Office for National Statistics

Scoping UK coastal margin ecosystem accounts

Scopes the development of a coastal margins ecosystem account and discusses several methodological challenges arising from the unique characteristics of coastal margin habitats.

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1 . Collaboration

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2 . Summary

This article scopes the development of a coastal margins ecosystem account and discusses several methodological challenges arising from the unique characteristics of coastal margin habitats. Recommendations are also given where possible. Further development of methodologies and an in-depth review of data sources will be required in order to develop an initial account for coastal margins as part of the 2020 Natural Capital Accounting Roadmap.

Feedback from experts in the various disciplines covered in the article will be essential for the successful development of ecosystem accounts. All feedback is welcome and can be sent to environmental.accounts@ons.gsi.gov.uk.

3 . Main points

A combined marine and coastal margins account is recommended. This would retain separate identification of services distinctive to each habitat whilst providing a single composite account for less tangible services which it is not meaningful to attribute to one habitat or the other.

It is recommended to follow the UK National Ecosystem Assessment habitat classification when defining coastal margins.

We recommend using the Countryside Survey dataset. Once a more detailed update has been completed, the land cover map data from the Centre for Ecology and Hydrology (CEH) can be considered as well. The final accounts should also take account of the potential to estimate habitat extent via satellite data.

Coastal margins comprise a narrow strip of land around the UK's coast. Depending upon how it is defined and on the dataset used, it covers between 137,000 and 152,000 hectares.

Many coastal margin habitats are amongst the most sensitive to climate change: increased sea level rise can lead to "coastal squeeze" and susceptibility to increased storminess; changing rainfall and temperature will also have adverse impacts.

Instead of assigning cultural services to one or other of the marine or coastal margins accounts, we recommend a joint overarching marine and coastal margins account with (i) sub-accounts for provisioning and regulating services attributable to coastal margin or marine habitats; and (ii) a composite account for cultural services.

A number of services can potentially be included in a monetary account with varying degrees of robustness: carbon sequestration, sea defence, pollution absorption, recreation and tourism.

4 . Introduction

This work is part of the Department for Environment, Food and Rural Affairs and Office for National Statistics (Defra-ONS) project "Accounting for the value of nature in the UK: A roadmap for the development of natural capital accounts within the UK Environmental Accounts" which includes the development of 8 broad habitat ecosystem accounts by 2020 . Natural capital accounting is a means to account for society's wealth in natural assets and benefits from ecosystem services.

The purpose of national level ecosystem accounts is to provide evidence to inform and improve decision-making by integrating environmental and economic information. The accounts can be a tool to help decision-makers understand the trade-offs between different ecosystem services, and between alternative land uses.

By providing a link between the ecosystem and the benefits which humans receive from the natural environment, the accounts help us to understand the contribution the environment makes to economic activity and human well-being. Further, by valuing the stocks of these natural assets and the flows of benefits, the accounts facilitate comparison with other economic and social information and help to emphasise the importance of maintaining and improving the stock of natural capital.

More information on our programme of work in this area can be found on the natural capital accounts webpage.

This study scopes the development of a coastal margins ecosystem account , discusses several methodological challenges that come with the unique characteristics of coastal margin habitats and gives a recommended solution where possible. It has drawn on the results of a range of studies including the UK National Ecosystem Assessment (UK NEA 2011), the UK National Ecosystem Follow-on (UK NEAFO), and the scoping study on the marine ecosystem accounts (eftec 2015). This work follows the principles of ecosystem accounting previously published by ONS and Defra (Defra/ONS 2014), which in turn are based on System of Environmental-Economic Accounting Ecosystem Accounting guidance (SEEA EEA).

This article has benefited from expert advice from Defra group and ONS experts and from academics [1].

Notes for Introduction

1. Special thanks due for the valuable contributions and comments from colleagues at Defra, ONS, Natural England and JNCC and from Laurence Jones (Centre for Ecology and Hydrology).

5 . Classifying and defining the asset

The UK National Ecosystem Assessment (UK NEA) highlights the important role that coastal margins play as an "interface between land and sea" whose habitats "provide some unique ecosystem services and drivers of change due to their location as a transition zone between marine and terrestrial systems". While this unique feature of coastal margins justifies a stand-alone account, issues over defining coastal margins remain as the coast is a complex environment and hence difficult to define.

It is possible to define coastal margins based either on the high-water mark or based on ecological or physical area such as an ecosystem or habitat. The UK NEA followed the latter and defined 8 broad habitat categories, distinguishing between marine and coastal ecosystems. The marine scoping study commissioned by Defra (eftec et al 2015) diverged from this, and instead used a definition based on the mean high water mark; and tidal limit of estuaries was used as the boundary between marine and terrestrial accounting (eftec 2015). As the interim review of the natural capital accounting 2020 roadmap states (ONS/Defra 2015), habitat accounts should ideally be combined in a consistent, additive way. This section discusses both approaches.

Ecological or physical area based approach

An ecological area-based definition can be based on habitats, land cover or land use. These are separate concepts that are not always distinguished clearly enough. The definitions in Table 1 are from the UK NEA glossary.

Table 1: Habitat, land cover and land use definitions, UK NEA

Habitat / ecosystem	An ecological or environmental area that is inhabited by a particular animal or plant species.
Land cover	The physical coverage of land, usually expressed in terms of vegetation cover or lack of it. Related to, but not synonymous with, land use.
Land use	The human use of a piece of land for a certain purpose (such as irrigated agriculture or recreation). Influenced by, but not synonymous with, land cover.

Source: UK National Ecosystem Assessment (UK NEA)

Coastal margins do not easily fit these definitions. It is possible to define coastal margin through habitats, as in the NEA; many coastal margin datasets are based on land cover. Some coastal margin areas are also used as farmland (for example, saltmarsh) or for grazing sheep and could overlap with definitions based on land use (see Table 1).

Crucially, the coast is not defined only by its habitats, land cover or land use, but also by its geographical position as the transition zone between terrestrial and marine. In this context, other habitats or land cover categories, for example, grassland or urban areas, can be situated on what would be called “the coast”. Table 2 summarises the possible linkages between coastal habitats and the other NEA broad habitats. Such overlaps are also acknowledged in the reporting categories of the Millennium Ecosystem Assessment (MA): “a wetland ecosystem in a coastal region may be examined both in the MA analysis of coastal systems as well as in its analysis of inland water systems” (Christian and Mazzilli 2007). To avoid double-counting in cases where habitats overlap (for example, urban beaches), some assessment of the most important features (for example, urban or coast) is needed and then the area should be recorded in the appropriate account.

Table 2: Linkages between coastal habitats and other UK NEA broad habitat[1]

Coastal Margin habitat	Mountains Moorlands & Heaths	Semi-natural Grass-land	Enclosed Farmland	Woodlands	Fresh-waters	Urban	Marine
Sand Dunes	Dune heath	Dune grass-land		Afforested dunes	Dune slacks	Sandy beach	Sediment
Machair		Machair grass-land	Cultivated machair		Machair lochs		Sediment
Saltmarsh		Saltmarsh grassland	Enclosed saltmarsh				Sediment & water
Shingle						Shingle beaches	Sediment
Sea Cliffs						Soft cliffs	Sediment
Coastal Lagoons					Lagoon water bodies	Lagoon	Sediment & water

Source: UK National Ecosystem Assessment (UK NEA)

Notes:

1. UK NEA 2011, Chapter 11

A habitats-based approach will not define the whole of the geographical region people associate as “the coast”, for example, coastal towns or harbours. This is not just a public perception issue, since some of the data we are using to determine ecosystem services (such as MENE data for visits to the coast) depends on people self-classifying the habitat they visited. The habitats-based approach might also lead to an undervaluation of services provided by what is intuitively seen as “the coast”, if such services are provided by an area which is not defined as a coastal habitat, but nevertheless located along the coast.

In practice, a habitat-based approach will depend upon land cover definitions, as most datasets, for example, the Land Cover Map, are defined via land cover (see Table 3 for a summary of previously used definitions). These 2 definitions match reasonably well and hence this should not be seen as a problem.

Table 3: Summary of different definitions of "coastal margins"

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SEEA central framework	**Defines “coastal water bodies and inter-tidal areas” as “composed on the basis of geographical features in relation to the sea (lagoons and estuaries) and abiotic surfaces subject to water persistence (inter-tidal variations)”, which includes** · Water surfaces in estuaries (the wide portion of rivers at their mouths subject to the influence of the sea into which the water course flows; · Lagoons (cut off from the sea by coastal banks or other forms of relief with, however, certain possible openings)
UK NEA	The UK NEA defines six main habitats as coastal: Sand Dunes, Machair, Shingle, Saltmarsh, Sea Cliffs and Coastal Lagoons. This includes small islands, sand and shingle beaches but excludes coastal grasslands, mudflats, rocky shores and estuaries and coastal urban areas.
Land cover map (LCM 2007)	The land cover map (LCM2007) identifies classes and broad habitat sub-classes. The broad land cover class “coastal margins” includes the following LCM2007 subclasses: saltmarsh, littoral rock (maritime mask zone on a rocky coastline), littoral sediment (incl. littoral mud and sand), supra-littoral rock (incl. vertical rock, boulders, gullies, ledges and pools), supra-littoral sediment (incl. Sand dunes and shingle).
Countryside Survey	Identifies supra-littoral rock and supra-littoral sediment.
Eftec for the scoping study for Natural Capital Marine Accounts	A different approach is followed by eftec: the mean high water mark and tidal limit of estuaries was used as the boundary between marine and terrestrial accounting (eftec 2015). This means that in the scoping study for the marine accounts, the following UK NEA coastal habitats are classified as ‘marine’, when they are below the mean high water mark: · Sand dunes (incl. beaches) · Shingle (incl. beaches) · Salt marsh · Coastal lagoons

CORINE[1] data set	“Coast” is not defined as a category on its own, but different sub-classes include coastal habitats: Beaches, dunes, and sand plains ; Bare rock (incl. Cliffs, but also scree, rocks and outcrops); Natural grassland (incl. some heathland); Moors and heathland; and Coastal wetlands (incl. saltmarsh, intertidal flats and saline); Coastal lagoons

Source: Department for Environment, Food and Rural Affairs. Office for National Statistics
Notes:
1. CORINE Land Cover inventory

A definition based on the mean high water mark

The Eftec (2015) marine scoping study defined the “landward boundary of the marine ecosystem as the mean high water mark and tidal limit of estuaries”. As the study correctly identified, this “approach merges the UK NEA classes of marine habitats and some of its coastal margin habitats”. If this approach were to be followed, the following UK NEA coastal margin habitats would be included within the marine ecosystem assets accounting area, to the extent that they are below the mean high water mark: sand dunes (sandy beaches and shingle beaches would be affected); salt marsh; and coastal lagoons.

Applying the same boundary definition for coastal margins raises 2 challenges for a coastal margins account.

It would artificially truncate the scope of coastal assets within the account: a broad habitat account of coastal margins, which focuses on the unique features, should logically include all the coastal margin habitats, and not just those above the mean high water mark (HWM). For example, following the mean HWM definition would put some salt marsh in the marine ecosystem and potentially split it up into “coastal” and “marine” salt marsh. Yet many of the services it provides are strongly terrestrial (for example, grazing sheep, wildfowling). This split would be unsatisfactory.

How to define the inland boundary? One could either define a general boundary, for example 1 kilometre above the mean high water mark, but that is likely to include habitats that aren’t truly coastal and exclude habitats that are. In addition, this would mean that the aggregate extent of the coastal account would never change which would not pick up coastal erosion.

An alternative option is to use the habitat definitions, but only use them for above the mean high water mark, but this would not offer any advantage over using a habitats-based definition for the marine boundary as well.

Recommendation

Following Defra/ONS principles on ecosystem accounting (Defra/ONS 2014), we recommend following the UK NEA broad habitat definition (as summarised in Table 4) to define coastal margins and to use the Land Cover Map[1] (LCM 2007) as a proxy for this definition wherever possible.

Table 4: Table 4 UK NEA "broad habitat definitions"

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Sand Dunes	**According to the UK NEA, coastal Sand Dunes occur all around the UK. Formed from sand that is blown inland from the beach, they are usually stabilised by vegetation. Main vegetation types are dry dune grassland and dune slacks, with dune heath on some acidic sites. Sand Dunes provide a highly diverse mix of habitats and services – often on the same site - due to differences in successional age, soil pH, local disturbance, management history, steepness and aspect of slopes, groundwater chemistry and the hydrological regime in dune slacks.**	**Land cover map 2007 class 18 Supra-littoral Sediment**
Shingle	The term “shingle” applies to any sediment with a mean grain size of between 2 and 200 mm, which define thresholds for wind and wave transport (UK NEA Ch. 11). Shingle beaches and structures occur around the whole of the UK’s coastline. Shingle habitats most often occur as fringing beaches deposited at, or near, the limit of high tide.	
Machair	Machair is a unique form of dune system, found nowhere other than on the north-western seaboards of Scotland and Ireland. It shares many of the characteristics and processes found in Sand Dunes.	
Saltmarsh	Saltmarshes occur between mean high water spring tides and mean high water neap tides at temperate latitudes and are widely distributed across the UK, the most extensive areas occur along estuaries in the countries of Hampshire, north Kent, Essex; Norfolk Lincolnshire and Lancashire. Saltmarshes occur between mean high water spring tides and mean high water neap tides at temperate latitudes. According to the Environment Agency, Saltmarsh can be readily mapped from air photos taken at low tide, so data will be available. Specific Data on the spatial extent of saltmarsh is available.	Land Cover Map 2007 class 21 Saltmarsh
Coastal Lagoons	Also referred to as ‘saline lagoons’, used to describe a wide range of coastal water bodies of varying salinity form nearly freshwater to fully marine. Lagoons are shallow, quiet water bodies, adjacent to the sea but sheltered from its direct effect and quite diverse in form. Many lagoons have been altered to protect against flood or wave energy and some also have been created artificially.	Land Cover Map 2007 class 15 Salt Water

Sea Cliffs	Cliffs can broadly be classified as ‘hard cliffs’ and ‘soft cliffs’. The UK Biodiversity Action Plan for maritime cliffs and slopes defines the former as “vertical or steeply sloping, they tend to be formed of rocks resistant to weathering, such as granite, sandstone and limestone, but can be formed of softer rocks, such as chalk, which erode to a vertical profile” and soft cliffs as “formed in less resistant rocks such as shales or in unconsolidated materials such as boulder clay”. The cliff-top zone can extend landward to at least the limit of maritime influence, which may continue for up to 500m inland. On the seaward side, they extend to the limit of the supra-littoral zone.	Land Cover Map 2007 class 18 Supra-littoral Rock

Source: UK National Ecosystem Assessment (UK NEA)

Notes for Classifying and defining the asset

1. CEH has advised that there is ongoing work to better define coastal habitats within the forthcoming CEH Land Cover Map (personal communication)

6 . Scoping the extent account

Data on the physical extent of coastal margins is limited, with the exception of data for protected areas.

This section gives an overview of the data sources currently available and their suitability for ecosystem accounting as well as some initial estimates of coastal margin extent. Nevertheless there remains a severe lack of data on extent and lack of consistency and comparability. Further research on extent is recommended in order to develop a final account.

Very high-level estimates based on land cover data and Biodiversity Action Plan reporting exists, but does not distinguish, for example, different types of saltmarsh or sand dune. Available datasets on coastal margins extent include the Land Cover Map 2007 (LCM2007), CORINE data and Countryside Survey data. These different sources are used by different reports and studies to define the extent of coastal margins, including the UK Land Cover Account, the UK National Ecosystem Assessment (UK NEA), and academic studies such as Beaumont et al (2014). Natural England and the Environment Agency also provide various Geographic Information Systems - digital boundary datasets shape files to map the extent of particular areas.

LCM, CORINE and Countryside Survey compared

The UK Land Cover Accounts were published in 2015 and reviewed the suitability of the Land Cover Map, CORINE and Countryside Survey for land cover accounting purposes.

The Land Cover Map's weakness is a lack of comparability between both LCM2000 and LCM2007 and an error of around 20% when using spectral signature when measuring habitat extent. If future versions of the map have greater consistency in terms of classification, they can be used to map extent, but it is not recommended at the moment.

CORINE land cover overcomes the errors that the LCM makes by using computer-aided visual interpretation of satellite imagery. Yet, it is using a much larger minimum map-able unit of 25 hectares, which is why a land cover account based on CORINE data will underestimate the area of habitats which tend to be relatively scattered.

The Countryside Survey is a field-based survey, carried out since 1978 at regular intervals. The main advantage of this data source is that land cover is measured consistently over time and land cover change is assessed with great care.

We recommend initially using the Countryside Survey data and in future Land Cover Map data. CORINE Land cover data can be used to benchmark and analyse the results.

However, those datasets are land cover datasets – they don't report the extent of individual coastal margin sub-habitats. Data on the extent is available via the Joint Nature Conservation Committee (JNCC) and it is based on the Biodiversity Action Reporting System. It gives a first indication of the extent of coastal margins, but for many habitats and countries the data is based on very outdated surveys. There is currently no plan to update those numbers through surveys, but it might be possible in future to estimate the extent of those habitats via earth observation data.

For now, we recommend using the estimates of coastal margin extent disaggregated by sub- habitat (Table 5) as very indicative estimates only. For the final accounts, it has to be assessed whether future potentially more detailed Land Cover Map data can be used to estimate habitat extent or whether satellite data (potentially earth observation data) can be used. Further research could also focus on the trend in coastal margins extent – the habitat is in decline and faces pressures due to sea level rise (coastal squeeze, see Box 1).

Box 1: Coastal squeeze

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Sea level rise and coastal erosion[1] continue to pose a significant threat to many of these habitats and can lead to so-called 'coastal squeeze'. The term describes a form of intertidal habitat loss. Pontee (2013) defines it as:
"Coastal squeeze is one form of coastal habitat loss, where intertidal habitat is lost due to the high water mark being fixed by a defence or structure (i.e. the high water mark residing against a hard structure such as a sea wall) and the low water mark migrating landwards in response to sea level rise."
According to JNCC, it is mainly saltmarsh that is affected by this issue. Coastal squeeze can have significant impact on the ecosystem and the services it provides but it is not clear how severe habitat loss is due to coastal squeeze. Pontee (2013) concluded that the extent of coastal squeeze has previously been over-estimated. Yet, this might become more severe due to climate change and expected further sea level rise and increased storminess.
1. Note that coastal erosion of soft cliffs does not imply a loss of cliff habitats, as erosion is part of the natural cycle of constantly renewing geological exposures and recycling the botanical succession of this habitat (UK NEA 2011).

Coastal margins extent – existing estimates

Table 5 summarises existing estimates for the extent of coastal margins. The methods and data used include the ONS land cover accounts, JNCC data and other survey data (UK NEA and Beaumont et al 2014). All three studies differ in their estimates of extent, in some cases (e.g. in Northern Ireland) significantly. Whilst some of these differences can be attributed to different data sources and reporting years, further research would be needed in order to establish consistent and additive figures and commence a time series. Table 6 details the extent of the various sub-habitats which make up the total extent of coastal margins as set out in the UK NEA estimates in Table 5.

Table 5: Coastal margins extent in different studies

Hectares

Country	UK land cover accounts following NEA definition (stock in 2007) [1] [2]	As given in the UK NEA[3] [4]	Beaumont et al 2014 [5]
UK	152,000	141,631	137,182
England	64,000	49,382	45,350
Scotland	61,000	76,368	75,063
Wales	18,000	14,010	14,970
Northern Ireland	9,000	1,871	1,799

Source: Department for Environment, Food and Rural Affairs. Office for National Statistics

Notes:

[1] ONS 2015. “UK Natural Capital Land Cover in the UK”.

[2] Based mainly on Countryside Survey

[3] Based on JNCC data (for details see Annex 1), Dargie 2000. “ Sand dune vegetation survey of Scotland: national report”, and NIEA, www.doeni.gov.uk/niea

[4] Includes Sand Dunes, Machair, Saltmarsh, vegetated Shingle

[5] Includes Sand Dunes, Machair, Saltmarsh

Table 6: Extent of "sub-habitats" following the UK NEA

Habitat class	Extent in UK	England	Northern Ireland	Scotland	Wales
Sand Dunes (ha)	71,569	11,897	1,571	50,000 [2]	8,101
Machair (ha) Scotland only, by definition	19,698 [9]			19,698 [3]	
Saltmarsh(ha)[4]	44,512	32,462	250	6,000	5,800
Shingle (ha) (note: only vegetated shingle)	5,852	5,023	50 n/a [5]	670	109
Sea cliffs (km) (assumed to be comparable to JNCC habitat class ‘Maritime Cliffs and Slopes’)	2.700 km (total length)	1,082	500	2,450	522
Coastal Lagoons (ha) (assumed to be comparable to JNCC habitat class ‘Saline Lagoons’)	5,184	1,205	42	3,900	37

Source: UK National Ecosystem Assessment (UK NEA)

Notes:

[1] All based on JNCC data except when stated otherwise

[2] Based on Dargie 2000. “ Sand dune vegetation survey of Scotland: national report.”

[3] Based on Dargie 2000. “ Sand dune vegetation survey of Scotland: national report.”

[4] All based on JNCC data except when stated otherwise

[5] Based on NIEA

7 . Scoping the condition account

The condition accounts are intended to shed light on changes in the state of the ecosystem and hence its capacity to provide ecosystem services into the future. As the provision of each service may depend upon different aspects of condition, in practice a range of condition indicators are needed. The System of Environmental-Economic Accounting Ecosystem Accounting guidance (SEEA EEA) groups these indicators together into broader common categories of biodiversity, soil, water and carbon. Even so, there is a wide range of different options within each category. In addition, the condition account can be extended to include indicators of management practices (particularly important for farmland ecosystem services), access facilities (important for recreation services) and protected status (important for conservation). Table 7 summarises a number of options for indicators to be included within the condition account.

Table 7: Overview of condition indicators

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Indicator	Discussion	Recommended source
Soil	Soil can sequester or emit carbon depending on management. Increases in soil carbon stock estimates are given by Natural England (2012). Carbon stock in vegetation is currently not known.	Soil Carbon stock (Natural England 2012)
	The Carbon stock account (ONS forthcoming) uses carbon stock average estimates by broad habitat published by Natural England (2012). The report gives a figure of 48 tonnes of soil carbon stored per hectare of Coastal Margins habitat. Combining this with the 2007 SEEA-EEA Land Cover estimate for Coastal Margins of 153,000 hectares produces an estimate of 7.3 MtC stored in the relevant soil assets.	
Biodiversity	Multiple possible indicator sources for biodiversity exist, including bird surveys, seabird nesting counts, Butterfly Monitoring Schemes and different species abundances or diversity indices.	Breeding Bird Survey
	The Breeding Bird Survey and the Wetland Bird Survey are the most suitable indicators, as their data is spatially explicit and available annually. The Breeding Bird Survey (BBS) provides national population trends for over 100 species. The Wetland Bird Survey (WeBS) monitors non-breeding water birds in the UK.	For coastal wetlands: Wetland Bird Survey (WeBS)
Conservation status	Designated areas are important as they protect endangered habitats and species and also are an indicator for heritage and other cultural values. SSSI condition status is monitored and it is a Government objective to improve it.	SSSI designation and percentage in favourable condition
Water	There are several relevant indicators.	· Coastal & transitional water body with 'High' or 'Good' ecological status (%) of the WFD
	Blue flag status is awarded annually based on various beach quality criteria. Although only partially related to ecosystem condition, this can be a good proxy and will be relevant for recreation services as well as for some supporting services.	· Number of Blue Flag beaches

	Compliance with the Bathing Water Directive is an indicator for recreational and other cultural services. Annual Water Framework Directive reports. Good status is considered to be a proxy for the capacity to provide ecosystem services including drinking water, fish production and recreation and other cultural services.	· Percentage of beaches complying with Bathing Water Directive
Access	There are different options for an indicator for accessibility: According to AECOM (2015) "the extent of paths and trails within a habitat can act as a proxy indicator for cultural ecosystem services associated with access to and interaction with nature." Census data for England and Wales is available to give the percentage of population with access to habitat. In Scotland, no directly comparable data source for 'accessible area of habitat' is available. AECOM (2015) developed an alternative approach to determine the percentage figure of the population that find a habitat type accessible, which is based on the number of people close to the habitat.	· Length of national trails (km) · Accessibility to habitat to local population – Census data for England and Wales, together with the AECOM (2015) method for Scotland

Source: Department for Environment, Food and Rural Affairs. Office for National Statistics

Trends in extent and condition of coastal margin habitats

Overall, the UK National Ecosystem Assessment (UK NEA) concludes that "the quality of coastal margin habitats has declined since 1945." As described in Jones et al (2010), there is a downward trend in the area of all UK coastal margin habitats, as shown by Table 8 [1] and Figure 1 (Beaumont et al 2014). Climate change will have an adverse impact on coastal margins as well, as they are one of the most vulnerable habitats. Box 2 describes climate change impacts in more detail.

Box 2: Climate change

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An increased sea level rise is not the only impact that climate change will have on coastal margins: in addition to increased storm-severity/frequency; changing rainfall and temperature will also have an impact. According to Clakre and Sanitwong (2010), those other climate change impacts are a factor or two greater than the effects of sea level rise or afforestation. Hence coastal habitats are among the most sensitive to climate change.
Dune slacks are very sensitive to climatic changes because dune groundwater levels are closely tied to climatic patterns and the net recharge to groundwater is strongly dependent on a fine balance between rainfall and evapotranspiration; and it is as dependent on the timing of rainfall during the year as it is on total annual rainfall (Curreli et al. 2013). Research has suggested that a drastic, long-term decline in water levels of more than 100 cm is likely at west coast UK site (Clarke and Sanitwong 2010). Future decreases in rainfall and altered seasonality of rainfall are predicted to lower dune water tables by up to 1 metre by 2080 (Clarke & Sanitwong, 2010). Associated drying out of dune slacks will result in a loss of many rare species, and may cause release of stored soil carbon due to faster decomposition (UK NEA 2011). Stratford et al. (2013) predict a 30% loss in area of dune wetlands in England over a 23 year period, coupled with a shift from wet to drier dune slack communities in the remaining habitat. In fact, Curreli et al. (2013) suggest that towards the end of the 2030s conditions are no longer favourable for wet slacks and only dry slack communities can persist; also that by the end of the 2050s it is likely that even dry slack communities will be replaced by dry dune grassland.

Trends in coastal margin habitats in detail (Beaumont at el 2014) are as follows.

Salt marsh has declined by approximately 15% since 1945. Historically, declines have been caused by land use change for agriculture and industry; in future further losses of 4.5% over 20 years are expected due to sea level rise (Beaumont et al. 2014).

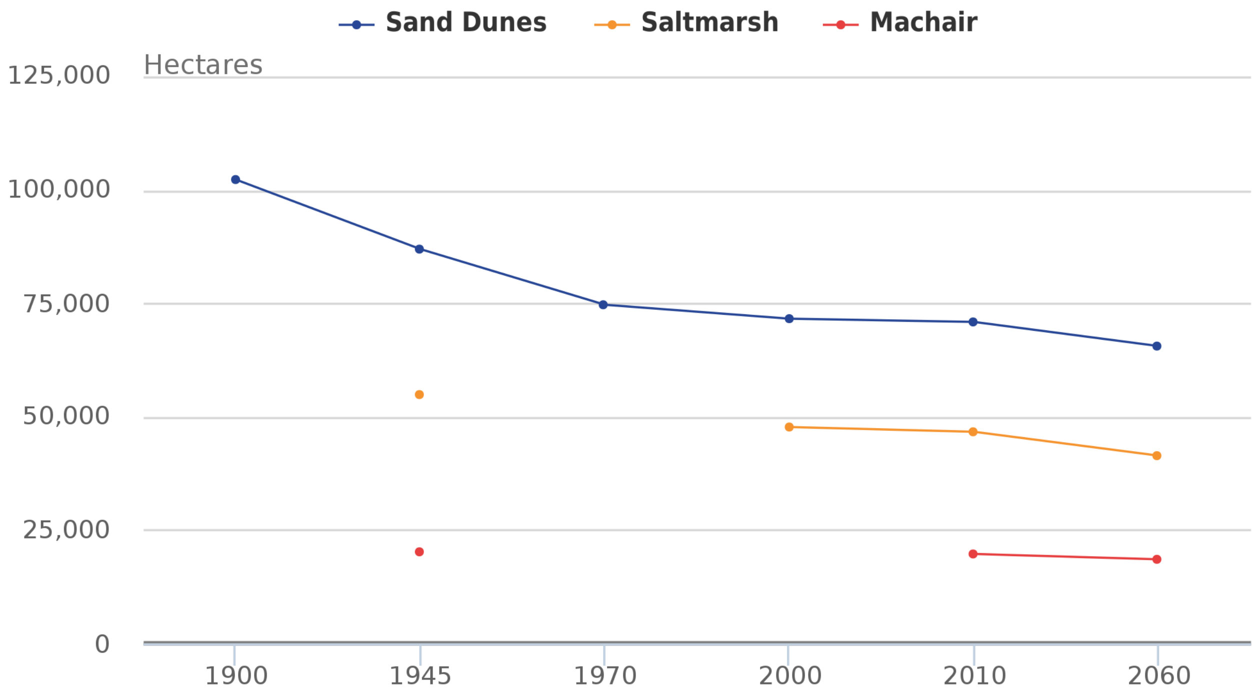
Sand dunes have declined by 30% since 1990; the decline was historically driven by urban expansion and forestry planting (until 1945), later primarily by agricultural improvement and continued infrastructure development. In future, sand dunes are further expected to decline by 2% over 20 years due to coastal erosion and sea level rise. The UK NEA reports that sand dunes have not only changed in extent but also in character. There has been a consistent trend towards increased vegetation cover in the UK, in contrast with the high proportion of bare sand of many dunes in the mid-1940s (Beaumont at el 2014).

Shingle and machair areas have decreased mainly due to erosion and sea level rise. Future losses of machair are predicted to be 2% over 20 years. Climate is the major variable affecting community distribution and species range of shingle vegetation (UK NEA).

Sea cliffs face various pressures, but it is difficult to provide a meaningful account of the status as there hasn’t been a national survey conducted. A major concern has been the loss of habitat due to agricultural encroachment, urban or industrial development and holiday accommodation.

Figure 1: Predicted change in coastal margin habitat extent

UK, 1900 to 2060



Source: Source: Beaumont at el 2014

Table 8: Historical and predicted future extent of coastal margin habitats

UK, 1900 to 2060

		1900	1945	1970	2000	2010	2060
Sand Dunes	UK	102,241	86,905	74,636	71,569	70,853	65,528
	England	16,996	14,446	12,407	11,897	11,778	10,707
	N. Ireland	2,244	1,908	1,638	1,571	1,555	1,430
	Scotland	71,429	60,714	52,143	50,000	49,500	45,857
	Wales	11,573	9,837	8,448	8,101	8,020	7,534
Saltmarsh	UK		54,836		47,683	46,631	41,369
	England		39,476		34,327	33,572	29,795
	N. Ireland		288		250	244	216
	Scotland		6,900		6,000	5,865	5,190
	Wales		8,173		7,107	6,950	6,168
Machair	Scotland		20,171			19,698	18,516

Source: Beaumont et al, 2014

Notes for Scoping the condition account

1. Extent in 2060 is based on a linear extrapolation of estimated shorter trends

8 . Physical and monetary accounts for ecosystem services

The System of Environmental-Economic Accounting Ecosystem Accounting guidance (SEEA EEA) recommends compilers to “initially select a limited rather than a comprehensive set of ecosystem services for inclusion in ecosystem accounting”. The selection should take into account environmental policy priorities, economic importance and the availability of data, as well as the assessments of state and significance set out in the UK National Ecosystem Assessment (UK NEA). This section first gives an overview of the different ecosystem services and their importance for coastal margin habitats. It then does a “deeper dive” into each of the 3 main types of services, assessing which individual services are of importance from a natural capital accounting perspective and should hence be included in the final accounts. This assessment is summarised using the following structure:

- “service” identifies the individual, specific good or service, for example, the provision of shellfish
- “flow” identifies the annual flow of the service we want to measure and in what metric
- “data” assesses available data sources and their robustness
- “valuation” assesses whether monetary valuation is possible and if so, whether it can be consistent with accounting principles

Overview of final ecosystem services

Ecosystem service accounts can be both in physical and monetary terms. Physical accounts will have a range of physical metrics and are not readily aggregated. There are 2 types of monetary accounts:

- annual flow accounts of the value of ecosystem services that can be given a monetary value which is consistent with SEEA accounting principles of “exchange values”
- asset accounts which value the future flow of services (up to 50 years) discounted to a “net present value”.

These are explained in more detail in the Defra-ONS Principles of Natural Capital Accounting, which are in the process of being updated.

According to these Principles of Natural Capital Accounting (Defra/ONS 2014), ecosystem services are classified using the Common International Classification of Ecosystem Services (CICES) as a checklist, distinguishing between provisioning, regulating and cultural services. As the principles point out, “supporting services” (which are part of the functioning of the ecosystem) should be excluded from an account, as this could lead to double-counting of final services. Biodiversity is important to supporting services, and its relevance for accounts is addressed in Box 3.

Box 3: The treatment of biodiversity within ecosystem accounts

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In its broadest sense, ecosystems accounts are all about biodiversity. However, within the accounts themselves, the focus is on species biodiversity as an indicator of the condition of the ecosystem. The indicators may have a number of objectives: they may be focused on particular (rare) species which have special value, some of which may be assessed through the valuation of cultural services such as recreation; they may be focused on species which are important to the functioning of the ecosystem in a more general sense; or they may be developed as part of more composite indicators which together provide information about the overall condition of the ecosystem and its capacity to continue to deliver services.

It follows that species biodiversity is not treated as a final ecosystem service in its own right, but is better viewed as a supporting or intermediate service which contributes towards the final goods and services which benefit society.

Nor is species diversity treated as a distinct environmental asset: because the ecosystem is valued by reference to the final goods and services provided, it is not possible to isolate particular components of the ecosystem, such as species biodiversity, and put a meaningful value on those components.

The UK NEA (Chapter 11) identifies the following final ecosystem services from coastal margin habitats:

Provisioning services

Following the SEEA EEA definition, provisioning services are defined as “contributions to the benefits produced by or in the ecosystem, for example, a fish, or a plant with pharmaceutical properties. The associated benefits may be provided in agricultural systems, as well as within semi-natural and natural ecosystems.” This includes nutrition (crops, fish, and plants), materials (for example, trees) and energy (for example, nuclear power) (CICES).

The UK NEA identifies the importance of provisioning services of coastal margins as relatively minor, with the most important being meat and wool from salt marsh, and timber from afforested sand dunes. The relevant habitats for provisioning services are sand dunes, machair and salt marsh.

Based on a consultation with different experts from the Defra Group[1] and the Centre for Ecology and Hydrology (CEH), this scoping study concludes that the use of timber provisioning from sand dunes is likely not to be significant, as there are only a few sites with plantations (approx. 14% (8,000) hectares are afforested) and harvesting is not economically viable as timber from dune forests is of low quality. That is not to say that afforested sand dunes have no value as they provide other services such as sea storm protection. Due to the provision of cooling water and their often remote and peripheral settings, coastal margins are a favoured location for power plants.

Coastal shellfisheries and fishing bait are significant, at least on a local scale. Data on productivity of shell fisheries are likely to be available from Sea Fisheries Committees. The Marine Scoping Study (eftec 2015) outlined a method for the inclusion of wild capture fisheries for fish and shellfish into an ecosystem account and how to monetise the value. The difficulties of isolating particular resource rents from a complex system were illustrated and further research was recommended in order to determine the best and most consistent approaches to the calculation of resource rent. This scoping study draws attention to another important issue concerning the production of wild fish services: to what extent should some of the value be attributed to coastal margins rather than the marine ecosystem given the importance of salt marshes as nursery grounds?

Regulating services

The SEEA EEA defines regulating services as those services which “result from the capacity of ecosystems to regulate climate, hydrological and biochemical cycles, Earth surface processes and a variety of biological processes”. For coastal margins, relevant services are climate regulation, [water quantity], hazard regulation, waste breakdown andand detoxification and wild species diversity. In an accounting context, it is also useful to identify the beneficiaries of the services, and the extent to which changes in the number of beneficiaries affect the value of the service.

The UK NEA identifies the most important regulating service as sea defence (hazard regulation), to which all habitats contribute. In this context the term “sea defence” does not refer to man-made sea defence structures, and hence for accounting purposes we use the term “natural sea defence”.

Climate regulation: Carbon sequestration rates are relevant in some coastal habitats such as salt marsh, sand dunes and machair due to rapid soil development or sediment accumulation. Their contribution to climate change regulation can be valued by applying Department of Energy and Climate Change (DECC) non-market carbon price (DECC 2012).

Waste breakdown and detoxification: Sand dunes, machair and shingle areas remove nutrients from groundwater through a natural filtration process. Salt marsh and coastal lagoons contribute to the purification of close-by surface waters. However, natural filtration processes that remove nutrients from groundwater in the UK are not well studied, and quantification and monetisation is therefore difficult.

The high diversity or the existence of rare or unique plants, animals and birds can be considered a regulation service when it regulates the resilience of an ecosystem, but is more often viewed as a supporting or intermediate service. This can include pollination and pest control services.

Cultural services

Cultural services are defined in the SEEA EEA as “the intellectual and symbolic benefits that people obtain from ecosystems through recreation, knowledge development, relaxation and spiritual reflection.” This includes:

- religious and spiritual cultural heritage value and media values
- aesthetic and inspirational benefits from outdoor recreation and nature-based tourism
- physical and mental health benefits and education and ecological knowledge

According to the UK NEA, cultural services are the most important services provided by coastal margins. Recreation values are substantial and likely to be of high value as they may include all recreational activities related to coastal margins, for example, sunbathing, walking, bird watching, etc. Activities which are more purely maritime, such as deep sea diving or a boat cruise, would be more properly recorded in the marine ecosystems account.

Coastal areas are popular destinations for tourism and generate substantial economic benefits. In addition, the coast has significant amenity, cultural, and historic value shaped by collective memory: for the UK as an island nation, the coast shapes national identity and has an important place in the national psyche. Whilst there is strong evidence of these values, they are not readily susceptible to measurement and replication. Possible quantification include the length of the Heritage Coast and Coastal Areas of Outstanding Natural Beauty designations. It might also be possible to assess numbers of coast-related art or photographs, but any such measures will be difficult to assign monetary values to.

Notes for Physical and monetary accounts for ecosystem services:

1. Common International Classification of Ecosystem Goods and Service (CICES)

9 . Deep-dive: Provisioning services

Ecosystem service provided: Contribution of coastal habitats to fisheries.

Coastal habitats are an important nursery area for fish and shellfish, and provide a suitable environment for Atlantic salmon and sea trout. Salt marshes in particular may be a significant resource in the life cycle of many commercially important species. Research undertaken in the US showed that a loss in coastal vegetated wetlands resulted in a serious loss in fish production. Similar research on how fish use European salt marshes have rarely been undertaken, because it is more difficult to study the links between salt marsh and fish communities in Europe than to collect data. In Europe, mean tide levels only just border the marsh and salt marshes are often only flooded during high spring tides, meaning that fish only utilise this environment during short immersion periods (Laffaille et al (2000 cited Stevenson (2002)). According to Stevenson (2002), this period is often overlooked and only the mudflats of estuaries and lagoons are considered to be nursery locations. Even so, salt marshes are a significant resource in the life cycle of many commercially important fish species, as the fauna of mudflats and salt marshes provide a substantial food source (Laffaille et al (2001 cited Stevenson (2002)).

In theory, it is possible to value the nursery service of coastal margins as part of the ecological production function of fish. A production function aims to “relate the output of marketed goods (the fish) to the inputs of ecosystem services through the use of econometric techniques” (Obst et al (2014). A production function approach would identify the contribution of the coastal wetland in the fish production so that their value could be attributed to the habitat. Unfortunately, it hasn’t been able to apply such an approach yet. Stevenson (2002) aimed to identify a production function approach following the Ellis-Fisher-Freeman Model, but results were not significant, probably because of the unsuitability of the model for a national scale assessment. That does not mean that the influence of coastal margins is insignificant itself – as Stevenson (2002) discusses, the Ellis-Fisher-Freeman-Model is likely to simplistic to be useful at the national level. A more complex, dynamic model might provide a better fit.

Despite the difficulties of valuing the contribution of coastal margin habitats like salt marsh to fish production, its value should not be overlooked. Salt marsh is of growing policy relevance, because of the rise of managed realignment projects. Natural flood solutions have drawn more attention to the benefits of coastal habitats to commercially important fisheries species, not just in coastal water bodies but also in temporally flooded habitats such as salt marsh. By acknowledging and better understanding the co-benefits of natural flood solutions, cost-benefit-analysis of managed realignment projects should become more accurate.

Table 9: Provisioning services summary

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Service	Flow	Data	Valuation
Contribution to fish production	Providing nutrition to juvenile fish – measureable in how long fish stay in this habitat and how much they consume in that time (in % of their body weight) (Laffaille et al 2001)	Laffaille et al (2001) is a case study from France, so may not be applicable to the UK. Their results:	Difficult. Previous production function approaches based on the Ellis-Fisher-Freeman Model were not successful. More sophisticated modelling would be necessary.
		Juvenilesea bass stay 1 -2 hours and consume on average a minimum of 8% of their bodyweight.	

Source: Department for Environment, Food and Rural Affairs. Office for National Statistics

10 . Deep-dive: Regulating services

Climate regulation (Carbon sequestration)

Coastal margin habitats are significant for climate change mitigation, due to their high capacity to sequester and store carbon. Through carbon sequestration, carbon is removed from the atmosphere and deposited in long-term storage. For example, salt marsh traps carbon in the layers of deposited sediment, and carbon is taken up by the vegetation that grows on salt marshes (eftec 2015).

According to the UK National Ecosystem Assessment (UK NEA), rates of carbon sequestration are high in both dry dune and wet slack habitats and even higher in salt marshes. There is a severe knowledge gap about carbon sequestration rates in vegetated shingle, maritime cliff grasslands or saline lagoons (Beaumont et al. 2014) but as those habitats occupy less than 10% of the UK coastal margin area, it is justifiable to concentrate on sand dunes, salt marsh and machair. In these habitats, sequestration rates are especially high due to rapid soil development or sediment accumulation and/or vegetation development.

Table 10 gives an overview of the different carbon sequestration rates, taken from different sources. Sequestration is influenced by habitat condition and habitat decline (due to environmental change and human land use decisions), but data is not currently available on carbon sequestration rates for different categories of condition and the data collection would be labour and resource intensive.

Table 10: Different carbon sequestration values by habitat and sources

Habitat			Carbon sequestration tCO_2 per hectare	Source
Sea grass meadow			0.73 – 267.67	Romero et al (1994)
Kelp forest			14.67	Gevaert et al (2008)
Saltmarsh			7.7	Chmura et al (2003)
			2.38 – 8.0	Carnell et al. (1999)
Intertidal mud			0.59	Andrews et al (2006)
Subtidal coarse and sandy sediments (to 12 nautical miles)			0.37	Painting et al (2010)
Dune habitats	Dry dunes grasslands	2.13 ± 0.95	Weighted average: 2.16 ± 0.91 t	Jones et al. (2008)
	Wet dune slack	2.68 ± 0.8		

Source: Department for Environment, Food and Rural Affairs. Office for National Statistics

To estimate the value of carbon sequestration, this section summarises the methodology of a case study by Beaumont et al. (2014). The following carbon-sequestration rates used, based on an assessment of the different available sources summarised in Table 10:

Sand dune = 1.25 – 3.12 total carbon dioxide ($tCO2_2$) per hectare per year

Machair = 0.70 – 1.87 tCO_2 per hectare per year

Salt marsh = 2.35 – 8.04 $tCO2_2$ per hectare per year

The rates for machair are based on the assumption that machair is similar to dune grassland and that they have been developing over similar time periods, based on common trend of change in dune systems across north-west Europe. Applying the non-traded 2014 Department of Energy and Climate Change (DECC) carbon price (£61 per $tCO2_2e$) to annual sequestration rate by habitat gives the following per hectare values for coastal margin habitats (in 2014 prices):

Sand dune = £18.36 – £45.9 per hectare per year

Machair = £10.26 – £27.54 per hectare per year

Salt marsh = £34.56 – £118.26 per hectare per year

Assuming that the habitat in 2015 had the following extent (based on a linear extrapolation of Beaumont et al (2014) habitat estimates), the service was provided by coastal margin habitat in 2015.

Table 11: Monetary value of carbon sequestration in coastal margins

Habitat	Extent in ha in 2015	2014 annual value in million £ (2014 prices)	
		Range	Average
All habitats	136,005	12.93 – 38.61	25.7
Sand dune	70.321	5.41 – 13.5	9.4
Saltmarsh	46,104.80	6.67 – 22.84	14.7
Machair	19,579.80	0.84 – 2.25	1.5

Source: Department for Environment, Food and Rural Affairs. Office for National Statistics

When calculating the net present value of this service for ecosystem accounts, it is appropriate to assume a decline in habitat extent in future as long as this is based on robust projections. The value is based on the estimates of gross flows of sequestered carbon and (unlike Beaummont (2014)) does not take into account releases to the atmosphere as a result of the degradation of the ecosystem. Using the Green Book Social Discount Rate (HM Treasury 2003) and the mid-point estimates shown in Table 11, the discounted net present value of carbon expected to be sequestered over the next 50 years is £1.14 billion [1].

Further research

Further research on the estimation of carbon sequestration rates and how they are influenced by condition, as well as research on the current carbon stocks and organic sediment depths, would be desirable (Beaumont 2014). Natural England has advised that more research is underway on carbon sequestration for saltmarshes; results are expected later in 2016. The Office for National Statistics (ONS) are also reviewing methods of estimating values for carbon sequestration with results due out later in 2016.

Table 12: Climate regulation summary

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Service	Flow	Data	Valuation
Climate regulation	Carbon sequestered (in tonnes)	Different estimates of carbon sequestration are available. There exist uncertainties around coastal margins extent and future degradation. We recommend to use the following averages: Sand dune = 1.25 – 3.12 total carbon dioxide (tCO_2) per hectare per year Machair = 0.70 –1.87 tCO_2 per hectare per year Saltmarsh = 2.35 –8.04 tCO_2 per hectare per year	Carbon can be priced using the DECC carbon price (£61 for 2014). Annual value in 2014: £12.39 – £38.6million NPV over 50 years: £ 1.14 billion

Source: Department for Environment, Food and Rural Affairs. Office for National Statistics

Hazard regulation

All coastal margin habitats provide significant protection from the sea, for example, by dissipating wave and tidal energy and thereby substantially reducing the cost of flood defence measures or even replacing the need for artificial sea defence structures completely, as is the case for wide dune systems (Beaumont et al. 2010). There are different methods of valuing this service:

- replacement costs
- damage costs avoided
- value transfer

Replacement costs approach

This method calculates the cost of replacing a habitat with a sea wall providing equivalent protection. It comes with significant limitations. According to Day (2011) it lacks coherence with other methods used to evaluate productive activities, so that those values cannot be directly compared. There is a risk that this approach overstates the value, since it assumes that replacement would always take place, which might not be the case. For example, building a sea wall might be more expensive than the damage that would be caused by a flood. Day (2011) recommends avoiding replacement costs.

In contrast, Obst et al (2015) assesses replacement cost approaches as potentially useful for accounting purposes, as long as valuation is based on the least-cost alternative and that replacement of the service is to be expected in case it would be lost. For developing the final account, we recognise that replacement cost methods have to be used with caution, but that using these methods is appropriate when the cost is a viable alternative which society would be willing to pay. Bearing these caveats in mind, Table 13 presents different estimates based on these methods.

Table 13: Overview of different monetary values of Natural Sea Defence services estimated by replacement costs approaches

Value (adapted to 2014 prices)		Source	Comments
£4.05 billion capital value	£2.53 billion capital cost saving on sea defence for England provided by saltmarsh	UK NEA (2011), based on Environment Agency (2007)	The Environment Agency guideline average costs of building seawalls are £1.775 per metre. The UK NEA scaled this figure up by coastline length of Saltmarsh. Likely to overestimate, because it is assumed all saltmarsh provide this service and would need to be replaced by sea walls.
	£606 million Natural sea defence value of dunes in England	UK NEA (2011) based on Environment Agency (2007)	Capital cost savings: scaled by coastline length and accounting for costs of maintaining natural habitats
	£921 million Natural sea defence value of shingle in England	UK NEA (2011) based on Environment Agency (2007)	Capital cost savings: scaled by coastline length and accounting for costs of maintaining natural habitats
£ 173.7 million / £54.2 million Natural sea defence value for England / Wales provided by dunes		Pye et al 2007	Conservative estimate. Taking into account only those dunes protecting high value land and those lacking any artificial defence structures.

Source: Department for Environment, Food and Rural Affairs. Office for National Statistics

Damage cost avoided approach

This method calculates the costs which are avoided by not allowing an ecosystem service to degrade (UK NEA 2011). Penning-Roswell et al (2010) present methods calculate potential damage costs to land, property and recreational uses and emergency costs by assessing the vulnerability of an area to flooding (from both rivers and the coast) and coastal erosion, together with the probability of flooding. As Beaumont et al (2010) point out; this method might provide a more accurate assessment of the costs and benefits to a flood protection scheme. Yet for national accounting purposes, it is more similar to a willingness-to-pay value than an exchange value, which makes it less suitable than the replacement costs method. In addition, data are not available on a UK-wide scale.

Value transfer

Value transfer is a method that allows existing economic valuation evidence to be applied in a new context, such as estimating the monetary value of environmental benefits associated with a proposed policy. Morris and Camino (2011) use this method to value ecosystem services provided by wetlands, including coastal wetlands. They follow CORINE land cover definitions, that is, coastal wetlands comprise saltmarsh and intertidal mudflats. For this scoping study, salt marsh is relevant and the Morris and Camino (2011) analysis can be used to give an indicative estimate, even though this study is not based on CORINE data and hence estimation error may arise due to different classifications.

If a coastal wetland provides flood control, Morris and Camino (2011) value this on average at £4,030 (adjusted to 2015 prices) per hectare[2]. Assuming a decline of salt marsh as estimated in Beaumont (2014), the discounted net present value of this service over 50 years is £4.59 billion. This assumes that all salt marsh in the UK actually provide this service, even though the extent to which individual salt marsh sites provide the service is not known.

The Morris and Camino (2011) value transfer is a function based on a meta-analysis of a number of valuation studies, which is useful for estimating aggregate values. The evidence base on valuation of wetland ecosystem service is reasonably extensive (Provins 2013) and this particular meta-analysis value transfer function was taken from Brander et al. (2008), which is considered to be the most appropriate function for the UK case. The function [3] is based on a regression model based on 264 studies globally, and included 78 European sites.

In general, using benefit transfer for accounting purposes can be difficult because many values in the literature relate to changes in welfare values[4] and may not be suitable for exchange values. In general, as Provins (2013) notes, the reliance on value transfer can be legitimate for first-cut experimental Natural Capital or Ecosystem accounts, as its practical application will help improve understanding of its limitations. Where the estimates are based on a large number of valuations in well-researched areas such as wetlands, these limitations are less important and the values are more likely to be suitable for accounting purposes.

This estimate gives a good indication of the magnitude of the flood control benefits provided by salt marshes, but it comes with several caveats and should be taken as indicative in the first instance.

Summary of the methods

Until other methods are available, replacement costs and value transfer methods are the most suitable options for the valuation of natural sea defence benefits. Future research on the extent to which particular coastal habitats contribute to the provision of the service would help to refine the estimates.

It is important to note that the value of the natural sea defence service and the value of the storm buffering service might overlap and should not be summed up or used together, to avoid double counting. The estimates differ significantly from each other since one is based on an area (measured in hectares) and the other on the linear coastline (measured in metres).

Table 14: Hazard regulation summary

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Service	Flow	Data	Valuation (2014 prices)
Natural sea defence	£1,775 per metre saltmarsh £1,712 per metre shingle £1,734 per metre dune	Habitat specific data is lacking which affects accuracy of estimates. Data here based on Beaumont et al (2010).	Replacement costs (with a risk of being an overestimate): £4.05 billion provided by salt marsh, shingle and sand dunes
Coastal control and storm buffering for saltmarsh	£4,019 per hectare (2014 prices)	Based on Beaumont et al (2014) habitat extent estimates and the Morino and Camillo (2011) average per hectare value which is based on value transfer.	Average annual flow value: £176.85 million Net present value: £4.58 billion.

Source: Department for Environment, Food and Rural Affairs. Office for National Statistics

Air quality regulation

In a recently completed study for ONS, AECOM estimated the value of vegetation in removing the particle matter (PM_{10}) and sulphur dioxide ($SO2_{10}$) at a UK level. The value of this service in coastal margin habitats was estimated to be £4 million in 2012; this is relatively low when compared with the total UK annual value of £4.5 billion. It is important to note, this study looked only at the value of vegetation in absorbing pollution, yet water bodies also remove considerable amounts of pollution. If this service were valued it would be somewhat more significant.

Full methods and results of this study will be presented in the forthcoming 2016 UK Environmental Accounts publication. The table provides initial estimates for value in coastal margin habitats.

Table 15: Air quality regulation summary

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Service	Flow	Data	Valuation
Air quality regulation	Tonnes of PM10 and SO2 absorbed	AECOM study: Quantity absorbed: PM10 (based on CORINE 2012 data): 163 tonnes Based on LCM 2007 data: 183 tonnes SO2: 4 tonnes[l1]	AECOM study: Annual value in 2012: PM10 £4 million SO2 £0.01 million

Source: Department for Environment, Food and Rural Affairs. Office for National Statistics

Notes for Deep-dive: Regulating services

1. The net present value is calculated by combining the DECC non-traded carbon price with the carbon sequestration rates. This gives the annual service value in each year for the next 50 years. The annual service value (flow) is then discounted, using the Green Book discount rate of 3.5% for the first 30 years and 3.0% for years 31 to 50. The sum of the discounted flow over 50 years is the net present value of the asset.

2. This unit value is for saltmarsh and intertidal mudflats combined. Unit values for flood protection by saltmarsh are likely to be higher than this.

3. Brander, L.M., Ghermandi, A., Kuik, O., Markandya, A., Nunes, P.A.L.D., Schaafsma, M. & Wagtendonk, A. (2008) Scaling up ecosystem services values: methodology, applicability and a case study. Final Report, EEA. Fondazione Eni Enrico Mattei.

4. Changes in welfare value, for example, in willingness-to-pay, show the total producer and consumer surplus change, which is not consistent with an exchange value like, for example, a market price. A welfare value is usually larger than an exchange value.

11 . Deep-dive: Cultural services

Following the UK National Ecosystem Assessment (UK NEA) definition, cultural services are derived from “the environmental settings that give rise to the cultural goods and benefits that people obtain from ecosystems”. They are produced by the interaction between people and nature and are an essential part of everyday human life. As an island nation, the coast has a special importance for people in the UK and is of great cultural significance.

As discussed above, many cultural ecosystem services are provided in combination with marine habitats. It is exactly the combination of close proximity to the marine environment without being a marine environment itself that defines the coast and makes it attractive to society (see Box 4).

Instead of attributing cultural services to one or other of the marine or coastal margins accounts, we recommend a joint overarching marine and coastal margins account with a sub-account for provisioning and regulating services that can be attributed to coastal margin or marine habitats and a composite account for cultural services.

Box 4: Methodological challenge: Services provided by the combination of coastal and marine ecosystems

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Many cultural ecosystem services are not provided by coastal margins alone, but by the combination of coastal margins and the marine environment. The marine scoping study for Defra (eftec 2015) acknowledges this for recreational services: "for example, dive sites are often offshore, but most of the benefits associated with them are captured close to the coast". For this reason, that study concluded that the high water mark (HWM) is not a suitable boundary to delineate the marine environment for recreational ecosystem services and instead used the concept of "coastal strip" recreation services.
Whilst this scoping study does not adopt the HWM delineation, it does recognise the inseparable roles of marine and coastal ecosystems in providing many cultural services – as the UK NEA says, "a large part of the attraction to the coast hinges on its juxtaposition between land and sea." Those services include all recreational activities along beaches and coastal paths; amenity value from enjoying an ocean view; resource rents from higher property prices on coastal property; spiritual and heritage values that people associate with the coast, etc. For example, tourists visit a beach to enjoy the sea (even though they might not actually use it for swimming); conversely, the sea with no beach will be less attractive for many tourists. Beaches provide access to the sea and many highly valued beach activities (such as enjoying the ocean without getting wet, walking along the shore, collecting shells, children playing in the sand, etc.) are provided by a combination of beach and sea. The same is also true for a hiker along the coast path or a tourist in a sea side hotel – both elements are required.

Aesthetics

Much of the value of the coast is generated by the scenic view it offers. This service is difficult to measure or value, but AECOM (2015) have developed an experimental method to do that by analysing the number of pictures uploaded onto the Panoramia website. The quantity of pictures of nature can be used as a proxy for the relative amenity of coastal areas compared with others. It also gives an indication of how many people engage with the aesthetic features of a particular area.

From an economic perspective, aesthetic value only exists if it is enjoyed in some way, for example, through seeing a picture of it, experiencing it by being there and looking at it or interacting in other ways. A coastal lagoon that no-one ever visits cannot have any aesthetic value[1] since no one is there to value it (although it may have other non-use values such as existence value). Thus the number of pictures taken from particular sites is a good proxy for identifying areas of relative aesthetic value. The AECOM (2015) research also takes into account the most intensely photographed sites, that is, the number of photos relative to the total area of each habitat. They find that coastal margins are amongst the most intensely photographed habitats, which is an indication of the significant aesthetic value of this habitat.

We recommend using the same method to quantify and identify the most aesthetical sites for the final accounts. Assigning a monetary value to such a metric is practically challenging and conceptually problematic in view of potential double-counting with recreational services.

Table 16: Aesthetics summary

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Service	Flow	Data	Valuation
Aesthetics	Number of photos uploaded	Panoramio website	No method yet

Source: Defra. ONS

Tourism

The UK NEA reports on the values that are generated by the economy through tourism in coastal areas. However, from an ecosystems accounting perspective, we would need to take into account the inputs of other forms of capital involved in the economic production such as labour and produced capital, before attributing any share of the economic value of tourism to the ecosystem. This process is known as the calculation of the resource rent. It requires the identification of those elements of the tourism industry which benefit from being associated with coastal margins, and then an assessment of the extent to which they benefit from that association. An alternative way of disentangling the value to the tourist industry of the natural environment is to use a hedonic pricing approach as described in Box 5. These options are both areas for further research.

Box 5: The possibilities of a hedonic pricing approach

.tg {border-collapse:collapse;border-spacing:0;} .tg td{font-family:Arial, sans-serif;font-size:14px;padding:10px 5px;border-style:solid;border-width:1px;overflow:hidden;word-break:normal;} .tg th{font-family:Arial, sans-serif;font-size:14px;font-weight:normal;padding:10px 5px;border-style:solid;border-width:1px;overflow:hidden;word-break:normal;text-align:left;}

hedonic pricing value is already captured by the national accounts, but enables us to identify the environment's contribution to gross value added (GVA). The approach identifies the so-called "resource rent". Obst et al (2015) defines the resource rent method as "deriving the value of the ecosystem service as a residual after the contributions of other forms of capital have been deducted from the operating surplus". In the case of a hotel for example, the contribution of coastal margins could for example, be the provision of sea view. A hedonic pricing approach would compare through econometric analysis how much more a room with sea view is worth compared with a similar room in the same hotel without sea view.

Since the residual reflects the return to the ecosystem asset that is used in production of marketed goods, this method is consistent with exchange values.

It is important to distinguish these hedonic pricing values from other non-market values: for example, whilst the recreational value is not necessarily included in a market price (for example, an open access beach can be enjoyed free of charge), the hedonic value of a habitat is realised and reflected by the market, for example, the price of a hotel room close to the beach. In the case of tourism, the value is captured by the producer, for example, the hotel owner, and hence is already included in the national accounts as marketed output that is, the ecosystem provides an input to GVA.

The best way to disentangle the aesthetic value of the sea is to assess hotel prices of rooms with sea views. The ecosystem service provided in this case is purely aesthetic value: the proximity to the coast is provided both by a hotel with or without sea view, hence this won't be reflected by the " sea view" mark-up. This approach has been undertaken by Fleischer (2011) for the Mediterranean Sea. The result was that prices for rooms with sea views were 10% higher than rooms without sea views. This result comes with some limitations, as it assumes that the price offered online will actually be paid (that is, the market will clear). Yet, this assumption is not unreasonable and this methods seems to be the best available to identify the aesthetic value of the sea.

A hedonic pricing model can also be used to determine the value that is provided by living in close proximity to the coast. Such an analysis is undertaken by Gibbons et al (2011). They find that distance to the coastline lower the average 2008 house price by £275 per kilometre, yet these estimates weren't statically significant. In addition, this method wouldn't identify the specific ecosystem service that is provided, as it doesn't give information why people are willing to pay more for a house closer to the coastline. This could be motivated by different reasons: close proximity to a nearby freely accessible beach (recreation), because of expected health benefits from fresh sea air (health benefits), sea view (aesthetic value) or all of this together.

Another potential object for a hedonic pricing model which has not yet been explored is beach huts. It is reasonable to assume that the main benefit beach huts provide is recreation. There are roughly 20,000 beach huts in Britain (Ferry 2009), selling for prices from around £5,000 up to £170,000. These prices are clearly not reflecting the value of the hut itself (maintenance costs are around £300 a year) but rather the value of the location: the beach. In theory, one could assess the mark-up of beach huts compared with similar huts (for example, in gardens or allotments).

Outdoor recreation

According to the Monitor of Engagement with the Natural Environment (MENE) data (Natural England 2012), approximately 10% of visits to the natural environment in England were to the coast, with 7% going to a seaside resort and 3% going to other coastal areas. The most popular activity was dog walking (45% of participants). The UK NEA reports that more than 250 million visits are made to the UK's coast per year, of which, around one-third are to natural habitats. The MENE survey reports 110 million visits to the English coastline [2]. Upscaling this number according to population provides an initial rough estimate of 131 million visits to the British coast every year. According to Sen et al (2014), an average trip to the coast can be valued at £4.26 per visit (in 2014 prices). This gives a total value of £558 million per year and a discounted net present value over 50 years of £13.64 billion. Valuing recreational services for the purposes of ecosystem accounting is currently being reviewed by ONS and Defra, so these estimates should be taken as experimental pending further development.

Table 17: Recreation summary

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Service	Flow	Data	Valuation
Recreation	131 million visits per year (daytrips)	Monitor of Engagement with the Natural Environment Willingness to Pay values (Sen et al 2014)	£558 million per year (2014 prices) Discounted net present value over 50 years of £14.24 billion

Source: Defra. ONS

Notes for Deep-dive: Cultural services

1. Note that it can still have 'intrinsic value': some argue that there is a value of nature itself, independent from human-based valuation. By definition, it is not possible to value or even perceive this intrinsic value, but that does not mean we don't recognise it.

2. Monitor of Engagement with the Natural Environment, Headline Report from the 2014 to 2015 survey

12 . Summary of final ecosystem services

Table 18 summarises the above discussed ecosystem services and their physical flow and monetary value. Since this is a scoping study the estimates must be treated as indicative only. Some of the values shown overlap (such as the 2 options for sea defence), for others like recreation, more research on consistent valuation for ecosystem accounting purposes is being undertaken. Nevertheless, this first-cut assessment provides substantive evidence that coastal margin habitats provide socially important and economically valuable services.

Table 18 Summary of ecosystem service flow and valuation

Ecosystem Service		Physical flow	Indicative monetary value (2014 prices if not otherwise indicated)
Climate regulation (carbon sequestration)		Sand dune = 1.25 - 3.12 tCO_2 / ha / yr	Annual value in 2014: £25.7 million
		Machair = 0.70 - 1.87 tCO_2 / ha / yr	Net present value over 50 years: £1.1 billion
		Saltmarsh = 2.35 - 8.04 tCO_2 / ha / yr	
Natural sea defence	Capital cost savings (not a net present value)	2307 km protected	£4.05 billion provided by saltmarsh, shingle and sand dunes in England
	Coastal control and storm buffering provided by UK saltmarsh	Ca. 46,000 hectares protected	Annual value in 2014: £185.73 million Net present value over 50 years: £4.6 billion
Air quality regulation		Absorbed PM_{10} in 2012: 198 tonnes Absorbed SO_2 in 2012: 4 tonnes	Annual value of absorbed PM_{10} and SO_2 in 2012: £4 million and £10 million
Recreation (attributable to marine and coast together)		Approx. 131 million visits to the coast per year	Annual value in 2014: £558 million Net present value over 50 years: £14.2 billion

Source: Department for Environment, Food and Rural Affairs. Office for National Statistics

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14. Annex 1: Details on the JNCC data for each sub- habitat and country

Sand dunes

- Sand dune vegetation survey of Great Britain: a national inventory: Radley, G.P. for England (1994) and Dargie, T.C.D. for Wales (1995).

- Scotland extent is based on Dargie 2000

- Northern Ireland extent is based on Northern Ireland Habitat Action Plan 2005

- Extent of vegetated shingle is more recent, for England based on a review of the existing habitat inventory for England in 2007 and for Wales based on Sneddon, P. &and Randall, R. E. 1993. Coastal vegetated shingle structures of Great Britain: Appendix 1. Shingle sites in Wales. Joint Nature Conservation Committee, Peterborough, UK.

Salt marsh:

- Burd, F., 1989. The saltmarsh survey of Great Britain: An inventroy of British Saltmarshes. Ncc Research and Survey in Nature Conservation. No. 17. Ncc, Peterborough.

This is the last complete survey of saltmarsh extent in the UK and was completed in the late 1980’s. Since then, surveys have been ad hoc, fragmentary and uncoordinated. They have been undertaken for a range of different purposes and show that, in places, there has been significant habitat loss.

Good coverage, but out of date. Habitat loss known to have occurred especially in SE England - perhaps as much as 100ha a year.

- Northern Ireland extent based on NI Habitats Action Plan published in March 2008

- Welsh extent based on CCW's Lowland Habitat Survey of Wales, 1987 to 1997

Saline lagoons (assumed to be comparable with Coastal Lagoons)

- Survey Data from 2008, no source identified

Maritime cliffs and slopes (Assumed to be comparable with Sea cliffs)

- UK data assessed pre-1995, based on:

Coasts and seas of the United Kingdom (JNCC Publications). Regions 1-17, 13 Hill, C. et al. 2002. Maritime Cliffs and Slope Inventory. English Nature Research Reports. Peterborough

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