[12], the dominant wave direction is from the south, with secondary direction from SSE in the autumn and winter and from SSW in the summer. Waves generally approach the Thames estuary from the north-northeast direction (Halcrow 2010) with high energy waves approaching from the northeast (Essex and South Suffolk Shoreline Management Plan 2010), but the wave impact is reduced due to the interaction with the complex system of sand banks in the outer estuary. Wave action is more important in the outer reaches of the Medway and Swale estuaries, and decreases into the estuary (Halcrow 2010). Limited information is available on measurement of waves inside the Thames estuary but some studies indicate that wave heights in the Medway are usually lower than 1 m and extreme waves do not exceed 2 m (CHaMP 2002). Erosion is observed in the coastline of Southend (Essex and South Suffolk Shoreline Management Plan 2010). All six conservation areas are somewhat protected from direct wave attack. Although wave heights at the entrance of Portsmouth and Langstone harbours tend to be higher than waves reaching the Thames estuary, wave action inside the harbours is reduced. Although higher waves are observed at the entrance of Langstone Harbour, Portsmouth Harbour is more affected by boat wake. Potentially, higher wave energy may reach Benfleet and Southend Marshes (as these are exposed to the waves approaching from east and southeast, and coastal erosion is observed). Therefore, this SSSI was assigned the highest level of exposure of the six areas (0.6). The Swale and the Medway are located closer to the outer estuary and, although protected by the Isle of Sheppey and Isle of Grain, they have some frontage exposed to the waves from the east and northeast. Swale and Medway were assigned values of wave exposure of 0.5 and 0.4, respectively. The South Thames Estuary and Marshes has its eastern edge subjected to wave exposure similar to Benfleet Marshes; however, most of its area is subjected to lower wave action. It is considered here that the South Thames Estuary has a wave

[12] Channel Coast Observatory, http://www.channelcoast.org/data_management/real_time_data/charts/?chart=71&tab=stats&disp_option=.

exposure value similar to the Medway, while Portsmouth Harbour and Langstone Harbour are considered relatively more sheltered (value of 0.3).

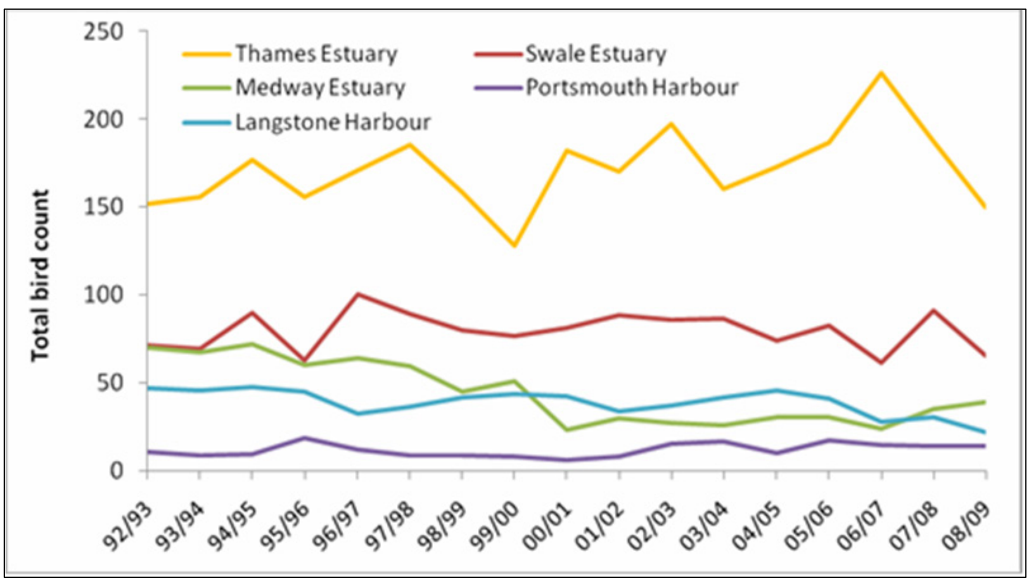
**Loss of saltmarsh areas**. Saltmarshes are important intertidal habitats that support biodiversity and provide essential ecosystem services. Reduction in the area of saltmarshes occurs as a response to natural processes (e.g. erosion, inundation, climatic variability) and human activities (e.g. land reclamation, pollution, introduction of exotic species, dredging). In the Thames estuary, wave impact is considered to have caused most of saltmarsh loss since 1970 (Thames Estuary Partnership 2005), although many continued to accrete vertically despite relative sea-level rise (van der Wall and Pye 2004). Historically, saltmarsh areas have been greatly reduced (Figure 8.13) due to the impact of human activities and only a fraction of the original habitat remains. The analysis of aerial photographs has indicated a rapid erosion of salt marshes in both Portsmouth and Langstone harbours between 1946 and 2005 (Cope and Gorczynska 2007). Land reclamation contributed to saltmarsh loss in Portsmouth Harbour, especially in the period between 1971 and 1984, when approximately 2.5 km$^2$ of intertidal area was reclaimed (based on data obtained from the Channel Coastal Observatory). From 1946 to 2002, more than 83% of salmarsh areas have been lost in both Portsmouth and Langstone harbours (Cope et al. 2008). Saltmarsh loss has reduced greatly in last few decades, mainly as a result from environmental policies and statutory conservation status. To allow relative comparison between the SSSIs in the two study areas, indicators values are based on data illustrating saltmarsh loss from early 1970s to mid-late 1980s are used here. For the area of Portsmouth, saltmarsh losses were measured between 1971 and 1984; for the Thames Gateway losses were measured between 1973 and 1988.

*Figure 8.13. Reduction in saltmarsh area in study areas. Data for Portsmouth and Langstone Harbours were obtained from the Channel Coastal Observatory, for the other areas from English Nature (1997).*



**Bird count.** Figure 8.14 shows the total bird count in the conservation areas. Note that for the purpose of bird count areas, Thames estuary comprises also the Benfleet and Southend Marshes, therefore the same data are used to represent both areas in the calculation of the indicators. All areas have shown a decrease in bird count between 1992 and 2008, except Portsmouth Harbour, which showed a 32% increase. Variability in the bird count between 1992 and 2008 is high, with maximum changes ranging from 43% to 68% of total numbers. Changes observed between consecutive years are also high, especially for Portsmouth Harbour, where bird count can differ up to 94%. Therefore, indicator values are very sensitive to the time interval considered in the assessment. Downward trends could be inter-annual variations not linked to changes in environmental quality. Alternatively, peaks and troughs for 2005-2008 for the Thames/Medway/Swale areas could be partially due to inter-area movement between years, with, for example, the Thames Estuary in 2006 being more favoured than both Swale and Medway.

*Figure 8.14. Total bird count in the study areas (Data from the British Trust for Ornithology).*




**State of conservation of designated SSSI** according to Natural England assessment. Natural England is the organisation responsible for managing the statutory conservation areas. Assessments are conducted regularly to evaluate the environmental conditions that support the criteria set for the maintenance of designations. Therefore, the assessment considers aspects related to environmental quality, biodiversity, existing pressures, implemented management measures and observed trends, which gives an indication of the overall state of conservation. Natural England classifies the SSSI sub- units into five classes: destroyed, unfavourable declining, unfavourable no change, unfavourable recovering, favourable. Table 8.7 shows the percentage of the total SSSI area classified under each category. Clearly, Swale shows the most favourable conditions, while the Medway shows the least areas in favourable conditions. Indicator values are estimated based on the sum of the areas not meeting the target (i.e. unfavourable no change, unfavourable declining and destroyed). Therefore, Benfleet is the SSSI with larger percentage of 'unfavourable' areas.

*Table 8.7. Percentage of total area under each category of state of conservation.*

| SSSI | Favourable | Unfavourable recovering | Unfavourable no change | Unfavourable Declining | Destroyed |
|---|---|---|---|---|---|
| Portsmouth Harbour | 27.4 | 72.6 | - | 0.0 | - |
| Langstone Harbour | 24.4 | 75.6 | - | - | - |
| Benfleet and Southend Marshes | 78.0 | 14.2 | - | 7.7 | - |
| South Thames Estuary | 95.3 | 2.4 | 0.6 | 1.8 | - |
| Medway Estuary | 0.5 | 98.8 | 0.7 | - | 0.5 |
| Swale | 100 | - | - | - | - |

*Mapping of critical areas in unsustainable use*

None of the areas in this assessment are considered to be currently in unsustainable use as there is evidence that environmental quality is improving due to adequate management measures. However, it is important to emphasise that, in the past, human activities have contributed to the significant reduction in the area of saltmarshes and only a fraction of the original areas remain. Additionally, in the future, it is possible that the impacts of climate change, especially sea-level rise, might result in further reduction in the area and/or quality of intertidal habitats.

*Management Status of the Environment and Resources*

The intertidal environments assessed here are statutory conservation areas being managed by Natural England, private owners (i.e. the Ministry of Defence) and in collaboration with other relevant organisations. Policy responses have contributed to reduce the environmental degradation experienced during most of the 20th century and now regulate potentially impacting activities and control intensity of uses. Regular assessment of the environmental conditions of statutory protected areas conducted by Natural England focus on maintaining and/or improving the quality of the habitats following the targets set by the UK Biodiversity Action Plan. Examples of the types of management needed to maintain SSSI include: introducing grazing animals at particular times of year; controlling water levels; clearing scrub; removing invasive species etc. Coastal squeeze seems to be the main threat causing the decline of intertidal habitats and increasing conflict between environmental conservation and flood risk management. Management realignment is a preferred management option at some sites, but the need to maintain flood protection to developed areas might result in the continued loss of intertidal habitats. In these cases, compensatory habitat recreation is usually required; however, suitable locations are scarce and not always available locally. Planning permissions have been the cause of the destruction of some SSSI areas, such as the infilling of a coastal lagoon for the construction of a car park in the Sheerness Docks (Medway Estuary and Marshes). Statutory conservation and the provision of legal instruments to regulate and control uses have been paramount for reducing loss of habitat and species biodiversity.

## 5. Conclusions

Protective legislation has reduced many of the direct human pressures on coastal habitats, especially since the 1990s. Although human activities affecting the conservation of intertidal habitats are now well regulated, coastal squeeze remains as the main threat to the future sustainability of these ecosystems. Habitat and biodiversity loss affect the delivery of ecosystem services, causing environmental and economic impacts that cannot always be adequately measured. In addition to rising sea levels, population growth and economic changes are the main drivers of environmental change. Eight selected indicators were used to calculate an index of sustainability for the intertidal habitats within statutory conservation areas in Portsmouth and the Thames Gateway: population growth, growth in the number of industries, increase in urban areas, sea-level rise, wave exposure, loss of saltmarshes, bird count and the area of SSSI in unfavourable conditions. Six conservation areas were analysed: Portsmouth and Langstone Harbours in the area of Portsmouth and Benfleet Marshes, South Thames Estuary, Medway Estuary and the Swale in the Thames Gateway. Based on the reduction of a number of pressures and impacts observed in recent decades and the improvement of overall environmental quality, all areas are considered to be in sustainable use. The ranking in decreasing order of combined pressure is: Medway, Langstone Harbour, Portsmouth Harbour, South Thames Estuary, Benfleet Marshes and the Swale. This ranking indicates the areas which were subjected to the highest absolute changes based on the selected indicators.

The rankings provide only a qualitative comparison on the level of pressure resulting from the selected indicators, which could be estimated using a variety of methods. Furthermore, some of the indicators reflect a direct impact on the conservation of intertidal habitats, such as the loss of saltmarshes. Other indicators have an indirect impact on coastal habitats that are difficult to quantify and are variable in space and time (e.g. the number of industries). Similarly, some biodiversity indicators, such as bird counts, fluctuate through time due to factors that are not intrinsic to the areas being evaluated. Therefore, assumptions that reduction in bird count results from local environmental degradation are not necessarily correct. A further complicating factor results from the complex interactions between the indicators. For example, saltmarsh decline might result in mudflat increase (i.e. saltmarsh has eroded and transformed into mudflat), which could create greater feeding areas for birds and potentially lead to increases in bird numbers. In this example, an increase in bird count could result from degradation of saltmarshes, which is opposed to the assumptions made in the index calculation (i.e. that an increase in bird count reflects improved environmental conditions).

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# ANNEX

## 1. Methodology on indexes

The index of sustainability (IS) is calculated by:

$$IS = \frac{1}{n}\sum_{i=1}^{n} Indicator_i \ .weight_i \qquad \text{.............1}$$

Sensitivity tests were conducted by assigning different weights to the indicators and results showed high variability in the resulting IS. Therefore, it was considered that the methodology would not warrant the use of IS values as an absolute scale to measure pressure intensity in each area. As a consequence, the arbitrary use of a threshold value to determine 'unsustainable use' becomes meaningless. IS values resulting from 27 selected tests are used here to provide a comparative ranking of the six areas, which indicates the areas under higher or lower pressure levels without actually quantifying them. The ranking ($Rank_i$) was estimated for 27 sensitivity tests by assigning value 1 to the area showing highest IS value (i.e. decreasing level of pressure). The final ranking RankIS was then obtained by calculating the mean (ISrank) of the 27 $Rank_i$ values:

$$IS_{rank} = \frac{1}{27}\sum_{i=1}^{27} Rank_i \qquad \text{.............2}$$

Additionally, to provide a relative comparison between the pressure levels at the six areas, a Relative Index of Sustainability (RIS) was estimated. The RIS was calculated by considering the highest value of each indicator as 100% and the other values as a proportion of the maximum value. The RIS then indicates the levels of pressure of each area in comparison to the maximum pressure observed between the six areas. As for the SI, tests of sensitivity were conducted and the respective RIS values were used to provide a comparative ranking. The same method as described above was applied and the final ranking was obtained by calculating the mean rank value ($RIS_{rank}$) from 27 tests.

## 2. Sustainability of natural resources in the study area

Taking into account that: the DPSIR analysis here focuses on statutory conservation areas; most pressures show evidence of alleviating; and management measures are generally in place to maintain and/or improve the current state of conservation, all six SSSI areas are considered to have sustainable use. Therefore, here the application of indicators to calculate an index of sustainability will only provide a relative comparison of the level of pressure and impact affecting each area. Furthermore, due to limitations of the method, there is no confidence that the index values can be used to quantify the absolute difference in the level of pressure/impact between the areas. Index values are used here only to rank the SSSI areas from the most to the least pressured based on current trends of selected indicators.

*Indicators and trends*

State of conservation of designated SSSI

Table 8.8 shows the values estimated for each indicator used in the calculation of the sustainability indexes SI and RSI. Higher values indicate higher pressure. The highest values for each indicator are shown in red and the lowest values are highlighted in blue. Some indicators show a large variability between the six areas (e.g. bird count and saltmarsh loss), while others show a much narrower range of values (e.g. population and number of industries growth). It is clear that although there is no one area receiving highest pressure from most indicators (red values), Langstone Harbour and Benfleet show the lowest values (in blue) for three of the indicators.

*Table 8.8. Indicator values used in the calculation of the sustainable index*

| Indicator | Portsmouth Harbour | Langstone Harbour | Benfleet | Thames Estuary | Medway | Swale |
|---|---|---|---|---|---|---|
| Population growth (%) | 5.99 | 4.90 | 2.88 | 7.23 | 7.20 | 15.72 |
| Growth in number of industries (%) | 12.19 | 17.26 | 5.25 | 9.20 | 10.06 | 9.60 |
| Increase in urban area (%) | 0.36 | 0.18 | 0.84 | 0.45 | 0.46 | 1.25 |
| Relative rise in sea level (cm) | 10.1 | 10.1 | 7.5 | 13.7 | 12.2 | 12.2 |
| Exposure to waves | 0.3 | 0.3 | 0.6 | 0.4 | 0.4 | 0.5 |
| Loss of saltmarsh area (%) | 78.5 | 10 | 28.5 | 22.5 | 23.5 | 0.9 |
| Decline in bird count (%) | -32.42 | 53.46 | 1.18 | 1.18 | 44.53 | 7.72 |
| Unfavourable state of conservation (%) | 0.03 | 0 | 7.74 | 2.38 | 1.16 | 0 |

*Sustainability of natural resources*

It is considered here that currently, all areas have adequate management and implemented measures that will support their sustainability in the short and medium term. Environmental and planning policies have reduced considerably the pressures currently affecting the conservation of intertidal habitats in comparison with past conditions. Therefore, the IS should be interpreted only as a relative comparison between the ongoing pressures on the conservation of designated intertidal habitats. The indicator values shown in Table 8.8 and the weights assigned to the indicators based on expert judgement (Table 8.9) were used to estimate IS and RIS. However, tests to assess the sensitivity of the method showed high variability in the results. Appendix C and D show the estimated IS and RIS values, respectively, for each SSSI for the 27 selected tests. Higher IS values indicate areas subjected to higher pressure levels (i.e. likely to negatively affect the conservation state of intertidal habitats). IS and RIS values were then used to rank the SSSI areas in decreasing order of pressure (rank = 1 indicates highest pressure level) and the mean rank values were used to provide the final $IS_{rank}$ and $RIS_{rank}$ for the six areas (Table 8.9). The $IS_{rank}$ order indicates that the Medway is the area under highest combined pressure, despite the fact it is not subjected to the highest pressure from any single indicator (see Table 8.8). The Swale, despite the largest increase in population and urban area, shows the lowest combined pressure. However, the $RIS_{rank}$ order is considerably different: the Swale shows the highest relative pressure and Porstmouth Harbour the lowest. While the $IS_{rank}$ indicates the changes observed from absolute measurements; the $RIS_{rank}$ reflects the relative intensity of changes compared between the six areas.

*Table 8.9. Mean rank values and final rank based on the Index of Sustainability ($IS_{rank}$) and the Relative Index of Sustainability ($RIS_{rank}$).*

| | Portsmouth Harbour | Langstone Harbour | Benfleet | Thames Estuary | Medway | Swale |
|---|---|---|---|---|---|---|
| Mean rank | 3.1 | 2.0 | 4.8 | 4.1 | 1.5 | 5.5 |
| $IS_{Rank}$ | 3 | 2 | 5 | 4 | 1 | 6 |
| Mean rank | 5.7 | 4.0 | 3.1 | 4.6 | 2.2 | 1.5 |
| $RIS_{Rank}$ | 6 | 4 | 3 | 5 | 2 | 1 |

## 3. Conclusions

Protective legislation has reduced many of the direct human pressures on coastal habitats, especially since the 1990s. Although human activities affecting the conservation of intertidal habitats are now well regulated, coastal squeeze remains as the main threat to the future sustainability of these ecosystems. Habitat and biodiversity loss affect the delivery of ecosystem services, causing environmental and economic impacts that cannot always be adequately measured. In addition to rising sea levels, population growth and economic changes are the main drivers of environmental change. Eight selected indicators were used to calculate an index of sustainability for the intertidal habitats within statutory conservation areas in Portsmouth and the Thames Gateway: population growth, growth in the number of industries, increase in urban areas, sea-level rise, wave exposure, loss of saltmarshes, bird count and the area of SSSI in unfavourable conditions. Six conservation areas were analysed: Portsmouth and Langstone Harbours in the area of Portsmouth and Benfleet Marshes, South Thames Estuary, Medway Estuary and the Swale in the Thames Gateway. Based on the reduction of a number of pressures and impacts observed in recent decades and the improvement of overall environmental quality, all areas are considered to be in sustainable use. Therefore, the index of sustainability is used here only to provide a qualitative measure of impact/pressure over the six conservation areas in recent times, which is given in the form of a ranking. The ranking in decreasing order of combined pressure is: Medway, Langstone Harbour, Portsmouth Harbour, South Thames Estuary, Benfleet Marshes and the Swale. This ranking indicates the areas which were subjected to the highest absolute changes based on the selected indicators. However, when a relative index is estimated based on proportions of the maximum values for each indicator, the ranking is considerably different. The ranking based on a relative index is: the Swale, Medway, Benfleet, Langstone Harbour, Thames Estuary and Portsmouth Harbour.

These findings should be considered with caution as the index values and respective ranking are highly dependent on the indicators used and their relative weights.

# APPENDIX A: REASONS FOR NOTIFICATION OF DESIGNATIONS IN THE TWO STUDY AREAS

## 1. Langstone Harbour SSSI

(http://www.sssi.naturalengland.org.uk/citation/citation_photo/1001182.pdf)

**Area:** 2,069.4 ha

**Date Notified (Under 1949 Act): 1958; Date Notified (Under 1981 Act): 1985**

**Reasons for Notification:**

Langstone Harbour comprises one of the largest areas of mixed saltmarsh on the south coast of England, with an extensive deteriorating cord-grass *Spartina anglica* marsh. The *Zostera angustifolia* and *Z.noltii* beds are among the largest in Britain. The intertidal system is among the twenty most important in Britain as a summer and autumn assembly ground for waders during the moult and post- moult. Dunlin *Calidris alpina* often exceed 30,000 individuals, or 6% of the British winter population, or 3% of the European and North African wintering population. Grey plover *Pluvialis squatarola* and black- tailed godwit *Limosa limosa* achieve numbers which represent 1–2% of the European and North African migration flyway population; and redshank *Tringa totanus* and ringed plover *Charadrius hiaticula* do so periodically. At times as many as 20% of the black-tailed godwit, 8% of the ringed plover and 8-10% of the grey plover wintering in Britain are present in the harbour. The total numbers of waders present sometimes exceeds 40,000. In the 1970s and 1980s Langstone Harbour alone has consistently supported in excess of 5,000 wintering dark-bellied geese *Branta bernicla*, or 5-10% of the world population depending on fluctuating population levels. It has supported up to 2.5% of the European winter population of shelduck *Tadorna tadorna* and regularly supports substantial numbers of other ducks in autumn and winter.

Farlington Marshes intrudes into the northwest sector of the harbour. Its vegetation is strongly influenced by drainage water from the chalk and by brackish water infiltration. The marshes embrace a variety of habitats – brackish marsh, fresh marsh, a large lagoon with associated reed *Phragmites* beds, *Agrostis stolonifera* grassland and scrub. It is a vital high water wader roost for the Harbour and a major feeding ground for Brent geese after the *Zostera* beds in the Harbour have been consumed. Few comparable sites have survived agricultural improvement on the south and east coasts of England, where the habitat was formerly common: the grassland flora is especially rich for reclaimed silt, and includes over 50 species of grasses.

## 2. Portsmouth Harbour SSSI

(http://www.sssi.naturalengland.org.uk/citation/citation_photo/1003174.pdf)

**Area**: 1,266.09 ha

**Date Notified (Under 1949 Act)**: 1974; **Date Notified (Under 1981 Act)**: 1985; **Date of Last Revision**: 29 October 1992 (confirmed 22 July 1993) - extended to include intertidal areas at Brick Kiln, Forton, Haslar and Tipner Lakes.

**Reasons for Notification:**

The biological richness and productivity of Portsmouth Harbour is reflected in the numbers of wetland birds, particularly waders and wildfowl, of which total numbers can exceeded 20,000 at times. Portsmouth Harbour is of national importance for the numbers of three species of waders (grey plover, black-tailed godwit and dunlin) it supports and for the overwintering dark-bellied Brent geese. The intertidal area of Portsmouth Harbour includes 776 ha of mudflats and about 173 ha of cord-grass *Spartina* marshes. The mudflats support a total fauna of about 60 species of benthic marine animals, of which about ten occur in very large numbers. The mud surfaces support extensive beds of eelgrasses *Zostera noltii* and *Z.angustifolia* and extensive areas of the mudflats support a high density of green algae, mainly *Enteromorpha* species and *Ulva lactuca* in summer. The eelgrasses and algae are mutually exclusive in distribution on the mudflats. The eelgrass beds are among the most extensive in Britain and Portsmouth Harbour is one of only four intertidal areas on the south coast to support extensive eelgrass beds. The beds have a rich associated benthic and epiphytic fauna and algal fauna and the eelgrass itself is an important food of the Brent goose. The cord-grass marshes occur on mudflats in the upper part of the tidal range and are dominated by *Spartina anglica*. Since the late 19$^{th}$ century, *Spartina anglica* has colonised the accreted mud platforms, which are dissected by ramifying systems of drainage creeks. However, the plants are dying back and the muddy platforms are eroding and slumping back to a profile similar to the former mudflat. At the uppermost levels *Spartina* is replaced locally by saltmarsh dominated by sea purslane *Halimione portulacoides*. The nationally scarce golden samphire *Inula crithmoides* occurs at the upper limits of sea purslane marsh and at the toe of some sea walls. The SSSI includes two brackish lagoons adjoining Haslar Lake, but they are located outside Portsmouth City Council boundary.

### 3. Benfleet and Southend Marshes SSSI

(http://www.sssi.naturalengland.org.uk/citation/citation_photo/1004414.pdf)

**Area**: 2,099.69 ha

**Date Notified (Under 1949 Act)**: 1955; **Date Notified (Under 1981 Act)**: 1987

**Reasons for Notification:**

Benfleet and Southend Marshes comprise an extensive series of saltmarshes, mudflats, scrub and grassland which support a diverse flora and fauna. The south-facing slopes of the downs, composed of London Clay capped by sand, represent the line of former river cliffs with several re-entrant valleys. At their foot lies reclaimed marshland, with its associated dyke system, based on alluvium. Outside the seawalls there are extensive saltmarshes and mudflats, on which wintering wildfowl and waders reach both nationally (i.e. dunlin, redshank and ringed plover) and internationally (i.e. dark-bellied brent goose, grey plover and knot) important numbers. Nationally uncommon plants occur in all of the habitats and parts of the area are of outstanding importance for scarce invertebrates. The mudflats are colonised by eelgrasses *Zostera marina* and *Z.noltii* which, together with dense patches of *Enteromorpha* and, together with the rich invertebrate fauna, provide food for thousands of birds which overwinter on this shoreline. A survey of Southend Flat during the winter of 1985/86 suggests that, in addition to nationally important populations of the species already mentioned, this area alone supports nationally important numbers of bar-tailed godwit and oyster-catcher, whilst redshank reach levels of international importance. The saltmarsh has a high marsh flora of sea purslane *Halimione portulacoides* and common sea-lavender *Limonium vulgare*, together with sea arrow-grass *Triglochin maritima*, common saltmarsh-grass *Puccinellia maritima*, sea aster *Aster tripolium* and the scarce lax flowered sea-lavender *Limonium humile*. The lower areas and creek edges are noted for their diversity of glassworts *Salicornia* spp., including perennial glasswort *S. perennis*. Golden samphire *Inula crithmoides* occurs on the highest parts of the marsh, beneath the sea walls, whilst small cord-grass *Spartina maritimas* found on the lowest areas.

The uncommon bithynian vetch *Vicia bithynica* occurs in the grassland of the downs, together with hartwort *Tordylium maximum*, at its only British station, hairy vetchling *Lathyrus hirsutus* and slender tare *Viciate nuissima*. The reclaimed marsh is grazed by cattle and horses. It is dominated by grasses such as meadow foxtail *Alopecurus pratensis* and perennial rye-grass *Lolium perenne*, and sea clover *Trifolium squamosum*, strawberry clover *T.fragiferum* and hairy buttercup *Ranunculus sardous* are also present. Uncommon species occur in the dykes, including:

*C. submersum*, beaked tassel weed *Ruppia maritime*, brackish water-crowfoot *Ranunculus baudotii* and emerald damselfly *Lestes dryas*. This combination of scrub, grassland and open water with vegetated margins provides a habitat for many scarce and notable insects, such as the white-letter hairstreak *Strymonidia w-album* and marbled white *Melanargia galathea* butterflies, the latter occurring in Essex only along the Thames. Additional interest is provided by the diverse breeding bird community, including yellow wagtails.

### 4. South Thames Estuary and Marshes SSSI

(http://www.sssi.naturalengland.org.uk/citation/citation_photo/1003874.pdf)

**Area**: 5449.14 ha

**Date Notified (Under 1949 Act)**: 1951, 1968; **Date Notified (Under 1981 Act)**: 1984; **Date of Last Revision**: 1991.

**Reasons for Notification:**

The site consists of an extensive mosaic of grazing marsh, saltmarsh, mudflats and shingle characteristic of the estuarine habitats of the north Kent marshes. The saltmarshes support characteristic vegetation dominated by the saltmarsh grasses *Puccinellia*, the glassworts *Salicornia*, sea aster *Aster tripolium*, sea lavender *Limonium vulgare* and sea purslane *Halimione portulacoides*, with nationally scarce plants such as golden samphire *Inula crithmoides* and *Puccinellia fasciculata*. The mudflats have beds of eelgrass including *Zostera angustifolia* and *Z. noltii* and the Allhallows region of the site has areas of vegetated shingle with the nationally scarce sea kale *Crambe maritime* present. Freshwater pools and some areas of woodland provide additional variety and complement the estuarine habitats. The site supports outstanding numbers of waterfowl with total counts regularly exceeding 20,000. The mudflats attract large numbers of feeding waders and wildfowl with the site being regularly used by redshank *Tringa totanus*, knot *Calidris canuta* and dunlin *Calidris alpina* in internationally important numbers. Avocet *Recurvirostra avosetta* and ringed plover *Charadrius hiaticula* regularly exceed nationally important numbers. Species regularly reaching nationally important numbers in winter include: European white-fronted goose *Anser albifrons* spp *albifrons*, shelduck *Tadorna tadorna*, gadwall *Anas strepera*, teal *Anas crecca*, pintail *Anas acuta*, shoveler *Anas clypeata*, grey plover *Pluvialis squatarola*, curlew *Numenius arquata* and blacktailed godwit *Limosa limosa*. In addition, nationally important numbers of grey plover, curlew, black-tailed godwit, redshank and greenshank *Tringa nebularia* occur during autumn with redshank maintaining their nationally important numbers on spring passage.

During the breeding season the south Thames marshes support an outstanding assemblage of breeding birds including rare species such as garganey *Anas querquedula*, pintail, avocet and bearded tit *Panurus biarmicus*. Specially protected birds found within the site include hen harrier *Circus cyaneus*, short- eared owl *Asio flammeus*, ruff *Philomachus pugnax*, common tern *Sterna hirundo*, avocet and golden plover *Pluvialis apricaria*.

### 5. Medway Estuary and Marshes SSSI

(http://www.sssi.naturalengland.org.uk/citation/citation_photo/1000244.pdf)

**Area:** 6840.14 ha

**Date Notified (Under 1949 Act):** 1968; **Date Notified (Under 1981 Act):** 1984; **Date of Last Revision:**1992.

**Reasons for Notification:**

The Medway Estuary is believed to be the most important area in North Kent for wintering wildfowl occurring in numbers of international significance (shelduck *Tadorna tadorna*, brent goose *Branta bernicla*, grey plover *Pluvialis squatarola*, ringed plover *Charadrius hiaticula*, pintail *Anas acuta*, dunlin *Calidris alpina* and redshank *Tringa totanus*). Present in nationally important numbers are: turnstone *Arenaria interpres*, black-tailed godwit *Limosa limosa*, curlew *Numenius arquata*, great crested grebe *Podiceps cristatus*, shoveler *Anas clypeata*, teal *Anas crecca*, wigeon *Anas penelope* and white-fronted goose *Anser albifrons*. Passage migrants include ruff *Philomachus pugnax*, whimbrel *Numenius phaeopus* and avocet *Recurvirostra avosetta*. Breeding species include avocet, shelduck, shoveler, pochard *Athyia ferina*, mute swan *Cygnus olor*, tufted duck *Athyia fuligula*, teal *Anas crecca* and gadwall *Anas strepera*. The saltmarsh serves as a roosting area for waders at high tide and supporting breeding birds (redshank *Tringa totanus*, black headed gull *Larus ridibundus* and common tern *Sterna hirundo*). Several scarce plant species include: golden samphire *Inula crithmoides*, perennial glasswort *Salicornia perennis* and one-flowered glasswort *Salicornia pusilla*. The estuary is one of the best places in Britain for the study of glassworts. The grazing marsh has breeding and wintering birds of interest; the former include lapwing *Vanellus vanellus*, redshank, pochard, mallard *Anas platyrhynchos* and gadwall, while in winter large flocks of many wildfowl and wader species are present.

## 6. The Swale SSSI

(http://www.sssi.naturalengland.org.uk/citation/citation_photo/103678.pdf)

**Area:** 6568.45 ha

**Date Notified (Under 1949 Act):** 1968; **Date Notified (Under 1981 Act**): 1984; **Date of Last Revision:**1990.

**Reasons for Notification:**

The habitats comprise chiefly mudflats, saltmarsh, and freshwater grazing marsh, the latter being intersected by extensive dykes and fleets. The area is particularly notable for the internationally important numbers of wintering and passage wildfowl and waders. Several species regularly overwinter in numbers of international importance: wigeon *Anas penelope*, teal *Anas crecca* and grey plover *Pluvialis squatarola*. Present in winter in nationally significant numbers are: shoveler *Anas clypeata*, knot *Caladris canutus*, dunlin *Caladris alpina* and spotted redshank *Tringa erythropus*. Many of the birds use more than one habitat, some for example feed on the mudflats at low tide and then move up to roost on the saltmarsh or on fields inland of the sea wall. The mudflats support over 350 species of invertebrates, some of which are not found elsewhere in Britain (e.g. polychaete worm *Clymenella torquata*). The saltmarshes are among the richest for plant life in Britain and include: the saltmarsh- grasses *Puccinellia*, the glassworts *Salicornia*, sea aster *Aster tripolium*, sea lavender *Limonium vulgare*, sea purslane *Halimione portulacoides* and common cord-grass *Spartina anglica*. The scarce small cord- grass *Spartina maritima* and the rare golden samphire *Inula crithmoides* are also found. The grazing marsh complexes and grassland habitats present a number of scarce and rare species.

# APPENDIX B

| Table 8.10. Operations likely to damage the special interest at the SSSI in the two study areas.**Ref.** | **Type of Operation** | **Langstone**[13] | **Portsmouth**[14] | **Swale**[15] | **Thames Estuaries and Marshes**[d16] | **Medway Marshes**[e17] | **Foulness**[f18] | **Benfleet and Southend Marshes**[g19] |
|---|---|---|---|---|---|---|---|---|
| 1 | Cultivation, including ploughing, rotovating, harrowing, and re-seeding. | | | | | | | |
| 2 | Changes in the grazing regime (including type of stock, intensity or seasonal pattern of grazing and cessation of grazing). | | | | | | | |
| 3 | Changes in stock feeding practice. | | | | | | | |
| 4 | Changes in the mowing or cutting regime (including hay making to silage and cessation). | | | | | | | |
| 5 | Application of manure, fertilisers and lime. | | | | | | | |
| 6 | Application of pesticides, including herbicides (weedkillers). | | | | | | | |
| 7 | Dumping, spreading or discharge of any materials. | | | | | | | |
| 8 | Burning of vegetation. | | | | | | | |
| 9 | The release into the site of any wild or feral animal or domestic pig or any plant or seed. | | | | | | | |
| 10 | The killing or removal of any wild animal, including pest control. | | | | | | | |
| 11 | The destruction, displacement, removal or cutting of any tree, shrub, hedge, turf or aquatic plant or alga. | | | | | | | |
| 12 | The introduction of tree and/or woodland management, including afforestation, planting, clear and selective felling, thinning, coppicing, modification of the stand or underwood, changes in species composition, cessation of management. | | | | | | | |

13 http://www.sssi.naturalengland.org.uk/special/sssi/old/OLD1001182.pdf.

14 http://www.sssi.naturalengland.org.uk/special/sssi/old/OLD1003174.pdf.

15 http://www.sssi.naturalengland.org.uk/special/sssi/old/OLD1003678.pdf.

16 http://www.sssi.naturalengland.org.uk/special/sssi/old/OLD1003874.pdf.

17 http://www.sssi.naturalengland.org.uk/special/sssi/old/OLD1000244.pdf.

18 http://www.sssi.naturalengland.org.uk/special/sssi/old/OLD1002984.pdf.

19 http://www.sssi.naturalengland.org.uk/special/sssi/old/OLD1004414.pdf.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 13a | Drainage (including the use of mole, tile, tunnel or other artificial drains). | | | | | | | |
| 13b | Modification of the structure of tidal creeks and channels, streams, springs, ditches and drains, including their banks and beds, as by re-alignment, re-grading and dredging. | | | | | | | |
| 13c | Management of aquatic and bank vegetation. | | | | | | | |
| 14 | The changing of water levels and tables and water utilisation (including irrigation, storage and abstraction from existing water bodies and through boreholes). | | | | | | | |
| 15 | Infilling of ditches, drains, ponds, pools or marshes. | | | | | | | |
| 16a | The introduction of freshwater fishery production and/or management, including sporting fishing and angling. | | | | | | | |
| 16b | The introduction of new coastal fisheries or changes in coastal fishing practice or fisheries management and seafood or marine life collection, including the use of traps or fish cages. | | | | | | | |
| 17 | Reclamation of land from sea, estuary or marsh. | | | | | | | |
| 18 | Bait digging in intertidal areas. | | | | | | | |
| 19 | Erection of sea defences or coast protection works, including cliff or landslip drainage or stabilisation measures. | | | | | | | |
| 20 | Extraction of minerals, including peat, shingle, sand and gravel, topsoil, subsoil, shells and spoil. | | | | | | | |
| 21 | Construction of roads, tracks, walls, fences, hardstands, banks, ditches or other earthworks, or the laying, maintenance or removal of pipelines and cables, above or below ground. | | | | | | | |
| 22 | Storage of materials. | | | | | | | |
| 23 | Erection of permanent or temporary structures, or the undertaking of engineering works, including drilling. | | | | | | | |
| 24 | Clearance of boulders, large stones, loose rock and shingle, and re-grading of foreshores. | | | | | | | |
| 26 | Use of vehicles or craft likely to damage or disturb vegetation or fauna. | | | | | | | |
| 27 | Recreational or other activities likely to damage vegetation or fauna. | | | | | | | |
| 28 | Changes in game and wildfowl management and hunting practice. | | | | | | | |

# APPENDIX C

*Table 8.11. Index Of Sustainability (Si) Estimated For Each Area In 27 Tests Of Varying Weights.*

| Weights | Ranking | Portsmouth Harbour | Langstone Harbour | Benfleet | Thames Estuary | Medway | Swale |
|---|---|---|---|---|---|---|---|
| As in Table 8.2 | original | 22.00 | 15.79 | 12.14 | 13.52 | 18.76 | 11.71 |
| | all weights =1 | 9.38 | 12.03 | 6.81 | 7.13 | 12.44 | 5.99 |
| Weight = 2 (all other indicators with weight = 1) | Population | 10.13 | 12.64 | 7.17 | 8.03 | 13.34 | 7.95 |
| | Industries | 10.91 | 14.18 | 7.47 | 8.28 | 13.70 | 7.19 |
| | Urban area | 9.43 | 12.05 | 6.92 | 7.19 | 12.50 | 6.14 |
| | Sea level | 10.64 | 13.29 | 7.75 | 8.84 | 13.96 | 7.51 |
| | Waves | 9.42 | 12.06 | 6.89 | 7.18 | 12.49 | 6.05 |
| | Saltmarshes | 19.19 | 13.28 | 10.37 | 9.94 | 15.38 | 6.10 |
| | Bird count | 5.33 | 18.71 | 6.96 | 7.28 | 18.01 | 6.95 |
| | SSSI state | 9.39 | 12.03 | 7.78 | 7.43 | 12.58 | 5.99 |
| | Population and Sea level | 11.39 | 13.90 | 8.11 | 9.75 | 14.86 | 9.48 |
| | Population and Waves | 10.17 | 12.68 | 7.25 | 8.08 | 13.39 | 8.01 |
| | Population and Saltmarshes | 19.94 | 13.89 | 10.73 | 10.85 | 16.28 | 8.06 |
| | Population and Bird count | 6.08 | 19.32 | 7.32 | 8.18 | 18.91 | 8.92 |
| | Population and SSSI state | 10.13 | 12.64 | 8.14 | 8.33 | 13.48 | 7.95 |
| | Industries and Sea level | 12.17 | 15.45 | 8.41 | 9.99 | 15.22 | 8.71 |
| | Industries and Waves | 10.94 | 14.22 | 7.54 | 8.33 | 13.75 | 7.25 |
| | Industries and Saltmarshes | 20.72 | 15.43 | 11.03 | 11.09 | 16.63 | 7.30 |
| | Industries and Bird count | 6.85 | 20.87 | 7.62 | 8.43 | 19.26 | 8.15 |
| Weight = 0 (all other indicators with weight = 1) | Population | 8.63 | 11.41 | 7.42 | 6.52 | 11.68 | 4.02 |
| | Industries | 7.86 | 9.87 | 7.12 | 6.28 | 11.33 | 4.79 |
| | Urban area | 9.34 | 12.00 | 7.67 | 7.37 | 12.53 | 5.83 |
| | Sea level | 8.12 | 10.76 | 6.84 | 5.72 | 11.06 | 4.46 |
| | Waves | 9.35 | 11.99 | 7.70 | 7.38 | 12.53 | 5.92 |
| | Saltmarshes | -0.43 | 10.78 | 4.22 | 4.62 | 9.65 | 5.87 |
| | Bird count | 13.44 | 5.34 | 7.63 | 7.28 | 7.02 | 5.02 |
| | SSSI state | 9.38 | 12.03 | 5.84 | 6.83 | 12.29 | 5.99 |

# APPENDIX D

*Table 8.12. Relative Index Of Sustainability (Ris) Estimated For Each Area In 27 Tests Of Varying Weights.*

| Weights | | Portsmouth Harbour | Langstone Harbour | Benfleet | Thames Estuary | Medway | Swale |
|---|---|---|---|---|---|---|---|
| As in Table 8.2 | original | 37.62 | 47.75 | 51.15 | 45.45 | 53.10 | 55.45 |
| | all weights =1 | 42.39 | 51.65 | 53.44 | 51.20 | 58.83 | 67.95 |
| Weight = 2 (all other indicators with weight = 1) | Population | 46.45 | 60.25 | 54.95 | 52.11 | 60.39 | 62.40 |
| | Industries | 41.22 | 49.55 | 59.55 | 49.95 | 57.70 | 67.95 |
| | Urban area | 46.84 | 56.97 | 57.99 | 57.95 | 64.23 | 66.58 |
| | Sea level | 43.87 | 54.00 | 63.65 | 53.78 | 61.44 | 65.87 |
| | Waves | 50.12 | 49.35 | 55.69 | 49.03 | 56.84 | 55.59 |
| | Saltmarshes | 30.04 | 60.25 | 51.43 | 45.72 | 63.51 | 57.25 |
| | Bird count | 37.67 | 47.75 | 63.65 | 49.29 | 54.98 | 55.45 |
| | SSSI state | 72.47 | 68.15 | 75.51 | 77.53 | 84.03 | 104.22 |
| | Population and Sea level | 32.86 | 43.86 | 48.86 | 39.70 | 47.38 | 42.95 |
| | Population and Waves | 28.80 | 35.25 | 47.35 | 38.78 | 45.82 | 48.50 |
| | Population and Saltmarshes | 34.02 | 45.95 | 42.75 | 40.95 | 48.50 | 42.95 |
| | Population and Bird count | 28.41 | 38.54 | 44.31 | 32.95 | 41.97 | 44.32 |
| | Population and SSSI state | 31.37 | 41.50 | 38.65 | 37.11 | 44.77 | 45.03 |
| | Industries and Sea level | 25.12 | 46.16 | 46.61 | 41.86 | 49.36 | 55.31 |
| | Industries and Waves | 45.21 | 35.25 | 50.87 | 45.17 | 42.69 | 53.64 |
| | Industries and Saltmarshes | 37.58 | 47.75 | 38.65 | 41.60 | 51.23 | 55.45 |
| | Industries and Bird count | 51.60 | 60.87 | 60.28 | 63.70 | 69.96 | 79.08 |
| Weight = 0 (all other indicators with weight = 1) | Population | 48.64 | 57.90 | 65.94 | 59.53 | 67.16 | 78.37 |
| | Industries | 54.89 | 53.24 | 57.98 | 54.78 | 62.57 | 68.09 |
| | Urban area | 34.81 | 64.15 | 53.72 | 51.47 | 69.24 | 69.75 |
| | Sea level | 42.44 | 51.65 | 65.94 | 55.04 | 60.70 | 67.95 |
| | Waves | 55.67 | 69.47 | 61.79 | 64.61 | 71.52 | 73.53 |
| | Saltmarshes | 52.70 | 66.50 | 67.45 | 60.44 | 68.72 | 72.82 |
| | Bird count | 58.95 | 61.85 | 59.49 | 55.69 | 64.13 | 62.54 |
| | SSSI state | 38.87 | 72.75 | 55.23 | 52.39 | 70.80 | 64.21 |

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**ABSTRACT:** This chapter reports on the uses of the DPSIR framework to assess the sustainability of the intertidal environments within the two UK case study areas, Portsmouth and Thames Gateway. It focuses on statutory conservation areas dominated by intertidal habitats. Two are located in Portsmouth (Portsmouth and Langstone Harbours) and four in the Thames Gateway (Benfleet Marshes, South Thames Estuary, Medway Estuary and the Swale in the Thames Gateway). Based on the reduction of a number of pressures and impacts observed in recent decades and the improvement of overall environmental quality, all six SSSIs are considered to be sustainable in the short and medium term. In the future, it is possible that the impacts of climate change, especially sea-level rise, might result in further reduction in the area and/or quality of intertidal habitats. Further integration between conservation and planning objectives (both for urban development and management of flood risk) at local level is needed to support the long-term sustainability of intertidal habitats.

**KEYWORDS:** DPSIR; intertidal habitats; UK case studies; Portsmouth; Thames Gateway.

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