Definition of Favourable Conservation Status for seagrass beds

Defining Favourable Conservation Status Project

Natural England

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Executive summary

This document sets out Natural England's view on favourable conservation status for seagrass beds in England.

Favourable conservation status is the situation when the habitat can be regarded as thriving in England and is expected to continue to thrive sustainably in the future. The definition is based on the available evidence on the ecology of seagrass beds. Favourable conservation status is defined in terms of three parameters: natural range and distribution; extent; structure and function attributes (habitat quality).

A summary definition of favourable conservation status in England follows. Section 1 of this document describes the habitat and its ecosystem context, Section 2 the units used to define favourable conservation status and Section 3 describes the evidence considered when defining favourable conservation status for each of the three parameters. Section 4 sets out the conclusions on favourable values for each of the three parameters.

This document does not include any action planning, or describe actions, to achieve or maintain favourable conservation status. These will be presented separately, for example within strategy documents.

The guidance document Defining Favourable Conservation Status in England describes the Natural England approach to defining favourable conservation status.

Summary definition of favourable conservation status

Seagrasses are flowering plants with long, green, grass-like leaves that grow in sediment on the sea floor. They are the only flowering plants that can live underwater. They grow on sandy or muddy seabeds in sheltered, shallow bays and estuaries, where they're protected from the extremes of storms. Seagrasses grow best in undisturbed, clean water, and can form extensive meadows or beds. Because they need sunlight to photosynthesise, they're found in shallow water from areas exposed at low tides up to around ten metres deep. Seagrass beds are among the most productive ecosystems in the world and provide habitats and food for a diversity of marine life.

Prior to the 1920s or 1930s, the majority of intertidal and subtidal muddy sand habitats in the UK would have supported seagrass beds. The distribution and abundance of seagrass beds has declined dramatically in English waters and beyond over the last century. This followed an outbreak of wasting disease and a subsequent increase in anthropogenic activity leading to poor water quality, habitat loss and habitat degradation.

Recovery, naturally or via conservation management has been slow, if at all. Seagrasses are now found in discrete communities in sheltered locations around the UK coastline but are largely absent from most previously occupied locations, although the range in English waters remains unaffected. Extent, patch size, quality and shoot density have all declined. Current extent is 3,050 ha, though Environment Agency modelling (based on wave energy, current, depth and salinity) predicts suitable habitat for seagrass is present across approximately 45,000 ha. Seagrass beds remain vulnerable to continuing declines in water quality, climate change, habitat loss and further outbreaks of disease.

Favourable Conservation Status would be achieved when:

- Seagrass beds occupy all sea areas with suitable habitat including areas from which they are currently absent including the Dee, Solway, Wash, Humber and much of north-west England.
- Extent is increased to approximately 45,000 ha.
- Maximum coverage (appropriate to the habitat and the microtopography) is achieved. Established seagrass beds should extend over 1 ha, with greater than 60% cover. However, it is acknowledged that this degree of coverage will not be possible in all areas (due to natural variability in the habitat characteristics) and that seagrass cover is naturally patchy with areas of bare sediment being typical.
- 95% of the habitat should meet favourable structure and function requirements including high water quality, a natural hydrodynamic regime and natural levels of light, salinity, temperature and nutrients determined by local environmental conditions. There should be connectivity between seagrass beds and beds should demonstrate natural zonation and transitions.

Table 1: Confidence levels for the favourable values

Favourable conservation status parameter	Favourable value	Confidence in the favourable value
Range and distribution	Seagrass beds occupy all sea areas with suitable habitat.	Moderate
Extent	An increase in extent from 3,050 ha to 45,000 ha	High
Structure and function	95% of the favourable habitat extent meets the favourable structure and function requirements (see Section 4.3)	High

As of June 2022, based on a comparison of the favourable values with the current values seagrass beds do not achieve favourable conservation status. Note, this conclusion is based solely on the information within this document and not on a formal assessment of status nor on focussed and/or comprehensive monitoring of status.

Contents

About the Defining Favourable Conservation Status project

Natural England's Defining Favourable Conservation Status (DFCS) project is defining the minimum threshold at which habitats and species in England can be considered to be thriving. Our Favourable Conservation Status (FCS) definitions are based on ecological evidence and the expertise of specialists.

We are doing this so we can say what good looks like and to set our aspiration for species and habitats in England, which will inform decision making and actions to achieve and sustain thriving wildlife.

We are publishing FCS definitions so that you, our partners and decision-makers can do your bit for nature, better.

As we publish more of our work, the format of our definitions may evolve, however the content will remain largely the same.

This definition has been prepared using current data and evidence. It represents Natural England's view of favourable conservation status based on the best available information at the time of production.

1. Habitat definition and ecosystem context

1.1 Habitat definition

Seagrass beds represent a broad habitat type that is described in similar terms by the OSPAR Commission (OSPAR 2009), European Nature Information System (EUNIS) and in domestic legislation (Natural Environment and Rural Communities (NERC) Act 2006). In England, the dominant species are *Zostera noltei* (accepted nomenclature according to WoRMS (2019) but synonymous with *Z. noltii*) and *Z. marina. Z. angustifolia* is no longer considered a distinct species and is accepted as a variant of *Z. marina* (d'Avack and others 2015). There is, therefore, no further reference to *Z. angustifolia* in this document.

OSPAR (2009) describes seagrass or *Zostera* beds as comprising two communities or sub-types which, at a European level, are most closely represented by the following EUNIS habitats:

- A2.61 – Seagrass beds on Atlantic littoral sediments (relating to *Z. noltei*)
- A5.53 – Seagrass beds on Atlantic infralittoral sand (relating to *Z. marina*)

For simplicity and consistency with Natural England sub-feature names, *Z. noltei* beds will be referred to as 'intertidal seagrass beds' and *Z. marina* will be referred to as 'subtidal seagrass beds' throughout the remainder of this document.

Seagrass beds are not listed as an Annex I habitat in the Habitats Directive. However, in England Annex I habitats are composed of a standardised set of sub-features which describe the characterising communities. Both intertidal and subtidal seagrass communities represent sub-features of the following Annex I habitats: Subtidal sandbanks (H110), Mudflats and sandflats not covered by seawater at low tide (H1140), Coastal Lagoons (H1150), Estuaries (H1130) and Large shallow inlets and bays (H1160). Seagrass beds are also recognised as a supporting habitat for several bird species within Special Protection Areas (SPAs).

Seagrass is a feature of Marine Conservation Zones (MCZ) (JNCC & Natural England 2016) and can be listed under the broad-scale habitat 'Sublittoral macrophyte-dominated sediment' description (A5.5), or as a habitat feature of conservation importance 'Seagrass Beds'. Seagrass beds form an integral part of the Marine Protected Area (MPA) network and are legally protected where listed as features or sub-features within the European Marine Site (EMS) and Marine Conservation Zone networks. As MPA habitat features are described by the EUNIS classification this document makes no reference to the National Marine Habitat Classification biotopes.

1.2 Habitat status

The decline of seagrass is a worldwide phenomenon (Borum and others 2004), described by IUCN as "one of the most rapidly declining ecosystems on Earth" (Short and others 2010).

At the pan-European level, subtidal seagrass beds are categorised as Critically Endangered in the European Red List of Marine Habitats for both EU28 and EU28+; a reflection of substantial historical loss and continuing declines, equivalent to a ≥90% reduction in extent within Europe and associated loss of biotic quality (Criteria A3/C/D3). This status is afforded to only two features across the entire region (Gubbay and others 2016b). Intertidal seagrass communities have declined by 40-50% and are Near Threatened (Criteria A1, A3/C/D3) across all the regional seas assessed (Gubbay and others 2016c). However, a lack of data is acknowledged as a weakness in both estimates. In the north-east Atlantic, intertidal seagrass beds are regarded as declining in the North and Celtic Seas (Regions II and III respectively) (OSPAR 2008).

Reflecting different criteria, *Z. marina* and *Z. noltei* are considered to be of 'Least Concern' as losses, range restriction or other characteristics of population change are not sufficient or recent enough to warrant a more threatened category (Short and others 2010). Both species are considered to be nationally scarce in the UK (that is, present in only 16-100 ten km squares) (BRIG 2011).

In England and Wales, seagrass beds are identified as a Habitat of Principal Importance (formerly a UK BAP Priority Habitat, BRIG 2011) under the Natural Environment and Rural Communities (NERC) Act 2006.

1.3 Ecosystem context

There are 55 species of seagrass worldwide (Green & Short 2003), distributed throughout temperate and tropical seas (Short and others 2007; UNEP-WCMC 2018). Those found in England (*Zostera noltei* and *Z. marina*) are also found throughout the north-east Atlantic, Mediterranean, Baltic and parts of the Black Sea (Borum and others 2004; UNEP-WCMC 2018). Whilst this document is concerned solely with the communities found around the shores of England, it is informed by evidence relating to those found throughout the north-east Atlantic with which they have much in common and where considerable research has been carried out and which informs its outcomes.

Intertidal and subtidal seagrass beds are currently recorded throughout the UK, particularly western Scotland, north-east Scotland, parts of Wales, north-east England, East Anglia and the south and south-west coasts of England. A detailed description of seagrass distribution within England is given in Section 3.1

In appropriate conditions intertidal seagrass typically dominates the littoral or intertidal zone on sheltered sandy mud and muddy sand in full and variable salinity environments (Connor and others 2004). Although predominantly found on the mid-shore it can also, in the absence of competition, extend into the subtidal (Borum and others 2004). Subtidal seagrass beds occupy the lower shore and shallow subtidal waters or infralittoral zone in estuaries and saline lagoons. They are found on soft sediments, including sand, sandy mud and muddy sand, sometimes with gravel (Connor and others 2004; d'Avack and others 2014). However, complex unbroken transitions can occur between the two (and can extend into pioneer saltmarsh (BRIG 2011)) in response to beach micro-topography (Gubbay and others 2016b). To qualify as a seagrass bed, the cover of *Zostera* species is generally regarded to have to be at least 5%, with expert judgment being necessary when plant densities are low (OSPAR 2009). However, OSPAR (2009) states that 30% plant cover is more typical. WFD-UKTAG (2014) seagrass tool methodology states that all 'beds' in the waterbody with >5% cover of *Zostera* should be identified. However, there is no minimum area measurement to qualify as a seagrass bed because seagrass colonisation is dependent on habitat suitability which, in the absence of human pressures, is driven by environmental factors.

Subtidal seagrass beds can be found on all coastlines whereas intertidal beds more commonly occur in estuaries and bays, with *Zostera noltei* typically behaving as an annual species and *Z. marina* as a perennial.

Both communities experience large seasonal changes in cover and biomass (Connor and others 2004a) because of senescence, grazing by wildfowl and physical disturbance by winter storms. More than 60% reduction in leaf cover was reported from some sites due to natural factors (OSPAR 2008) although other reports suggest far less (OSPAR 2009). Seagrass beds can be very dynamic with varying growth rates and morphology and associated accretion and erosion shaping the landscape. Some more ephemeral annual populations die-back completely each year and if distant from more robust perennial communities, recolonisation is completely dependent on seed supply. More stable perennial communities may senesce above the substrate but where the rhizome persists, new shoots will grow asexually from the same or new growth rhizome each spring. The capacity of seagrasses to occupy space by clonal growth is a key factor in appearance, development and maintenance of seagrass landscapes (Boström and others 2006). Annual communities can vary in size from year to year, but others can remain fairly stable – this depends on the nature of the environment and the mobility of the substrate colonised.

Distribution is naturally limited by factors such as turbidity, wave action, water depth, nutrient concentration, competition and grazing (Borum and others 2004; UNEP-WCMC 2018). Anthropogenic pressures limiting seagrass distribution are detailed in Section 3.3. Borum and others (2004), Massa and others (2009) and Jackson and others (2013) summarised the habitat requirements of northern European seagrass species as:

- Light availability: one of the most important factors in regulating seagrass growth. Light is a limiting resource in aquatic habitats due to suspended solids and phytoplankton and attenuates exponentially with depth. Estimates from across the biological range of *Z. marina* suggest it requires between 12% and 37% of surface irradiance (SI) to survive in the long-term with a mean SI of 18% (Lee and others

2007; Erftemeijer & Lewis 2006). In England subtidal seagrass beds are rarely found beyond a depth of around 5 m or so but where light availability allows, this can extend to 10 m or more.

- Physical exposure: currents and waves control the upper depth limit (or intertidal distribution) of seagrasses. It is thought that seagrasses do not exist at current velocities exceeding 1.5 ms-1, although this is a generalisation. Physical disturbance of the substratum leads to sediment resuspension and reduced light availability whilst currents and wave action have the potential to uproot plants and destabilise the sediment, preventing new shoot growth.

- Substratum characteristics: seagrasses are found in soft sediments into which the roots can penetrate and the rhizomes can elongate. In the UK, this is generally sandy mud and muddy sand. However, high sulphide concentrations found in organic-rich, fine-grained sediments are toxic to seagrasses and they are generally absent from these, often anoxic, sediments.

- Salinity: seagrasses are found in low, variable and full salinity habitats, although in the UK most seagrass beds are recorded in variable and full salinity habitats.

- Oxygen: is required by the leaves, roots and rhizomes and is produced photosynthetically. However, in periods of high organic matter degradation and high temperatures, anoxic conditions may negatively affect growth and survival.

- Temperature: is important for photosynthesis and respiration. *Zostera* species occur throughout Europe and are therefore adapted to a range of temperature regimes. However, local adaptation is not necessarily transferrable to all latitudes. Hence, seagrasses can be susceptible to temperature shock.

- Competition: *Z. noltei* is generally restricted to the littoral zone because of competition from *Z. marina*. Extensive bed-forming mollusc species, such as blue mussel *Mytilis edulis*, native oyster *Ostrea edulis* and invasive non-native species (INNS) such as slipper limpet *Crepidula fornicata* and Pacific oyster *Magallana gigas*, may compete for space, supress plant growth and modify the sediment through the deposition of shell and pseudo faeces.

- Grazing: by waterfowl and invertebrates can reduce plant growth and remove leaves although, with the exception of a few areas in Europe, grazing is not thought to be a major controlling factor over seagrass distribution.

Established seagrass beds play an influential role in local sediment dynamics by increasing bed roughness, impeding water flow, encouraging sediment deposition, reducing turbidity and stabilising mobile substrata (even though the roots of both species are usually restricted to the top 20 cm of sediment) allowing the development of a diverse infaunal community. The significance of the role of seagrass beds in carbon sequestration is now widely acknowledged and that subtidal seagrass beds in the UK contribute substantially at the European level (Green and others 2018). Fourqurean and others (2012) concluded that seagrass beds were of an equivalent importance to forests in terms of carbon storage capacity. However, as forests are vulnerable to carbon release from forest fires, carbon storage within seagrass beds is considered more permanent.

The long, trailing, ribbon-like leaves (up to 100 cm in length for *Z. marina*; 20 cm for *Z. noltei*) can provide suitable conditions for an, at times, abundant community of diatoms, algae, stalked jellyfish and anemones, whilst the substrate may support amphipods, polychaetes, bivalve molluscs and echinoderms. However, species composition is heavily influenced by sediment type, salinity and exposure. Seagrass beds also provide shelter for a number of fish species (including gobies, pipefish and seahorses) and epibenthic invertebrates (including stalked jellyfish). The seagrass beds also serve as nursery grounds for economically important fish species including pollack, herring, cod and whiting, and provide important feeding grounds for wildfowl (BRIG 2011).

2. Units and attributes

2.1 Natural range and distribution

Specific location

BRIG (2011) and McConville & Tucker (2015) refer to range in the context of the number of 10 km^2 grid squares in which a species is present, as an indication of the geographical extent of distribution (for example, latitudinal, longitudinal or depth). Disappearance from grid squares would be considered indicative of a contraction of range. However, under the Marine Strategy Framework Directive (MSFD), indicators of Good Environmental Status relating to the distributional range of sediment habitats focus on the specific location of the habitat, recorded as latitude and longitude or National Grid Reference. Range refers to the geographical limits of distribution (which may include northerly and southerly limits, together with depth or tidal elevation).

Under the MSFD, the 'distributional pattern' within a defined range is measured as:

- Specific location within the defined range (latitude and longitude)
- spatial extent (ha)
- boundary of the habitat (latitude and longitude)

2.2 Extent

Hectare

It is useful to express the overall spatial extent of seagrass beds as hectares within a defined unit area. This unit of measurement allows temporal comparisons for seagrass bed extent to be made and enables high level judgement of whether the bed is expanding or contracting. For seagrass beds, the MSFD targets for 'Area' align with the Water Framework Directive, under which the spatial extent of the habitat is recorded in hectares at waterbody level.

Under this metric, total habitat area is recorded. This is distinct from the measure of spatial extent recorded under Natural Range and Distribution (Section 2.1) in that it refers to total habitat extent within a defined water body (or national resource), rather than habitat extent of a specific seagrass bed within a water body (WFD-UKTAG 2014). It is of note that the Water Framework Directive (WFD) only covers intertidal seagrass; subtidal seagrass is covered by the MSFD although aspects of the WFD assessment methods are employed.

2.3 Structure and function attributes

The structure and function attributes relating to habitat quality are based on the Supplementary Advice on Conservation Objectives (SACO) attributes provided for appropriate European Marine Sites and accessed via the link to 'supplementary advice' (refer to Section 3.1 for suitable links).

Structure attributes

In addition to the parameters listed below (derived from the SACO attributes), it is also recommended that **shoot density as percentage cover** (Foden & Brazier 2007; WFD-UKTAG 2014) is recorded. Low shoot density (and therefore, low percentage cover), particularly in beds <5 years old, was associated with high levels of mortality; a factor which decreased with age of the bed, increasing shoot density and percentage cover and reduced patch fragmentation (Jackson and others 2013). Hence, percentage cover is an important consideration when assessing conservation status and the resilience of seagrass beds.

The **associated community and the density of competitive species** (for example, *Mytilus edulis, Arenicola marina, Cerastoderma edule*) (Valdemarsen and others. 2011) should also be considered when assessing conservation status. The habitat should support a typical benthic community for a seagrass bed.

Extent (and availability) of supporting habitat

The extent of seagrass beds is determined by habitat suitability, for example, microtopography, sediment conditions, presence of standing water etc.

Connectivity

Because seagrass beds demonstrate large seasonal changes in cover and biomass, good connectivity with established patches is essential to ensure re-establishment of beds.

Presence and abundance of key structural and influential species

Good quality habitat will support a typical benthic community and a low density of competitive species.

Zonation

Good quality seagrass beds will exhibit zonation and transitions to other communities.

Patch size, coverage and ratio of patch size to perimeter

Larger patches, with high percentage cover of shoots may be indicative of high-quality seagrass beds.

Function attributes

In addition to the attributes below (derived from the SACO attributes), **sediment characteristics** in terms of broad Folk classification (sandy mud, muddy sand etc.), particle size, degree of anoxia (depth of the redox potential discontinuity) should also be considered (Borum and others 2004; Jackson and others 2013).

Non-native species and pathogens

A high incidence of non-native species and pathogens indicates a poor-quality seagrass bed.

Exposure and hydrodynamic regime

Hydrodynamic regime determines where seagrass beds can occur.

Light, temperature and salinity

Light availability, temperature and salinity will determine where seagrass beds can occur.

Water quality – dissolved oxygen

Oxygen is required for photosynthesis be seagrass beds.

Water quality – contaminants

Contaminants can restrict establishment and persistence of seagrass beds

Sediment contamination

Contamination can restrict establishment and persistence of seagrass beds.

Sedimentation rate

Sedimentation and erosion rates and associated coastal processes will determine where seagrass beds can occur.

Nutrients

Eutrophication can cause the loss of seagrass beds.

3. Evidence

3.1 Current situation

Natural range and distribution

Intertidal and subtidal seagrass communities are widely but patchily distributed around the littoral and sublittoral zones of the UK (Connor and others 2004b,c) although, where conditions allow, they can form substantial meadows with 95% cover (BRIG 2011; Jackson and others 2013; OSPAR 2008).

Seagrass beds were identified at 41 sites in England, from Lindisfarne and Budle Bay in the North East to Morecambe Bay (Piel Channel) in the North West (Table 2). Intertidal seagrass beds appear to be present in all regions of England, with the exception of the Humber, Wash, Dee, and Solway, and most of the north-west coastline. In contrast, subtidal seagrass beds appear to be restricted to south-west and south-east England in sheltered bays and estuaries (Table 2).

It is of note that these data are not exhaustive. For example, a small area of intertidal seagrass is known to be present in the Humber estuary but is neither recorded in the WFD data nor in MAGIC maps. There may be other, similarly small, areas of seagrass around England that are known locally (or not known at all) but are not formally monitored. Whilst probably small, these patches of seagrass could potentially expand under the right conditions and so their presence is worth noting. Weatherdon and others (2017) highlight that spatially explicit, consistent and accessible data on seagrass extent are lacking. Caution should therefore be applied to the interpretation of estimates of current distribution and extent.

Data were sourced from MAGIC Maps and the ‘Biology: habitats’ section of the WFD assessment: estuarine and coastal waters (for intertidal seagrass) (Water Framework Directive assessment: estuarine and coastal waters).

Table 2: Seagrass distribution in England (based on Water Framework Directive data). 'C' and 'E'' denote Coastal and Estuarine areas, respectively. Source: Water Framework Directive assessment: estuarine and coastal waters.

WFD water body name	Region	Water body type	Intertidal seagrass	Subtidal seagrass	Magic map link
Holy Island & Budle Bay	Northumbria	C	Y	N	Holy Island & Budle Bay
Burn	Anglian	E	Y	N	Burn
Orwell	Anglian	E	Y	N	Orwell
Blackwater	Anglian	E	Y	N	Blackwater
Crouch	Anglian	E	Y	N	Crouch
Stiffkey & Glaven	Anglian	E	Y	N	Stiffkey & Glaven
Essex	Anglian	C	Y	N	Essex
Thames Coastal North	Thames	C	Y	N	Thames Coastal North
Medway	Thames	E	Y	N	Medway
Thames Lower	Thames	E	Y	N	Thames Lower
Portsmouth Harbour	South East	E	Y	Y	Portsmouth Harbour
Western Yar	South East	E	Y	Y	Western Yar
Langstone Harbour	South East	E	Y	Y	Langstone Harbour

WFD water body name	Region	Water body type	Intertidal seagrass	Subtidal seagrass	Magic map link
Chichester Harbour	South East	E	Y	Y	Chichester Harbour
Solent	South East	C	Y	Y	Solent
Isle Of Wight East	South East	C	Y	N	Isle of Wight East
Pagham Harbour	South East	E	Y	N	Pagham Harbour
Carrick Roads Inner	South West	E	Y	Y	Carrick Roads Inner
Fal / Helford	South West	C	N	Y	Fal / Helford
Penzance	South West	C	Y	Y	Penzance
Plymouth Tamar	South West	E	Y	Y	Plymouth Tamar
Portland Harbour	South West	C	N	Y	Portland Harbour
Plymouth Coast	South West	C	N	Y	Plymouth Coast
Fowey	South West	E	N	Y	Fowey
Salcombe Harbour	South West	C	N	Y	Salcombe Harbour
Yealm	South West	E	N	Y	Yealm

WFD water body name	Region	Water body type	Intertidal seagrass	Subtidal seagrass	Magic map link
Carrick Roads Outer	South West	C	Y	Y	Carrick Roads Outer
Helford	South West	E	Y	Y	Helford
Plymouth Sound	South West	C	N	Y	Plymouth Sound
Poole Harbour	South West	E	Y	Y	Poole Harbour
Weymouth Bay	South West	C	N	Y	Weymouth Bay
Dorset / Hampshire	South West	C	N	Y	Dorset / Hampshire
Fleet Lagoon	South West	E	N	Y	Fleet Lagoon
Tor Bay	South West	C	Y	Y	Tor Bay
Scilly Isles	South West	C	Y	Y	Scilly Isles
Lyme Bay West	South West	C	N	Y	Lyme Bay West
Lyme Bay East	South West	C	Y	N	Lyme Bay East
Kingsbridge	South West	E	Y	N	Kingsbridge
Exe	South West	E	Y	N	Exe
Severn Lower	Severn	E	Y	N	Severn Lower

WFD water body name	Region	Water body type	Intertidal seagrass	Subtidal seagrass	Magic map link
Morecambe Bay (Piel Channel)	North West	C	Y	N	Morecambe Bay

Extent

Using Natural England's Marine Evidence Geodatabase, which comprises data from various sources, Swaile and others (2022) give the total area of seagrass as 30.5 km^2 or 3,050 ha. This evidence is based on polygon data available, and additional areas are known based on point data but the extent and area of such beds cannot be estimated without further monitoring.

Patch size and connectivity

At a water body level, the area occupied by intertidal seagrass ranges from <0.01 ha in Lyme Bay to 770 ha at Holy Island and Budle Bay. However, at most sites, intertidal seagrass beds are less than 100 ha in area. Subtidal seagrass beds range from 0.01 ha to 683 ha, with the largest beds being in the South West in Lyme Bay and the Isles of Scilly. Again, most beds are less than 100 ha in area.

Quality of habitat patches

There is little information available on the quality of seagrass beds.

MSFD and WFD assessments are completed at too coarse a scale to provide meaningful information for England. The assessments are carried out against reference conditions derived from the existing seagrass resource so are not indicative of conservation status (WFD-UKTAG 2014). Article 17 reporting under the Habitats Directive focuses only on the extent and distribution of the Annex 1 habitat, rather than its component sub-features and their attributes, so there is currently no detailed evaluation of seagrass beds within the Article 17 process.

In 2016 Natural England introduced a new Marine Protected Area (MPA) condition assessment methodology to assess condition of marine features designated within MPAs in England. The results from the new condition assessment (CA) methodology will be presented progressively as sites are assessed. Results of assessments from four sites containing intertidal or subtidal seagrass (or both) are available: Solent Marine SAC, The Wash and North Norfolk Coast SAC, the Fal and Helford SAC and Plymouth Sound and

Estuaries. Assessments were largely completed in 2018 and 2019 with some assessments for Plymouth Sound and Estuaries completed in 2021. Almost all beds were assessed as being in unfavourable condition with reasons commonly TBT contamination, nutrient enrichment and abrasion from recreational activities.

Wilding and others (2009) and Jones & Unsworth (2016) have both highlighted the degraded state of seagrass beds in the UK. Swaile and others (2022) noted that most anchoring and mooring activity takes place in sheltered, shallow locations in close proximity to shore. These areas are also highly suitable for seagrass beds therefore beds suffer direct damage from these activities. In addition, anchoring and mooring also releases sediment which increases turbidity and reduces light available for photosynthesis so causing indirect damage to seagrass beds.

Elevated nutrients from urban development and agricultural run-off are also detrimental to seagrass beds. Elevated levels of Dissolved Inorganic Nitrogen (DIN) levels are found particularly within estuaries and shallow inlets and bays suitable for seagrass beds. Based on a 2019 WFD assessment by the Environment Agency, Swaile and others (2022) found that 80% of seagrass beds were of Moderate DIN status (did not reach Good Ecological Status). This 2019 assessment covered 89% of all seagrass beds with less than 7% of assessed seagrass beds meeting High DIN status.

Confidence: Moderate

3.2 Historical variation in the above parameters

Over the last century, the distribution and abundance of seagrass beds have declined throughout the north-eastern Atlantic and English waters due to a combination of microbial pathogens (a ‘wasting disease’), reduced water quality and anthropogenic activities including, dredging, recreational boating activity and harbour development (OSPAR 2009).

Seagrass used to cover most sandy-mud sediment habitats close to English coasts (Davison & Hughes 1998). Then, between the First World War and 1930s, and encouraged by unusual climatic conditions, an infection associated with a slime-mould (*Labyrinthula zosterae*) led to the appearance of a ‘wasting disease’ and the subsequent large-scale decline in abundance, extent and quality of seagrass beds in English waters, and elsewhere across the North Atlantic (Gubbay and others 2016c; OSPAR 2009). There is evidence to suggest that outbreaks still occur although more recent declines in distribution and abundance around England have been attributed to poor water quality (particularly nutrients), coastal development and inappropriate land use (Jones & Unsworth 2016).

Whilst loss may be rapid, recovery can be a gradual process and whilst some increases in extent have been recorded in recent years, seagrass beds have not recovered to anything like the extent of a hundred years ago (Gubbay and others 2016c). Other observations from around northern and north-western Europe present a broadly similar pattern of widespread decline and a lack of subsequent effective recolonization, with recovery being described as slow (OSPAR 2008) or absent (Van Der Heide and others 2007). OSPAR (2009) suggests that whilst the decline of *Zostera* throughout Europe may have halted between 1990 and 2000, re-establishment has not occurred. Applied research in English waters appears to be lacking and it has been suggested (Foden 2007 in OSPAR 2009) that the lack of a consistent monitoring strategy in the UK compromises effective historical comparisons, a point supported in the UK Biodiversity Action Plan report (2005), compounded by the lack of accurate records prior to the onset of the wasting disease.

Krause-Jensen (OSPAR 2009) and Jones & Unsworth (2016) suggested that, although disease led to the widespread loss of *Z. marina* worldwide, it is the combination of disease, incomplete recolonisation and declines in water quality and clarity as a function of eutrophication that is responsible for the more recent loss of seagrass beds. For instance, both intertidal and subtidal seagrass beds are recorded to have declined in the Waddenzee as a consequence of eutrophication in the 1960s (Borum and others 2004; Den Hartog & Polderman 1975).

This appears to establish a pattern of decline caused by disease followed by incomplete recolonisation and then further decline as a consequence of anthropogenic factors.

Natural range and distribution

There are various references to the decrease in spatial extent of seagrass beds (for example, Jones & Unsworth 2016; Green and others 2018) but no specific reference to a change in range. Green and others (2018) highlight that much of the evidence for seagrass loss in the UK is anecdotal and therefore accurate mapping of temporal change in seagrass bed location and extent is challenging.

Variability and uncertainty over stable beds size and a lack of data on the current distribution of subtidal seagrass beds may mean that significant losses are not being recorded, leading to high uncertainty of the overall scale of loss.

Extent

In a recent review, Green and others (2021) estimated a loss of at least 44% of seagrass beds within the UK since 1936, and of this 39% has been lost since the 1980s. Areas where good historical data were available showed declines between 40% (Cornwall) and 100% (Suffolk). Using two simple models to estimate declines against habitat suitability models produced estimated losses of 84% (CI 83%-95%) and 92% (CI 72%-91%) if all suitable habitats areas were previously colonised with seagrass beds.

No specific figure for losses in England has been found.

Accurate quantification of losses is problematic as spatially explicit, consistent and accessible data on seagrass distribution and spatial extent are lacking, making accurate assessment of temporal variation in these parameters difficult (Weatherdon and others 2017). Furthermore, many of the available data are derived from short-term studies at specific locations which limits their use in long-term assessment of change (Foden 2007;

Weatherdon and others 2017). Weather, sea state and turbidity may also limit the coverage of surveys at different time periods, making direct comparison less accurate. Whilst extensive beds may remain, it is sometimes difficult to identify the scale of loss and ascertain if patches are all that's left of a once continuous bed or new growth (Böstrom and others 2006).

Quality of habitat patches

Whilst reliable, long-term evidence is lacking, based on the findings of Wilding and others (2009) and Jones & Unsworth (2016), overall, patch quality can be considered to be in decline.

Other sources: Den Hartog 1987; Jones and others 2000; Muehlstein and others1988; Short and others1988.

Confidence: Low to Moderate. Historic and more recent declines have been observed and recorded but are difficult to quantify and compare with some conflicting outcomes. Similarly, the triggers causing the major die-back of *Z. marina* from the wasting disease remain unclear (OSPAR 2008).

3.3 Future maintenance of biological diversity and variation in the habitat

Zostera species are highly vulnerable to human activities, especially those resulting in physical disturbance in the form of surface and sub-surface abrasion, physical removal and loss or change to the habitat (Thrush and others 2003; Campbell & McKenzie 2004; Cabaço and others 2008; Mazik & Smyth 2013; Mazik and others 2015). Such disturbance arises from, for example, construction work (pipelines, flood defence works, offshore windfarm cable routes, harbour works), moorings (Uhrin & Holmquist 2003; Eriksson and others 2004), quad bikes, trampling, dredging, benthic trawling and hydraulic dredging, bait digging, and beach nourishment schemes (Foden & Brazier 2007). These activities cause direct habitat loss but also cause wider impacts through the mobilisation of sediment, which reduces water clarity. In terms of vulnerability, young, sparse communities are more likely to suffer catastrophic loss via physical factors with larger, more established examples proving more robust.

Similarly, any activity that causes changes in water flow (current speeds, wave exposure, beach profile or water depth) has the potential to disturb seagrass communities.

Seagrasses are also highly sensitive to changes in water clarity and nutrient concentrations, with eutrophication being considered a major cause of seagrass decline in many parts of the world (Cabaço and others 2008; Jones & Unsworth 2016). There is evidence from the UK that improvements to sewage treatment because of implementation of the Urban Wastewater Treatment Directive and Water Framework Directive have started to reduce the scale of this particular threat (Jackson and others 2013). Wilding and others (2009) observe that improvements in water quality have alleviated some of the pressures on seagrasses and that their inclusion in conservation management objectives may have reduced the rate of decline. It was recognised that increased monitoring effort has enabled a better understanding of the distribution of seagrass beds and noted that care must be taken not to confuse recording effort with an expansion of the habitat.

D'Avack and others (2014) indicated that seagrasses in the UK may be subject to competition from to invasive species, particularly *Spartina* spp., and the seaweed *Sargassum muticum*. Whilst the latter is not necessarily a direct competitor, it can quickly colonise potentially suitable habitat. Similarly, although *Spartina anglica* is no longer introduced, existing stands continue to spread, providing competition and effectively sterilising otherwise suitable habitat (OSPAR 2008).

There is strong consensus that in global terms, the combination of climate change driven increases in water temperatures, rates of sedimentation and turbidity (from increased rainfall and surface run-off), acidification and storminess will have an overall negative effect on range and distribution of marine macrophytes (Borum and others 2004). Sea level rise (and coastal squeeze) is a particular threat as more than 70% of coastlines worldwide are projected to experience a change of around 20% (Borum and others 2004; Brodie & N'Yeurt 2018; Duarte and others 2018). Seagrasses can be susceptible to temperature shock (Massa and others 2009). With respect to acidification, the effects of climate change on seagrasses are complex and contradictory. For example, Falkenberg and others (2013) suggested that autotrophic growth may increase under conditions of enhanced CO_2 (and, hence, reduced pH) and this has indeed been observed in some areas (Sunday and others 2017). Additionally, Palacios & Zimmerman (2007) found increased reproductive output, increased below-ground biomass and increased vegetative shoot production to be associated with increased CO_2. However, Sunday and others (2017) emphasised that decreased seagrass biomass has also been associated with decreasing pH, and in some cases, no effect is observed at all. They suggested that the response of seagrass to changes in CO_2 and pH was context-specific and that other factors, such as competitive interactions with other primary producers (for example) may be important. Productivity, growth, flowering and distribution could all be affected as well as associated invertebrate, fish and wildfowl populations (MCCIP 2018). However, it remains true that potential changes could have both positive and negative effect for instance, senescence could reduce and productivity increase, but overall, potential impacts remain poorly understood.

Finally, the wasting disease of a century ago almost wiped-out the species in the north-Atlantic and occasional outbreaks are still recorded, strongly suggesting that the threat has not gone away. Assessment by Brakel and others (2019) found that *Labyrinthula zosterae* is unlikely to pose a greater infection risk with potential climate change.

Natural range and distribution

Based on the findings of Davison & Hughes (1998), and in a pressure-free scenario, the favourable range and distribution of seagrasses in England should comprise all soft sediment with favourable habitat characteristics (for example, depth/tidal elevation/shore profile, sediment particle size, water content and degree of anoxia, exposure, tidal current regime and salinity). This should also include those areas from which seagrass beds are currently absent including the Dee, Solway, Wash, Humber and much of north-west England (Davison and Hughes 1998).

Extent

To increase the resilience of seagrass beds to the threats that they face, the only reasonable approach is to reverse historical losses and seek expansion across the entire extent of suitable habitat.

The WFD data set indicates a total of 195,361 ha of intertidal soft sediment and 818,050 ha of subtidal soft sediment in England. However, based on monitoring data (Mazik & Boyes 2004; Boyes & Mazik 2005; Dawes & Thomson 2011; Jackson and others 2013), it is evident that seagrass will not necessarily colonise the entire area of suitable benthic habitat available due to natural environmental limitations. These include depth, water quality, wave exposure, microtopography, freshwater influence and subtle changes in sediment characteristics (particle size, water content, localised anoxia, erosion and deposition patterns).

Using Environment Agency modelling, merging data on wave energy, current energy, depth and salinity, Swaile and others (2022) selected thresholds tolerated by seagrass to identify an area of 447.77 km^2 or approximately 45,000 ha that could be suitable for seagrass beds. The results from this modelling should be treated with caution, as the whole of this area may not be suitable, due to factors such as specific grain size and organic content characteristics, shore height/depth, microtopography and water clarity. However, this modelling provides the best currently available figure for a favourable area for seagrass beds.

Quality of habitat patches

To ensure seagrass beds display resilience to future pressures and threats the quality of seagrass beds needs to significantly improve.

Patches may need to increase in size and shoot density. Mazik & Boyes (2004) and Boyes & Mazik (2005) found that maximum percentage cover occurred in areas of shallow standing water and that cover of over 80% was common, although patch size was usually quite small (<20 m^2). In areas of bare sand, without standing water, coverage of up to 50% was more common (but was frequently lower than 50%). OSPAR (2009) states that subtidal seagrass beds with <60% cover are generally more susceptible to storms than denser, more uniform beds. It is therefore suggested that favourable conservation status could be based on the 60% threshold, acknowledging that this density will not be achievable in all areas of the available habitat.

Confidence: Moderate

3.4 Constraints to expansion or restoration

There is substantial evidence to suggest that recovery of seagrasses is possible following the removal of natural and anthropogenic pressures, provided that the conditions are suitable (that is, sediment characteristics, exposure, currents and waves, suspended solids, removal of physical disturbance and contamination). However, the timescale for recovery is dependent upon the scale of the damage, scale of seagrass loss and the degree of change to the physico-chemical nature of the habitat (Mazik & Smyth 2013; Mazik and others 2015).

Natural recovery may be constrained by the limits of natural seed dispersal, germination and growth rate, disturbance events and natural variability (for example, relating to weather, climate). Furthermore, Jackson and others (2013) highlighted that seagrass beds are typically composed of patches or varying size and shoot density, with areas of bare sediment. Some beds have stable 'core' areas which are surrounded by more ephemeral cover and in other beds, complete winter die-back may occur.

Rapid recolonisation of damaged beds is possible if the disturbance causing the seagrass decline is limited in time and space, and rhizomes have remained intact or can re-grow, or if seedlings originating from the sediment bank or from neighbouring populations experience suitable growth conditions the following year. If the rhizomes have gone, and seedlings die, recolonisation must rely on the expansion of neighbouring populations; consequently, the process can be prolonged. However, patch growth is self-accelerating, which is responsible for asymmetry in seagrass patch shape and increased patch formation rates over time. Therefore, the timescale for recovery increases with increasing scale of disturbance and increasing homogenisation of the habitat (Mazik & Smyth 2013). Documented recovery times range from 2 years to over 7 years although, in some cases, recovery times of 25 years or more have been documented (Mazik & Smyth 2013). There is also literature to support the idea that, if the physical structure of the sediment is permanently altered, recovery may be unachievable.

Transplantation to assist the recovery of *Zostera* species has achieved limited success (Borum and others 2004) and data on the effectiveness and feasibility of transplantation techniques are limited. However, given the right approach, seagrass restoration is possible. For example, the planting of 200 acres of seagrass (from seed) in 2007 under the Virginia Seaside Heritage Programme resulted in a seagrass bed of almost 5,000 acres by 2013. A key outcome of this work was the finding that the potential for seagrass to recover without intervention is limited. Additionally, planting from seed has proved to be a successful strategy in Milford Haven (South Wales) although this success is based upon much trial and error and a significant amount of research has been required to optimise the approach to planting (R. Unsworth, Swansea University, pers. comm.).

Van Katwijk and others (2016) highlighted the importance of pressure removal and that eutrophic conditions and construction activities presented greater barriers to successful restoration than did natural disturbance, dredging or other 'localised' anthropogenic pressures. Biological factors that were correlated with restoration success included proximity to donor beds and the density of transplanted seeds or plants, with large-scale planting leading to greater restoration potential. The optimum density and spatial extent of transplantation was found to be site-specific, being related to levels of natural disturbance.

Improvements in coastal water quality and more effective site safeguard suggest that anthropogenic causes of decline could be addressed although the impacts of climate change are more difficult to address (Wilding and others 2009).

At the local scale, it remains that abundance and distribution will continue to be heavily influenced by topography, patch size, distance between stands and edge effects where on the geographical scale it is more related to seed dispersal and external environmental factors (substrate, light and exposure alongside new pressures, climate change or pollution for example).

Confidence: High

4. Conclusions

4.1 Favourable range and distribution

Seagrass beds should be found in all soft sediment with favourable habitat characteristics (for example, depth/tidal elevation/shore profile, sediment particle size, water content and degree of anoxia, exposure, tidal current regime and salinity). This means maintenance of the current distribution of seagrass beds and expansion into those areas from which seagrass beds are currently absent (including the Dee, Solway, Wash, Humber and much of north-west England).

4.2 Favourable extent

It is proposed that the favourable area is approximately 45,000 ha, being the area of potentially suitable habitat available.

4.3 Favourable structure and function attributes

Structure attributes

Extent (and availability) of supporting habitat

Occupation of 100% of the available and suitable habitat (subject to microtopography, sediment conditions, presence of standing water etc.).

Connectivity

There should be evidence of active rhizome growth and germination beyond existing, established patches where habitat conditions are suitable. Physical barriers should be absent (structures or unnatural features directly or indirectly leading to inappropriate habitat conditions).

Presence and abundance of key structural and influential species

Seagrass beds should support characteristic range of associated communities in typical abundance, composition and distribution. Presence of a benthic community typical of the biotope. There should be no evidence that seagrass spatial extent is being compromised by densities of bioturbators (for example, *Arenicola marina, Cerastoderma edule*) or excessive growth of mussels *Mytilus edulis*.

Zonation

Seagrass beds should display natural zonation and transition from intertidal to subtidal communities determined by local environmental conditions.

Patch size, coverage and ratio of patch size to perimeter

These parameters should reflect local environmental conditions and not be compromised through anthropogenic activity either directly through impacts on seagrasses, or indirectly through impacts on the habitat. Seagrass colonisation will naturally be patchy and of varying shoot density and of varying shape (perimeter/edge ratio). Temporal variability and natural died back in peripheral areas must also be considered. Established seagrass beds should extend over 1 ha, with greater than 60% cover.

Function attributes

Non-native species and pathogens

Non-native species and pathogens should be absent, or present at stable levels that do not impede seagrass growth & function.

Exposure and hydrodynamic regime

Wave exposure and/or the overall hydrodynamic regime are determined by natural environmental conditions. Anthropogenic impacts on the natural hydrodynamic regime should be minimised or eliminated in order to allow seagrass growth.

Light, temperature and salinity

A suitable light and salinity regime, typical to the location and according to the habitat characteristics.

Water quality – dissolved oxygen

Dissolved oxygen concentrations meet or exceed High Ecological Status (specifically ≥5.7 mg per litre (at 35 salinity) for 95% of the year).

Water quality – contaminants

Levels of aqueous contaminants (specifically tributyltin compounds and nitrogen) meet or exceed High/Good Status (according to Annex VIII and X of the Water Framework Directive) across all suitable habitat.

Sediment contamination

Surface sediment contaminants (<1 cm from the surface) are below the OSPAR Environment Assessment Criteria (EAC) or Effects Range Low (ERL) threshold across all suitable habitat.

Sedimentation rate

Natural sedimentation and erosion rates and associated coastal processes should be present across all suitable habitat (acknowledging that seagrass communities would not be expected to occur in areas with a naturally unfavourable sedimentation regime).

Sources of anthropogenic physical disturbance (which modify sediment characteristics and uproot plants) should be absent.

Nutrients

Natural mean winter dissolved inorganic nitrogen levels are not exceeded across all suitable habitat and opportunistic macroalgal and phytoplankton blooms are absent.

Quality of habitat patches

At least 95% of the favourable area of the habitat meets the structure and function requirements as described above.

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