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Common Standards Monitoring Guidance

for

Lagoons

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Common Standards Monitoring guidance for Lagoons

Contents

1 Definition of Lagoons

Lagoons are areas of shallow, coastal salt water, wholly or partially separated from the sea by sandbanks, shingle or, less frequently, rocks. Five main sub-types of lagoon (isolated, percolation, sluiced, silled and lagoonal inlet) have been identified in the UK, on the basis of their physiography, as meeting the definition of the habitat type. It may be also necessary to consider attributes of the sediment infaunal, epifaunal, phytoplankton and vegetative components of the lagoon system to comprehensively evaluate the condition of the lagoon itself. The variety of lagoonal communities appears to relate to the intrinsic variation in salinity within lagoons. The extent of a lagoon and its salinity may vary in the short term (tidal cycles) and in the medium term (in direct response to seasons and rainfall). In the longer term the lagoon will evolve, infill, shrink and in some cases disappear, in response to seasonal rainfall and drought (Bamber *et al*. 2001).

The term 'lagoon' includes the habitats listed in Box 1.

Box 1. Habitat types included in the term 'Lagoons'

Habitats Directive	BAP Broad habitat type[1]	BAP Priority habitat/Action Plan[1]	OSPAR Threatened Habitats[2]
Coastal Lagoons	Inshore sublittoral sediment	Saline Lagoons	*Zostera* beds, seagrass beds
Sandbanks which are slightly covered by sea water all the time (in part)	Littoral sediment	Sheltered muddy gravels	
Reefs (in part)	Littoral rock	Sea grass beds	
Mudflats and sandflats not covered by seawater at low tide (in part)	Inshore sublittoral rock	Tidal rapids	
		Sheltered muddy gravels	
		Sublittoral sands and gravels	

A condition assessment of Lagoons should be based on the attributes[3] and their associated targets derived from Table 1 in Section 6.

Section 2 and Table 1 (Section 6) list the generic attributes that are considered to most likely represent the condition of the feature. It will be necessary to develop a site-specific expression of some or all of

[1] These are derived from both the *Biodiversity: The UK Steering Group Report - Volume II: Action Plans and* the *UK Biodiversity Group Tranche 2 Action Plans - Volume V: Maritime species and habitats*. Further information on these habitat types can be found on the UK Biodiversity web site at http://www.ukbap.org.uk/habitats.htm – and form the reporting categories used within the Site Condition Monitoring Programme.

[2] These are derived from a provisional list agreed by the OSPAR Biodiversity Committee at their Leiden Workshop, 5-9 November 2001, and therefore may change when the final list is agreed.

[3] The Common Standards text defines an attribute as: a *characteristic of a habitat, biotope, community or population of a species which most economically provides an indication of the condition of the interest feature to which it applies*.

these generic attributes properly to represent the conservation interest of the feature, and fully to reflect any local distinctiveness.

Lagoons tend to have restricted exchange with the sea and concomitant reduced flushing of dissolved or suspended materials makes them potentially sensitive to water quality changes. This sensitivity is dependent on the type of lagoon and the nature of its stratification, the dominant sediment particle size classes and tidal exchange patterns. The water in lagoons can vary in salinity from brackish (hyposaline) to hypersaline. Lagoons can contain a variety of substrata, but most commonly include soft sediments. The plant and animal communities of lagoons vary according to the physical characteristics and salinity regime of the lagoon and therefore there are significant differences between sites. This is an acceptable part of the functioning of the feature and should be encompassed within the attributes and targets. These principles should inform the conservation objective.

2 Background, targets and monitoring techniques for individual attributes

Table 1 (Section 6) lists eleven attributes, four of which (*Extent, Isolating barrier – presence and nature, Salinity regime, Biotope composition)* are mandatory for all sites. The rest are site-specific attributes, used to highlight local distinctiveness when assessing the overall conservation value of a site, and may therefore not be applicable to all sites.

2.1 Extent

Extent of the lagoon is an essential structural component of the feature and therefore **must be assessed for all sites.**

2.1.1 Background to the attribute

Extent influences both sensitivity of the habitat and, together with shape (i.e. length to breadth (aspect) ratio) the diversity of the biological community present. Sites of 'high aspect ratio' (especially those with convolutions or islands) support a more diverse community than 'low aspect ratio' (large round or square) lagoons (Bamber *et al.* 2001).

Critical to both the definition and maintenance of a lagoon, and the community of species it supports, is the retention of most or all of the water mass within the system at low water in the adjacent estuary or sea. Concomitant with this is maintenance of a relevant depth of water.

Extent of water in late winter/spring may be taken as the likely extent of the lagoon basin. Extent of water in late summer in lagoons with a shallow basin is likely to be less than the extent of the basin. Therefore, when determining the extent of a lagoon, it is important to account not only for the extent of the water body, but also the extent of the basin itself.

Where the field assessment judges the extent to be unfavourable, and subsequent investigation reveals that the cause is clearly attributable to natural processes, the final assessment will require expert judgement to determine the reported condition of the feature. The feature's condition could be declared favourable where the officer is certain that the conservation interest of the feature is not compromised by the failure of this attribute to meet its target condition. Where there is a change outside the expected variation or a loss of the conservation interest of the site, (e.g. due to anthropogenic activities or extreme natural events such as storms causing unrecoverable losses) then condition should be considered unfavourable and potentially even partially destroyed . For example, the extent of a saline lagoon is much reduced due to the landward movement of its isolating barrier caused by a change in climatic conditions and reinstatement is not possible. Staff should refer to the flow diagrams in the introductory text to the marine features for more information on these issues.

Some changes may be considered acceptable or 'natural' and may be attributable to the following:

- *Infilling*

The geomorphology of saline lagoons ranges from the relatively stable rocky basins of lagoons in the Scottish Western Isles to relatively transient basins in the geologically dynamic unconsolidated sediments along the south and east coasts of the UK. English lagoons are notable in often being formed by shingle barriers, rather than sand. This is due to the existence of offshore glacial deposits and high-energy systems with enough power to move the deposits. For these reasons such lagoons are transient, as roll-over occurs and the barriers move landwards. Regardless of the nature of the substrate of a lagoon basin it may be subject to infill by sediments derived from the land or the sea. This will lead to a shallowing of the basin and a consequent loss of extent of the feature.

- *Erosion following winter storms or floods*

Storm events may cause erosion of the lagoonal sediments and/or loss of the isolating barrier. These should generally be perceived as acceptable changes, although some erosion may be exacerbated by coastal defences and should be treated similarly to 'coastal squeeze' (see below). However, natural re-establishment through geomorphological processes may occur over time.

Changes in extent would be considered unfavourable if attributable to the following:

- Loss or damage to a sluice or other flow control mechanism so that an open connection to the marine environment allows seawater exchange to occur on most tides. However, flow control mechanisms serve a more important function. They help facilitate the dispensation of peak freshwater input into the lagoon. Damage to sluices etc can lead to an increase in extent (and depth) of a lagoon. However, with retention of rain and run-off in the system the lagoon becomes hyposaline and then freshwater. This would be considered unfavourable when the salinity drops to a level at which the lagoonal biotopes / species populations were no longer sustainable.

- Anthropogenic alterations or storm damage to the separating barrier; artificial infilling, land claim or other developments. These impacts can lead to a direct loss in extent of the lagoon and associated extent of water (see later). However, good management practices regarding artificial infilling can sometimes bring lagoons into favourable condition by decreasing the depth of a lagoon to 1 metre or less. This is the favoured depth for many of the lagoonal specialist invertebrates. This may not necessarily decrease the extent of the lagoon. It can lead to an increase if the same volume of water is contained in the system.

- Vegetation encroachment: fringing plants such as reed (*Phragmites australis*) and sea club-rush (*Bolboschoenus maritimus*) can encroach into the shallows of lagoons as a result of anthropogenic activity (e.g. management as good bird habitat). This leads to a loss of extent and structural integrity of the site. Area loss due to this encroachment should trigger further research, as a drop in salinity may also be occurring. It should be noted that some lagoonal specialists such as the starlet sea anemone (*Nematostella vectensis*) can use the micro habitat of reed stems for attachment. Reedbeds may also be identified as a conservation feature for bird species, where relevant. Contextual information can be useful here to ascertain the origin of the reed bed.
- Coastal squeeze: the term applied to the effect of hard defences (including beaches fixed in position by control structures) when they interrupt the natural response of the shoreline to sea level rise. Sea walls or other embankments are often too steep to allow natural encroachment, restricting natural landward retreat and resulting in the intertidal zone being 'squeezed', with a change in topography and loss in the extent of intertidal and coastal habitats. Wave energy is reflected and intensified by hard sea defences, causing a scouring effect adjacent to these defences, which lowers the shore slope and consequently exposes the foot of sea walls, leading to eventual deterioration of the sea defence.

2.1.2 Setting a target

In principle, the target should be set at no loss of area of the lagoon during the monitoring cycle .It may be necessary to set a target that declines in steps over time where there is sufficient data available to predict (via a model) a downward trend in extent due to geomorphological trajectory. Departure

from this predicted target then would be a trigger for investigation and the condition of the feature may be considered unfavourable.

The target should indicate the recognised area of the feature measured in hectares. It is important that targets set for this attribute are flexible enough to relate to the natural coastal processes involved with this feature (see above text).

Extent can be measured in absolute terms, using an index approach such as point sampling over a grid, or by inference. The type of measure used should be linked to the known or likely threats posed by anthropogenic activities and take into account necessary consideration of dynamic processes.

When measuring extent, the following issues should be considered:

- The nature of the isolating barrier (may account for variation in water area due to tidal state).
- Check the timing (tidal & seasonal) of all aerial photographs used for making comparisons.
- Relative to the nature of the isolating barrier, consider recent flood/storm events that might account for sediment erosion/deposition and subsequent changes in feature extent.
- Anthropogenic factors such as coastal protection schemes, water abstraction and loss of integrity of any artificially controlled inlet can lead to extent losses/increases.

An example of how a target for this attribute might be expressed is shown in Box 2.

Box 2 A site-specific target for the attribute *Extent:*

Target	**Comments**
No reduction in extent of saline lagoon area. Extent identified as 24ha (English Nature 2003).	Condition would be judged unfavourable if loss in extent due to factors other than cyclical natural processes that are part of a wider coastal geomorphological management regime. See English Nature (2003) for lagoon area. Compare with aerial photographs. Where natural events (such as severe storm damage causing a barrier breach) cause a loss of extent of the feature, then this would also be considered unfavourable.

2.1.3 Suggested techniques

In most cases the area will be derived by referral to aerial photographs of the site. Broad-scale biotope maps at the Phase 1 scale may also be of benefit, showing distribution and extent of major habitats. Extent of small lagoons only may be directly measured.

English Nature's Saline Lagoon Habitat Inventory (2003) contains contextual information and mappable GIS polygons for all saline lagoons identified in England.

The Marine Monitoring Handbook (Davies *et al.* 2001) contains details of the techniques appropriate for monitoring the condition of designated features.

Possible methods provided in the handbook for measuring the extent of the feature are:

- 1-1 Intertidal resource mapping using aerial photographs.

Possible methods, not as yet detailed in the handbook are:

- aerial photography and photogrammetry (air photo interpretation)
- satellite and airborne multi-spectral remote sensing (remote imaging).

2.2 Isolating barrier – presence, nature and integrity

The *presence, nature and integrity of the isolating barrier* is fundamental to the structure and function of a saline lagoon, (indeed the nature of the barrier and degree of separation from the sea defines the type of lagoon in the UK. Therefore, this attribute **must be assessed for all sites.**

2.2.1 Background to the attribute

Lagoons with an open connection to the marine environment (silled and sluiced lagoons and lagoonal inlets) exchange a proportion of lagoon water on most tides. Lagoons with a regular exchange of water with the sea have a greater potential for recruitment of species, as there is a greater chance of colonisation of larvae from the sea, and, therefore, tend to support the most diverse communities. Except in the case of over-topping (isolated and some percolation lagoons) the key factor determining input and output of seawater is the height of the bottom of the inlet bed (sill, channel, sluice, weir or impermeable base of a percolation route) relative to ambient low water levels. Retention of the majority of the lagoonal water at low tide depends on this.

Where the field assessment judges the change in the isolating barrier to be unfavourable, and subsequent investigation reveals the cause is clearly attributable to natural processes, the final assessment will require expert judgement to determine the reported condition of the feature. Such circumstances include infilling or coastal erosion where coastal squeeze is not implicated) and cases where restorative measures are not viable and lagoons are being managed within a wider coastal geomorphological context (i.e. where they are expected to develop in some areas and disappear elsewhere). The feature's condition could be declared favourable where the officer is certain that the conservation interest of the feature is not compromised by the failure of this attribute to meet its target condition. Where there is a change outside the expected variation or a loss of the conservation interest of the site (e.g. due to anthropogenic activities or unrecoverable natural losses) then condition should be considered unfavourable. Staff should refer to the flow diagrams in the introductory text to the marine features for more information on these issues.

It should be noted that storms may pile up barrier material, preventing future over-topping with seawater, or cause break-through, opening the system to the marine environment. This should be reflected in the target by giving due initial consideration to the nature of the barrier.

Changes in presence, nature and integrity of the isolating barrier would be considered unfavourable if attributable to loss or damage of a sluice or other flow control mechanism or due to alterations in structure arising from anthropogenic activities.

2.2.2 Setting a target

In principle, the target should be set at no change in measure of the isolating barrier during the monitoring cycle.

The horizontal level of the isolating barrier should be a little below high water neaps to maintain optimum functionality. A suitable target might, therefore, be based on an assessment of the depth of the isolating barrier at a known state of tide. Where this is inappropriate, a visual assessment of the isolating barrier may be undertaken over a known portion of the tidal cycle.

An example of how a target for this attribute might be expressed is shown in Box 3

Box 3 A site-specific target for the attribute 'Isolating barrier – presence, nature and integrity'

Target	Comments
No change in height of base of the sluice at north end of lagoon. Base should be 0.5m below high water neaps (Bamber *et al.* 1992).	Changes in presence, nature and integrity of the isolating barrier would be considered unfavourable if attributable to loss or damage of a sluice or other flow control mechanism or due to alterations in structure arising from anthropogenic activities.

Target	Comments
Maintain integrity of sluices (i.e. no leaking).	Bamber *et al.* (1992) identified restoration works on sluice to be conducted by RSPB. Integrity of sluice has been maintained since 1994.

2.2.3 Suggested techniques

Most appropriate assessment techniques include demonstrating the integrity and nature of the barrier through direct measurement of tidal height/depth, *Air photo interpretation* and direct *in-situ* measurements/observations. Fixed viewpoint photography should be considered where appropriate, for reviewing activities with potential to alter the structure of the isolating barrier.

For different types of barrier, the following observations are important:

- Silled: width of entrance, height/depth of the sill in relation to the tidal range.
- Sluiced: height of base of sluice(s) (relative to basin and to tidal levels), integrity (leaking or not) and frequency of opening/closure.
- Inlet: width, depth of inlet channel (or, as a surrogate, an indicator of hydrological conditions around the mouth of the inlet).

The Marine Monitoring Handbook (Davies *et al.* 2001) contains details of the techniques appropriate for monitoring the condition of designated features.

Possible methods provided in the handbook for assessing the presence, nature and integrity of an isolating barrier are:

- 1-2 Fixed viewpoint photography; which should be considered where appropriate.

Other proposed methods, not as yet detailed in the handbook are:

- Aerial photography and photogrammetry (Air photo interpretation)

2.3 Salinity regime

Salinity regime is critical to both the structure and function of a lagoon, e.g. in defining the habitat and contributing to the overall diversity within a site and therefore **must be assessed for all sites**.

2.3.1 Background to the attribute

The evolution of a specialist lagoonal community appears to be related to intrinsic variation in salinity, both in time and space. Any changes in the prevailing salinity regimes may affect the presence and distribution of species, along with recruitment processes and spawning behaviour.

It is essential that the salinity regime is always assessed at a similar time of the year and state of tide on a site. Salinity of the adjacent source marine waters should be considered at the same time.

Where the field assessment judges the salinity change to be unfavourable, and subsequent investigation reveals the cause is clearly attributable to natural processes, the final assessment will require expert judgement to determine the reported condition of the feature. Where changes in salinity are attributable to wider geomorphological processes where lagoons are expected to appear and disappear, then this will be considered to be a normal change to the feature and should be reflected in the target. The feature's condition could be declared favourable where the officer is certain that the conservation interest of the feature is not compromised by the failure of this attribute to meet its target condition. Where there is a change outside the expected variation or a loss of the conservation interest

of the site (e.g. due to anthropogenic activities or unrecoverable natural losses) then condition should be considered unfavourable. Staff should refer to the flow diagrams in the introductory text to the marine features for more information on these issues.

Changes may be attributable to the following:

- *Changes in natural freshwater supply (rain or drought).*

  A freshwater supply is not necessary to the maintenance of a saline lagoon, although all will receive direct rainwater. A high rate of freshwater input (such as from groundwater seepage) is undesirable to maintaining a saline environment. If salinity drops below 5ppt then the hyposaline habitat is effectively freshwater and no longer able to support most lagoonal specialist species. Isolated and percolation lagoons are most susceptible to this pressure. Drought conditions lead to an increase in evaporation leading to hypersaline conditions. Once again, lagoons with a limited seawater exchange (isolated and percolation lagoons) are most susceptible. Increases above 50ppt are unlikely to sustain lagoonal species.

Where there are changes in salinity causing a severe loss or shift in community structure, such that the conservation interest is adversely affected, then this should be judged as unfavourable. These changes may be attributable to the following:

- *loss or damage to a sluice or other flow control mechanism*
- *water abstraction or discharge altering the freshwater input*
- *anthropogenic alterations to the isolating barrier,*

2.3.2 Setting a target

In principle, the target should be set at no significant deviation in salinity regime during the monitoring cycle.

When measuring salinity, the following issues should be considered:

- Salinity measurements should be made in the field at various locations within each site, to encompass functional aspects of the system (i.e. across site salinity gradients). The salinity of adjacent sea- or estuary- water must also be monitored. These sampling locations should be visited on subsequent occasions to generate meaningful comparisons between sampling episodes.
- Salinity measurements should be made at different states of the tide and in different seasons, to account for variation in the short term (tidal cycles), medium term (in direct response to rainfall) and in the longer term (in response to seasonal rainfall and periods of drought).
- Information relating to recent/annual weather patterns should be considered when comparing records over time, to help interpret any variations observed.
- Empirical analysis of lagoons and specialist lagoonal species in the UK suggests that average salinity throughout a site would be expected to lie within a range of between 15ppt and 40ppt. Variation outside this range is tolerable in the short term (days rather than weeks) but in many cases sustained levels of <10‰**ppt** and >50‰ **ppt** should trigger remedial management action and therefore a good understanding of local ranges and periodic variability is essential to individual site management.[4]

[4] See Martin *et al.* (2002) – *L. papulosum* can be found at sites with an annual mean salinity between approximately $6gl^{-1}$ to $31gl^{-1}$ BUT only at sites where annual mean Total Phosphorus (TP) does not exceed $103\mu g^{-1}$. Further reproductive performance appeared to be highly affected by responses to salinity regimes with the highest numbers of fertilised oospores being recorded at the site with the GREATEST salinity range over the year. So stable salinity regimes appear to encourage vegetative growth whilst variable regimes appear linked to reproductive performance which could have important consequences for local site management and assessment of favourable condition. Have to be careful in setting targets because may get vegetative growth at the expense of favourable reproductive performance.

- Lagoonal specialist species have optimal salinity ranges and associated critical minima and maxima. Maintenance of the population and associated biotope(s) may require closer observation of the salinity range. For example. The lagoon sand worm *Armandia cirrhosa* prefers salinities in the 25-35ppt range and the starlet sea anemone *Nematostella vectensis* will become moribund outside of the 16-35ppt range. The foxtail stonewort *Lamprothamnium papulosum* prefers an even wider range for stimulating reproductive performance. These ranges need to be considered when setting the target.
- Percolation lagoons have a long-term trend to become freshwater. This is a result of natural siltation preventing percolation of seawater into the system. It may also be a result of the separating barrier building up and preventing overtopping. The target may require revision over time to reflect such changes in the salinity regime if the site is being managed within a wider geomorphological context.
- Silled and sluiced lagoons and lagoonal inlets with an open connection to the marine environment exchange a proportion of lagoon water on most tides. This helps to dispense with peaks of freshwater input, to maintain salinity levels and to reduce the likelihood of extended periods of hyper– or hyposalinity.

An example of how a target for this attribute might be expressed is shown in Box 4

Box 4 A site-specific target for the attribute 'Salinity regime'

Target	Comments
Average seasonal salinity, and seasonal maxima and minima, should not deviate significantly from an established baseline (English Nature 2003) Winter: Av = 18ppt; max = 21ppt; min = 15ppt. Summer: Av = 22ppt; max = 28ppt; min = 17ppt.	Where changes in salinity are attributable to natural processes, then condition should be judged as favourable, and this should be reflected in the target. Salinity range identified for lagoon (English Nature 2003). Changes in salinity would be considered unfavourable if attributable to the following: loss or damage to the sluice, water abstraction or discharge altering the freshwater input; anthropogenic alterations to the isolating barrier.

2.3.3 Suggested techniques

Salinity regime may be assessed directly by measuring the salinity of the water, or indirectly via the presence of any specialist lagoonal species.

Possible methods not as yet detailed in the Marine Monitoring Handbook (Davies *et al.* 2001) for measuring the salinity regime directly within a lagoon are:

- routine monitoring of water chemistry parameters using in-situ data loggers
- recording using conductivity meters
- *in-situ* measurements using a refractometer.

2.4 Biotope composition

Biotope composition of a lagoon is an essential structural component of the feature therefore **must be assessed for all sites**.

2.4.1 Background to the attribute

The biotope composition attribute of saline lagoons should encompass the variety of biological communities present within the feature, and should reflect the conservation interest of the particular site. For England and Wales biotopes have been identified and described after Bamber (1997) and Bamber *et al*. (2000). Biotopes within Scottish lagoons are described by Covey 1999.

The attribute may address a subset of the biotopes identified for the following:

- overall biotope composition where the feature supports a diverse range of communities
- specific biotopes indicative of the character of the site or of conservation interest[5]
- biotopes that may be indicative of the condition of the feature with respect to the level of anthropogenic activity or input (e.g. ENLag.IMS.Ann.Imp indicates an impoverished biotope, stressed by low salinity or anthropogenic interference).

The resolution to which biotopes are expressed in the target will have to be considered with regard to their use in condition assessment. It may be appropriate to use higher level biotopes (e.g. biotope complexes) in preference to more detailed ones that may be difficult to identify in the field. Whilst this attribute aims to indicate the overall variety of communities present, it is likely that a degree of sub-sampling will be essential on all sites.

Where the field assessment judges the biotope composition to be unfavourable, and subsequent investigation reveals the cause is clearly attributable to cyclical natural processes, the final assessment will require expert judgement to determine the reported condition of the feature. The feature's condition could be declared favourable where the officer is certain that the conservation interest of the feature is not compromised by the failure of this attribute to meet its target condition. Where there is a change outside the expected variation or a loss of the conservation interest of the site (e.g. due to anthropogenic activities or unrecoverable natural losses) then condition should be considered unfavourable. Staff should refer to the flow diagrams in the introductory text to the marine features for more information on these issues.

2.4.2 Setting a target

In principle, the target should be set at no change in biotope composition during the monitoring cycle.

A subset of the biotopes should be identified where the feature supports a diverse range of communities, or the overall biotope composition should be determined and the biotopes specified where appropriate.

When setting target values, it is important to consider the following issues:

- An agreed level of biotope discrimination must be clearly established in relation to the most appropriate biotope classification scheme. You may wish to use a higher level in the classification if specific biotopes are difficult to differentiate without detailed sampling.
- A subset of biotopes of importance may be identified and listed, omitting ephemeral biotopes and biotopes considered to be of low conservation importance. You may only wish to choose biotopes considered to be of conservation importance within the site.
- Some biotopes occur in a natural cycle and may disappear and reappear over time. Isolated and percolation lagoons have very little water exchange with the marine environment. This affects the recruitment of species into the lagoon. Silled, sluiced and lagoonal inlets have much more water exchange with the marine environment, allowing greater and more diverse influx of euryhaline species. This may need to be expressed in the target. These cycles are a vital part of the interest of the feature and must be considered when phrasing a target value. Too tightly defined targets could lead to a false judgement of unfavourable condition. There is, however, very little cycling seen in some lagoon biotopes as the habitat is generally stable. SSSI citations, SAC Regulation 33 packages, biotope maps or more detailed survey records should help to determine the biotopes of nature conservation importance within a site, which in turn will determine the target list of biotopes. Due consideration should also be given to activities occurring within sites

An example of how a target might be expressed is shown in Box 5

[5] Examples would be nationally rare or scare biotopes, or biotopes supporting species of conservation value.

Box 5 A site-specific target for the attribute 'Biotope composition'

Target	Comments
Expect to find the following biotopes identified in Bamber *et al.* (1997): **ENLag.Veg** (may cycle with ENLag.Veg.Pot) & **ENLag.Ann** (may cycle with ENLag.Ann.Imp).	Where changes in biotope composition are attributable to natural processes (e.g. winter storm/ flood events, natural changes in supporting processes or mass recruitment or dieback of characterising species) then condition should be judged as favourable. Where there is a change in biotope composition outside the expected variation (cyclical partners identified) or a loss of the conservation interest of the site, then this should be considered as unfavourable. Biotopes identified from Bamber *et al.* (1997)

2.4.3 Suggested techniques

The Marine Monitoring Handbook (Davies *et al.* 2001) contains details of the techniques appropriate for monitoring the condition of designated features.

Possible methods provided in the handbook for measuring the biotope composition of a lagoon are:

- 1-1 Intertidal resource mapping using aerial photographs
- 3-1 *In situ* intertidal biotope recording
- 3-3 *In situ* survey of subtidal (epibiota) biotopes and species using diving techniques (subtidal biotope ID)
- 3-13 *In-situ* surveys of sublittoral epibiota using hand-held video.

Other proposed methods, not as yet detailed in the handbook are:

- aerial photography and photogrammetry (air photo interpretation)
- satellite and airborne multi-spectral remote sensing (remote imaging)
- mapping extent using point samples (using effort-limited biotope identification techniques).

2.5 Extent of sub-feature or representative/notable biotopes

Extent of sub-feature or representative/notable biotopes is considered a site-specific attribute used to highlight local distinctiveness when assessing the overall conservation value of a site and may therefore not be applicable to all sites.

2.5.1 Background to the attribute

This attribute may highlight important structural and functional components of the feature, depending on the biotopes/sub-features chosen. The biotopes chosen should reflect the site-specific interest of the feature. Actual extent may vary on seasonal cycles and the presence or absence of a biotope can change the results quite significantly. It is important to understand cyclical succession of biotopes, and to take this into account when choosing biotopes to reflect this particular attribute.

The advice concerning judgement of the feature condition provided under Extent (*Section 2.1.1 Background to the attribute)* equally applies to this section and should be consulted. Staff should refer to the flow diagrams in the introductory text to the marine features for more information on these issues.

2.5.2 Setting a target

In principle, the target should be set at no loss in extent of the sub-feature or representative/notable biotope during the monitoring cycle. The target needs to identify biotopes that would be expected to

be part of that natural cycle. It may be necessary to set a target that declines each monitoring cycle where there is an established natural loss of extent, or sufficient data available to predict (via a model) a downward trend in extent. Departure from this predicted target then would be a trigger for investigation and the feature may be considered unfavourable.

The following issues should be considered:

- The number of representative/notable biotopes present within the assessed feature.
- The natural 'cyclical partners' for the identified biotopes must be listed with the target.
- Where used, check that all aerial photographs and broad-scale maps have the same upper and lower boundaries, are at the same scale and to the same datum.

An example of how a target for this attribute might be expressed is shown in Box 6

Box 6 A site-specific target for the attribute ' *Extent of sub-feature or representative/notable biotope(s)*'

Target	Comments
No change in extent of *Zostera marina* bed identified in biotope map (English Nature 2003). ENLag.Veg.Zos = 1.8ha. (during periods of dieback may cycle with ENLag.Veg).	Where there is a change in extent outside the expected variation, leading to a loss of the conservation interest of the site, then this should be considered as unfavourable.

2.5.3 Suggested techniques

Extent can be measured in absolute terms, using an index approach such as point sampling over a grid, or by inference. The type of measure used should be linked to the known or likely threats posed by anthropogenic activities and take into account natural variation in extent or in cyclical succession between biotopes.

The Marine Monitoring Handbook (Davies *et al.*, 2001) contains details of the techniques appropriate for monitoring the condition of designated features.

Possible methods provided in the handbook for measuring the extent of sub-feature or representative/notable biotope are:

- 1-1 Intertidal resource mapping using aerial photographs.
- 1-3 Seabed mapping using acoustic ground discrimination interpreted with ground truthing.
- 1-4 The application of side scan sonar for seabed mapping (large lagoons only).
- 3-1 *In situ* intertidal biotope recording (Intertidal biotope ID).

Other proposed methods, not as yet detailed in the handbook are:

- aerial photography and photogrammetry (air photo interpretation)
- satellite and airborne multi-spectral remote sensing (remote imaging)
- point sample mapping

2.6 Extent of water

Extent of water is considered a site-specific attribute used to highlight local distinctiveness when assessing the overall conservation value of a site and may therefore not be applicable to all sites.

2.6.1 Background to the attribute

Critical to both the definition and maintenance of a lagoon, and the community of species it supports, is the retention of most or all of the water mass within the system at low water in the adjacent estuary or sea. The optimal conditions governing extent of water indicate that at least 60% of the water should persist at all times of year at all states of tide (Bamber *et al.* 2001).Concomitant with this is maintenance of a relevant depth of water.

Extent of water in late winter/spring may be taken as the likely extent of the lagoon basin (acting as a baseline value). Extent of water in late summer in lagoons with a shallow basin is likely to be less than the extent of the basin.

The advice concerning judgement of the feature condition provided under Extent (*Section 2.1.1 Background to the attribute)* equally applies to this section and should be consulted. Staff should refer to the flow diagrams in the introductory text to the marine features for more information on these issues.

2.6.2 Setting a target

In principle, the target should be set at no loss in extent of water during the monitoring cycle.

The advice concerning issues to consider when measuring extent provided under Extent (*Section 2.1.2 Setting a target)* equally applies to this section and should be consulted.

An example of how a target for this attribute might be expressed is shown in Box 7

Box 7 A site-specific target for the attribute *Extent of water:*

Target	Comments
Extent of saline lagoon water area not to decrease below 40% of baseline value. Extent identified as 24ha (English Nature 2003). Lagoon water extent not to decrease below 15ha.	Condition would be judged unfavourable if loss in extent of water is due to factors other than cyclical natural processes that are part of a wider coastal geomorphological management regime. See English Nature (2003) for lagoon water area. Compare with aerial photographs. Where natural events (such as severe storm damage causing a barrier breach) cause a loss of extent of water greater than 40% of baseline value, then this would also be considered unfavourable.

2.6.3 Suggested techniques

In most cases the area will be derived by referral to aerial photographs of the site. Broad-scale biotope maps at the Phase 1 scale may also be of benefit, showing distribution and extent of major habitats.

English Natures Saline Lagoon Habitat Inventory (2003) contains contextual information and mappable GIS polygons of all saline lagoons identified in England.

The Marine Monitoring Handbook (Davies *et al.* 2001) contains details of the techniques appropriate for monitoring the condition of designated features.

Proposed methods, not as yet detailed in the handbook are:

- aerial photography and photogrammetry (air photo interpretation)
- satellite and airborne multi-spectral remote sensing (remote imaging)
- direct measurement (for small lagoons only).

2.7 Distribution of biotopes

The *distribution of biotopes* is considered a site-specific attribute used to highlight local distinctiveness when assessing the overall conservation value of a site and may therefore not be applicable to all sites.

2.7.1 Background to the attribute

Assessing the distribution of biotopes throughout the feature should highlight any progressive loss or change in the biological integrity of the feature. This attribute complements an assessment of the biotope composition attribute by ensuring that the distribution of the conservation interest is maintained throughout the feature.

The issues described under *Biotope Composition* in relation to specifying biotopes equally apply to the present attribute. Unlike *Biotope Composition,* this attribute is concerned with the presence or absence of biotopes at specific locations.

It is important to understand that not only do biotopes show cyclical succession but they also often have no clearly defined perimeters in the field. There is a transition from one biotope to its neighbour with this 'boundary' consisting of a mixture of the two adjoining biotopes. It is important for the target to indicate (or make reference to) the likely succession between biotopes and highlight any differences expected in 'transitional' biotopes. Specific discreet biotopes found within the feature will be easier to assess than the-large ranging ones. Beds of the foxtail stonewort *Lamprothamnium papulosum,* for instance, may have a small area of distribution within the basin and are recognisably distinct from other lagoon features, so are suitable candidates for assessment.

Where a field assessment judges the condition of this attribute to be unfavourable and subsequent investigation indicates that the cause is due to natural factors, the final assessment will require expert judgement to determine the reported condition of the feature. The feature's condition could be declared favourable where the officer is certain that the conservation interest of the feature is not compromised by the failure of this attribute to meet its target condition. Where there is a change in biotope distribution outside the expected variation, or a loss of the conservation interest of the site, then condition should be considered unfavourable. Staff should refer to the flow diagrams in the introductory text to the marine features for more information on these issues.

2.7.2 Setting a target

In principle, the target should be set at no change in distribution of the biotopes during the monitoring cycle. The target must, however, consider any expected shift(s) in distribution. It is possible to use either an absolute measure or an index approach to measuring biotope distribution.

Issues to consider when specifying site-specific targets include:

- Biotope distribution may change in response to extreme low frequency events such as storm/flood action.
- Some biotopes will change distribution and/or spatial pattern naturally over time, in a cycle with other biotopes (and the target should identify these if possible).
- The precise location of biotopes will change, particularly in relation to salinity gradients and variable water exchange.

An example of how a target for this attribute might be expressed is shown in Box 8

Box 8 A site-specific target for the attribute ' Distribution of biotopes'

Target	Comments
Tidal rapids should contain SIR.Lsac.T & ENLag.Veg.Zos	Cross-reference of the biotope map to latest aerial photos shows distribution of the two biotopes. They are not expected

Target	Comments
should be found towards SE end of lagoon	to cycle naturally with other biotopes. Where there is a change in biotope distribution outside the expected variation, or a loss of the conservation interest of the site, then this should be considered as unfavourable.

2.7.3 Suggested techniques

It is possible to use either an absolute measure or an index approach to measuring biotope distribution.

The Marine Monitoring Handbook (Davies *et al.* 2001) contains details of the techniques appropriate for monitoring the condition of designated features.

Possible methods provided in the handbook for measuring the distribution of biotopes are:

- 1-1 Intertidal resource mapping using aerial photographs.
- 1-3 Seabed mapping using acoustic ground discrimination interpreted with ground truthing.
- 1-4 The application of side scan sonar for seabed mapping (large lagoons only).
- 3-1 *In situ* intertidal biotope recording (Intertidal biotope ID).

Proposed methods, not as yet detailed in the handbook are:

- aerial photography and photogrammetry (air photo interpretation)
- satellite and airborne multi-spectral remote sensing (remote imaging)
- point sample mapping

2.8 Species composition of representative or notable biotopes

Species composition of representative or notable biotopes is considered a site-specific attribute used to highlight local distinctiveness when assessing the overall conservation value of a site and may therefore not be applicable to all sites.

2.8.1 Background to the attribute

Species composition is an important contributor to the structure of a biotope. A determination of species composition gives an indication of the quality of the biotope, and a change in composition may indicate a cyclic change/trend in communities.

Ideally, any change in species populations should be assessed as an overall measure of community structure of the biotope rather than as a measure of an individual or indicator species. However, an assessment of species composition may be restricted to measure only the characterising species where the overall species composition of that biotope is poorly understood and subject to measurement error. The target should include a list of these characterising species.

Where the field assessment judges the species composition to be unfavourable, and subsequent investigation reveals the cause is clearly attributable to cyclical natural processes such as mass recruitment and dieback of characterising species, the final assessment will require expert judgement to determine the reported condition of the feature. The feature's condition could be declared favourable where the officer is certain that the conservation interest of the feature is not compromised by the failure of this attribute to meet its target condition. Where there is a change in species composition outside the expected variation, or a loss of the conservation interest of the site (e.g. due to anthropogenic activities or unrecoverable natural losses) then condition should be considered unfavourable. Staff should refer to the flow diagrams in the introductory text to the marine features for more information on these issues.

Examples of notable biotopes would be nationally rare or scarce biotopes, biotopes that are indicative of the 'health' of the feature or biotopes that indicate the level of anthropogenic activity or input.

Where infauna are monitored, associated monitoring of the sediment would be sensible where considered critical to the species or biotope concerned.

2.8.2 Setting a target

Species composition can be measured in absolute terms (number of species, density of a species), using an index (evaluating the overall number of species even if exact species compliment changes) or in terms of presence/absence. The type of measure will depend on the context in which the attribute is used.

The following issues should be considered:

- The biotope for which a species composition measure is required must be clearly stated in the attribute table and identifiable in the field.
- Biotopes may be selected for different reasons, for example their overall diversity or because they contain species of conservation importance. The reason for selection will determine what should be measured and hence the way a target is phrased.
- It may be appropriate to select a subset of the species present, avoiding species whose presence is ephemeral or difficult to sample or difficult to identify (a list of important lagoonal specialist species is supplied in Appendix A).
- It may be appropriate to develop a checklist of species for a biotope, for example those species that have important structural and functional contributions to the biotope's continued existence.
- For biotopes that have a high turnover of species, it is more appropriate to use an index measure, although careful consideration must be given to the choice of index. Indices have specific requirements in terms of the type of data used, and its method of collection.
- Species selected could be: nationally rare or scarce; species that have an important functional or structural role in the feature (for lagoonal specialist species – see Appendix A); species indicative of the 'health' of the feature; species indicative of the level of anthropogenic activity (e.g. *Lamprothamnium papulosum* as an indicator of levels of phosphate on a site).
- Species targets could be derived from existing records for that biogeographic region.
- Careful consideration must be given to the use of species that are known to have a high turnover or fluctuation in abundance. It is important to conduct the assessment at the same time of year as previous visits.
- Species recording has significant quality assurance issues in relation to the sampling methodology and particularly the taxonomic competence of the recorders. It may therefore be appropriate to select species that are capable of a relatively simple assessment. If necessary, a pre-assessment visit may help to identify or check the ease of recording. Target condition should be established with regard to these QA issues.

An example of how a target for this attribute might be expressed is shown in Box 9.

Box 9 A site-specific target for the attribute ' Species composition of representative or notable biotopes'

Target	Comments
No decline in quality of ENLag.Veg biotope due to change in species composition or loss of notable species, allowing for natural	Assessment should concentrate on characterising species for targeted biotope. These species can be identified from Bamber (1997) or Bamber (2000), using species with a typical abundance of common or above (using SACFOR abundance scale from MNCR classification). Target should include list

Target	Comments
succession/known cyclical change. Expect to find following characterising species at abundance of common or greater: *Ruppia* spp., *Chaetomorpha linum, Cerastoderma glaucum* (juv), *Hydrobia ulvae, Gammarus insensibilis.*	of characterising species.

2.8.3 Suggested techniques

Species composition is measured by quantitative sampling, which is both expensive and destructive. While a measure of species composition is important to give an indication of feature quality, its use should be balanced against the effect of destructive sampling. It is essential that disturbance to/within fragile lagoonal habitats is kept to a minimum. It may be appropriate to use sampling devices that take a small volume of sediment or reduce the number of samples recorded.

Note: assessing this attribute will require specialist taxonomic expertise.

The Marine Monitoring Handbook (Davies *et al.* 2001) contains details of the techniques appropriate for monitoring the condition of designated features.

Possible methods provided in the handbook for measuring the species composition of lagoonal biotopes are:

- *3-3 In situ* survey of subtidal (epibiota) biotopes and species using diving techniques (Subtidal biotope ID);
- 3-6 Quantitative sampling of intertidal sediment species using cores (Intertidal core sampling);
- 3-7 *In situ* quantitative survey of subtidal epibiota using quadrat sampling techniques (Subtidal quadrat sampling);
- 3-8 Quantitative sampling of sublittoral sediment biotopes and species using diver-operated cores (Subtidal core sampling);
- 3-9 Quantitative sampling of sublittoral sediment biotopes and species using remote-operated grabs (Grab sampling);
- 3-11 Littoral monitoring using fixed quadrat photography (Intertidal quadrat photography);

Proposed methods, not as yet detailed in the handbook are:

- intertidal quadrat sampling
- plankton sampling.

2.9 Species population measures

Population structure of a species or the presence/abundance of specified species are considered site-specific attributes used to highlight local distinctiveness when assessing the overall conservation value of a site and may therefore not be applicable to all sites. Whilst the use of this attribute is unlikely to be appropriate on all sites, a species **must be assessed** where it comprises a '*feature of interest*' (as listed on a citation for a site), or scheduled under the Wildlife and Countryside Act 1981 (e.g. *Lamprothamnium papulosum*

2.9.1 Background to the attribute

The species selected should serve an important role in the structure and function of the biological community (lagoonal specialist species are identified in Appendix A). The method for measurement will vary depending on the species, and how it is contributing to the structure and function of the lagoon. Changes in presence and abundance or population structure of a species (which may eventually lead to a change in abundance of longer-lived species) can critically affect the physical and functional nature of the lagoon, which may be considered as unfavourable.

Population measurements are made to ascertain whether there is continuing recruitment of a species into a population (i.e. to ensure the population is being maintained). Condition may be considered unfavourable if there is a sizeable shift in the age/size class structure (e.g. there may be a loss of mature adults or recruitment failure) which would cause a collapse in the population, leading to loss of the species altogether from the feature. This may only be applicable to a few of the specialist lagoonal species, such as the lagoon cockle *Cerastoderma glaucum*.

Presence or abundance of positive indicator species may also be indicative of the condition of the lagoon. These species may be of nature conservation importance, or particularly fragile or sensitive to disturbance (see list of lagoonal specialist species in appendix A). The condition of this attribute would be considered unfavourable if the species is lost, or there is a significant reduction in abundance.

Increased abundance of negative indicator species may also be indicative of the condition of the lagoon. The condition of the attribute would be considered unfavourable if there is a significant increase in abundance, which is detrimental to the feature as a whole. This part of the attribute can be linked to physical parameters such as salinity, depth and water quality. Certain undesirable species such as reed *Phragmites australis* are indicative of a reduction in salinity within a lagoon. They can also precipitate increased siltation, leading to a reduction in both extent and depth of the lagoon.

2.9.2 Setting a target

Population structure of a species and the presence or abundance of specified species can be measured in absolute terms (numbers of individuals within age classes, density of species), using an index or in terms of presence/absence. The type of measure will depend on the context in which the attribute is used.

The following issues should be considered:

- The species for which the attribute measure is required must be clearly stated in the attribute table and identifiable in the field.
- The reason for selection will determine what should be measured and hence the way a target is phrased. A target of ‘maintain age/size structure’ should be used where one species is long-lived and is providing a structural/functional role within the habitat.
- Representative species should be apparent from the site documentation, the SSSI citation or previous surveys (see Appendix A for list of lagoonal specialist species). Species could be: nationally rare or scarce species; species that have an important functional or structural role in the feature; species indicative of the 'health' of the feature; species indicative of the level of anthropogenic activity; non-native species (where their presence is considered unfavourable).
- Species targets could be derived from existing records for that biogeographic region.
- Careful consideration must be given to the use of species that are known to have a high turnover or fluctuation in abundance. It is important to conduct the assessment at the same time of year as previous visits.
- *In-situ* species recording has significant quality assurance issues in relation to the sampling methodology and particularly the taxonomic competence of the recorders. It may therefore be appropriate to select species that are capable of a relatively simple assessment. If necessary a pre-assessment visit may help to identify or check the ease of recording.

An example of how a target might be expressed is shown in Box 10

Box 10 A site-specific target for the attribute ' Species population measures '

Attribute	Measure	Targets	Comments
Characteristic species	- Population structure of *Cerastoderma glaucum*	Maintain age range of *C. glaucum* within lagoon.	Lagoon cockles are a key structuring component of the benthos and play an important role in the functioning of the lagoon. A range of age classes is an important indicator of cockle recruitment and growth.
Presence or abundance of specified species	Presence/absence or abundance of a specified species identified for the feature.	Maintain presence of *Lamprothamnium papulosum* and *Nematostella vectensis.*	Both lagoonal specialists were recorded from the lagoon and are protected under the Countryside & wildlife Act 1981 in schedule 8 & 5 respectively. They are also listed in the SSSI citation.

2.9.3 Suggested techniques

The Marine Monitoring Handbook (Davies *et al.* 2001) contains details of the techniques appropriate for monitoring the condition of designated features.

Possible methods provided in the handbook for measuring species population measures are:

- 3-3 *In situ* survey of subtidal (epibiota) biotopes and species using diving techniques (subtidal biotope ID)
- 3-7 *In situ* quantitative survey of subtidal epibiota using quadrat sampling techniques (subtidal quadrat sampling)
- 3-8 Quantitative sampling of sublittoral sediment biotopes and species using diver-operated cores (subtidal core sampling)
- 3-9 Quantitative sampling of sublittoral sediment biotopes and species using remote-operated grabs (grab sampling)

2.10 Water Depth

Water depth is considered a site-specific attribute used to highlight local distinctiveness when assessing the overall conservation value of a site and may therefore not be applicable to all sites.

2.10.1 Background to the attribute

Lagoons are depositional environments where fine sediments arriving in freshwater and marine inputs tend to accumulate and there is relatively little that can be done to control the composition of the substratum or rate of deposition of material.

The majority of UK lagoons are shallow, typically with a large proportion less than 2m. The one notable exception is Loch Obisary, which is 45m deep: it is also the only lagoon in Britain which is permanently stratified, with a more saline layer of water lying under a surface brackish layer.

Optimum depth is a balance between being sufficiently shallow to enable light penetration and therefore allow photosynthesis, and sufficiently deep to submerge vegetation and thereby affect oxygenation, food resource, habitat diversity and colonisation by lagoonal fauna. Depth determines

temporal duration of stratification and buffering against environmental change, particularly dehydration. To support specialist, marine, lagoonal species it is suggested that lagoons should be up to one metre deep (Bamber *et al.* 2001), but with the majority of lagoonal area less than this in small lagoons and the marginal areas of larger lagoons such as those found in Scotland. However, shallow margins may allow undesirable encroachment of reed *Phragmites australis* and/or sea club-rush *Bolboschoenus maritimus*. Areas of deeper water within lagoons will be buffered better against impacts such as dehydration, pollution or physical disturbance, and may offer refuges for some of the lagoonal species. Thus areas within a lagoon of a metre or more in depth may be advantageous.

Where changes in water depth are attributable to natural processes (sedimentation) then this should be reflected in the target. Where the field assessment judges the change to be unfavourable and subsequent investigation indicates the cause is due to natural factors, the final assessment will require expert judgement to determine the reported condition of the feature. The feature's condition could be declared favourable where the officer is certain that the conservation interest of the feature is not compromised by the failure of this attribute to meet its target condition. Where there is a change in water depth outside the expected variation or a loss of the conservation interest of the site (e.g. due to anthropogenic activities such as infilling, land claim/development, increased run-off/sedimentation arising from adjacent developments, or unrecoverable natural losses) then condition should be considered unfavourable. An exception to this will be where management allows the deliberate reduction in water depth to facilitate optimal conditions for lagoonal specialist species (e.g. at Cliffe Marsh lagoons, where dredge fines are being pumped into the lagoons in an environmentally sensitive mannerand the reduction in water depth will allow the lagoons to become more favourable for lagoonal specialist species).

Elsewhere, in created and actively managed site lagoons, where the conservation interest requires shallow water depth, natural processes leading to loss of water depth may cause the site to become unfavourable.

Staff should refer to the flow diagrams in the introductory text to the marine features for more information on these issues.

2.10.2 Setting a target

Average water depth should not deviate significantly from an established baseline, subject to natural change. Where it is appropriate to measure water depth to ensure maintenance of critical habitats (i.e. to guide/prompt management action where site integrity is threatened) then measurements should be undertaken at a series of locations throughout the site using simple, repeatable methods.

An example of how a target might be expressed is shown in Box 11

Box 1 A site-specific target for the attribute ' Water Depth'

Target	Comments
Margin depth: Summer = 0.2 – 0.7m Winter = 0.5 – 1m OS grid.: ST456789: Summer = 1.0 – 1.4m Winter = 1.2 – 1.8m	Depth ranges ascertained from EN Saline Lagoon Habitat Inventory Project (2003). Measurements recorded in January & August.

2.10.3 Suggested techniques

Proposed methods, not as yet detailed in the Marine Monitoring Handbook (Davies *et al.* 2001) are:

- bathymetric survey
- stick/gauge measurements.

Care should be taken when wading at the lagoon margin not to trample species or suspend sediments unnecessarily.

3 Other Environmental and physical parameters

Although condition assessment will look at attributes within the condition tables, in some cases the results may be difficult to interpret without some additional evidence in the form of data on environmental and physical parameters. Environmental and physical parameters are considered site-specific and should only be used as supporting information to highlight local distinctiveness when assessing the overall conservation value of a site, and should only be included where they are considered to be fundamental to the condition of the feature. For example an attribute reflecting nutrient enrichment may be considered where eutrophication may result in a loss of the feature.

It should be emphasised that if an attribute for an environmental or physical parameter is selected as part of the definition of favourable condition for the feature, it must be considered during the assessment process. It is therefore essential that a realistic target can be established, taking account of known inherent variation, and that a reliable method of measurement is available, since a failure to meet the target condition will render the condition of the feature unfavourable.

The following parameters, from which site-specific attributes may be derived, are known to influence the status of lagoons and/or their associated communities. This is not an exhaustive list and additional parameters may be appropriate, taking into consideration the comments in the preceding paragraph on the need for a strong justification for an attribute's use in condition assessment.

Percolation and isolated lagoons are potentially most likely to be sensitive to water quality changes because of their limited water exchange. Sluiced and silled lagoons will be less sensitive, but still have a restricted water exchange when compared with lagoonal inlets. Larger, deeper lagoons are better able to buffer the effects of water quality issues than small shallow ones. However it is important to understand that if an impact does occur then it is more difficult to reverse that change or restore conditions on larger rather than smaller sites. It will be necessary to relate any local measurements of physical parameters to contextual information for a wider geographical area when interpreting the data. Local changes may reflect a regional trend rather than any site-based anthropogenic activity.

3.1 Nutrient enrichment

Saline lagoons can be naturally rich in nutrients. This is due to their restricted water exchange and concomitant reduced flushing of dissolved or suspended materials. As such lagoons are sensitive to any further nutrient enrichment (Johnston & Gilliland, 2000) and relatively low additional inputs of nutrients could cause symptoms of eutrophication. Sources of such inputs could include freshwater and seawater inflows, groundwater, runoff from adjacent land, airborne particles and other anthropogenic sources. Where the inputs are from natural sources then the final assessment will require expert judgement to determine the reported condition of the feature. The feature's condition could be declared favourable where the officer is certain that the conservation interest of the feature is not compromised by the failure of this attribute to meet its target condition. But where the enrichment occurs as a result of anthropogenic causes the condition should be judged as unfavourable. Care has to be taken because the source of input can be associated with anthropogenic activities remote from the site of the lagoon (e.g. effluent discharge into a nearby river may impact the lagoon if overtopping of the barrier occurs). Further investigation into contextual information and a review of consented activities in the water catchment's area may be necessary. It is important to understand that enrichment by one nutrient may lead to a limitation by another nutrient (e.g. a shift to phosphorous limitation may follow nitrogen enrichment). This in turn may lead to light availability becoming the limiting factor for macroalgae and charophytes. Recovery from eutrophication may take a long time. A self-perpetuating cycle of nutrient cycling by plants in the system may occur. The algae and charophytes

utilise the nutrients during the growing season then release them back into the lagoon when the winter dieback occurs, where they remain until the following spring (Bamber *et al.* 2001).

Nutrient enrichment can manifest itself in a number of ways (Johnston & Gilliland 2000) including:

- Increased growth of epiphytic algae associated with eelgrasses, charopytes, tassleweeds and macroalgae. This contributes to increased competition for available light.
- Increased growth of blanketing or floating algae (e.g. *Cladophora* spp.) and associated light competition.
- Increased growth of ephemeral benthic algae and associated light and space competition.
- Increased phytoplankton standing crop with impacts upon light attenuation and turbidity of the lagoon. Harmful blooms, and toxins from blue-greens, may also impact upon lagoonal fauna.
- Reduction in available oxygen content of the water linked to phytoplankton blooms or decay of algae.

3.2 Turbidity

An increase in turbidity of the water column can impact upon saline lagoon communities in two ways:

- Increased light attenuation directly affecting photosynthesis by eelgrasses, charophytes, tassleweeds and macroalgae.
- Smothering and/or inhibition of feeding processes of fragile lagoonal specialists by suspended inorganic matter as it settles out of the water column.

Turbidity may be caused by phytoplankton blooms (biotic growth) in the water column, or by suspended particles (Johnston & Gilliland 2000). The aspect ratio of a lagoon and its exposure to prevailing wind will also affect the turbidity of the water column. Long narrow lagoons (high aspect ratio) with prevailing wind conditions in parallel to the linearity of the basin may be subject to wave activity. This wave action can re-suspend particles, or prevent their settlement, leading to increased turbidity.

Scottish lagoons and obs may have water colour affected by peat and this will influence light penetration and thus the photosynthesis of plants and algae. Although the vegetation will be adapted to these conditions, a change due to increased peat erosion may have an adverse affect.

Although an increase in turbidity can be caused by natural processes (e.g. sediment carried into system by overtopping of barrier in winter storms) these can be exacerbated by anthropogenic inputs (e.g. septic tank discharge into Harbour Farm Lagoon, Isle of Wight). Where it is clear that the turbidity increase is due to natural causes then the final assessment will require expert judgement to determine the reported condition of the feature. The feature's condition could be declared favourable where the officer is certain that the conservation interest of the feature is not compromised by the failure of this attribute to meet its target condition. But if there are links to an anthropogenic source then the condition should be recorded as unfavourable. As with nutrient enrichment, the use of contextual information and a review of consented activities in the water catchment area may be necessary.

3.3 Toxic contamination

Johnston and Gilliland (2000) state "no examples were found of saline lagoons being affected by toxic contamination". However, because of the restricted water exchange of such systems they are very susceptible to such inputs. This sensitivity is increased when the proximity of many saline lagoons (especially in England) to urban and industrial development is considered. Any toxic contamination should lead to condition being recorded as unfavourable. The characteristics of lagoons mean that once impacted by inputs of contaminants, they may be slow to clear them or to recover from associated impacts.

The following toxic contaminants may be of concern:

- Heavy metals and organic substances, which can affect the growth of eelgrass *Zostera* spp.
- Synthetics such as herbicides and pesticides, which can inhibit the growth of and cause a loss of eelgrass and charophytes.
- Hydrocarbon (oil) pollution and any associated dispersant, which can impact upon fauna.

It would be appropriate to use this site-specific attribute in areas where known sources of toxic contaminants are identified in close proximity to the saline lagoon. Such areas could include: neighbouring industrial developments, harbours, power stations, farms and associated farmland runoff.

3.4 Organic enrichment

Organic enrichment is likely to be of little concern, as saline lagoons are naturally high in organic material. Further investigation is required (Johnston & Gilliland 2000).

4 Recommended visiting period and frequency of visits

4.1 Seasonal effects

Most lagoonal submerged plant species show marked seasonal cycles of growth and/or die back. For example, populations of the lagoonal specialist charophyte *Lamprothamnium papulosum* die back in the winter and should thus be monitored in the summer. Seagrasses (*Zostera* spp. and *Ruppia* spp.) have similar seasonal patterns in their population density. Seasonal changes in vegetation must be considered when undertaking any remote sensing investigation because a change in 'colour' of the water or land surface will significantly affect any temporal comparison between images (Pooley & Bamber 2000). Most invertebrate species are present throughout the year, although some species have an annual life cycle and will show seasonal patterns in abundance. Bamber *et al*. (in prep.) concluded that "unsynchronised annual monitoring (i.e. not at the same time each year) is likely to give results of little value where seasonal patterns do exist." In general, monitoring studies should be undertaken in late summer and late winter/early spring to identify and coincide with seasonal low and high salinity/water levels.

Seasonal changes in rainfall may affect the salinity regime, water depth and extent of a lagoon. Such changes will be directly related to the dimensions of the lagoon. Lagoons with a large water volume are more able to buffer seasonal variations. Seasonal changes in the rate of inundation may affect the rate of sediment deposition or re-suspension, with a consequent change in turbidity that may influence the lagoon vegetation.

4.2 Time of assessment

It is important to consider seasonal patterns when planning timing of a condition assessment. Sampling should always be undertaken at the same time of year if seasonal variation is likely to affect an attribute. It is important to synchronise timings with previous data collected at the site.

To determine salinity conditions (and other key physical and chemical attributes such as water levels) it is important to measure salinity at times of highest and lowest salinity, normally late summer and mid-winter/early spring respectively. Thus as a generalisation, appropriate times for the UK would be January-March and August each year. This should be regarded as a minimum. It would be preferable to monitor monthly, as it only takes 2-3 weeks of adverse conditions to have a significant impact on the community. In addition there should be response monitoring to particular events such as inundation (sea-wall breaches), rainstorms or drought. Monitoring the biota should also, ideally, be on an annual basis. The timing and frequency will partly depend on whether particular species are being investigated, when the timing of previous surveys needs to be taken into account to enable sound comparisons to be made. Otherwise, it is convenient to sample at the same time as other attributes, particularly in August (Bamber *et al.*, 2001).

4.3 Meteorological changes

Salinity is a key factor determining the biological composition and its associated spatial organisation. A lagoon, by definition, has a limited exchange with the open sea, where the restriction is often linked to tidal cycles. Tidal inundation may vary with ambient conditions (air pressure has an inverse effect on tidal height), storm action and the stage of the monthly or annual tidal cycle. Rainfall will also influence the salinity in a lagoon, particularly those lagoons with very restricted links to the open sea.

Weather cycles can result in changes in the biotic assemblages. Wind may push algal communities or floating vegetation over sediment, particularly after a seasonal dieback. A large bank of detached vegetation was blown onto the shore of the Fleet lagoon by strong winds during November 1999. This vegetation obscured the underlying habitat and affected the classification of remote sensing images. Prolonged wind exposure can change the turbidity at exposed sites. This can lead to an increase in light attenuation and smothering or inhibition of lagoonal invertebrates. Highly turbid water also inhibits the growth of eelgrasses *(Zostera marina*) and tassel weeds (*Ruppia* spp.) by reducing the amount of light available for photosynthesis. Phytoplankton blooms, resulting from nutrient enrichment, can increase turbidity and have been shown to reduce the biomass production and the depths to which *Zostera marina* can grow (Johnson & Gilliland, 2000).

5 Additional information

5.2 Planning a sampling programme

The whole feature must be considered when planning a sampling programme. Clearly, this poses considerable logistical problems when dealing with very extensive sites. The scale of larger lagoons, such as many sites in Scotland and the Fleet, Dorset, poses particular challenges for monitoring. Many lagoons can be treated as a collection of sub-habitats which may therefore be studied separately, whereas extensive areas of uniform habitat will need to be ‘sub-sampled’ by transects or by stratified random sampling. The greatest difficulty is posed by mosaic habitats, where site-specific protocols will need to be devised. In larger lagoons remote sensing techniques may facilitate monitoring of the extent and other attributes of certain biotopes.

Land surrounding a lagoon will often be under private ownership and therefore it will be necessary to seek the landowner's permission to gain access to the water. Where boat access is required, it may be necessary to seek permission to use a private pier or jetty.

Access for monitoring a lagoon will depend on the size and depth of the lagoon and its substrata. Small, shallow lagoons may be sampled from the edge or by wading carefully. Large, shallow lagoons may be snorkelled while large, deeper lagoons may require boat access. Nevertheless, the substrata will have an overriding influence on the mode of access. In Loch Maddy cSAC, the mud in the lagoons is so soft and flocculent that even snorkelling would cause undesirable disturbance to the habitat, and direct sampling was not feasible (Howson & Davison, 1999). In the extensive Fleet lagoon, Dorset, a prohibition order on motorised vessels made biological sampling difficult and arduous, and restricted the options available when planning a survey strategy.

In all cases, field staff must take account of the need for minimal disturbance to this fragile habitat.

DGPS should be used for recording position[6]. Marking sampling stations within a lagoon is more difficult and must take full account of the fragile nature of the habitat. For small sites, permanent marking of stations in sediment is unlikely to be necessary; larger sites should be considered case-by-case. For smaller lagoons, the location and refinding of sampling stations could use transits/bearings from landmarks and drawings/sketches of specific local features. Whilst landmarks may often be

[6] See the Marine Monitoring Handbook Procedural guideline N^{o} 6-1.

extremely valuable when relocating stations, it is important not to rely to closely on the location of features within lagoons as they are liable to change.

5.3 Health and safety

All fieldwork must follow approved codes of practice to ensure the health and safety of all staff. Risks specific to working in lagoons are detailed in the Marine Monitoring Handbook (Davies *et al.* 2001) the NMMP's Green Book[7] and references therein.

Subtidal sampling in lagoons may involve snorkelling and SCUBA diving techniques. All diving operations are subject to the procedures described in the Diving at Work Regulations 1997[8] (see: **http://www.hse.gov.uk/spd/spddivex.htm**) and must follow the Scientific and Archaeological Approved Code of Practice[9] (**http://www.hse.gov.uk/spd/spdacop.htm - a**).

[7] See **http://www.marlab.ac.uk/NMPR/NMP.htm** for information on the NMMP and **http://www.marlab.ac.uk/greenbook/GREEN.htm** for the Green Book.

[8] The Diving at Work Regulations 1997 SI 1997/2776. The Stationery Office 1997, ISBN 0 11 065170 7.

[9] Scientific and Archaeological diving projects: The Diving at Work Regulations 1997. Approved Code of Practice and Guidance – L107. HSE Books 1998, ISBN 0 7176 1498 0.

6 Generic attributes table

The following table lists the generic attributes that should be used to define the condition of lagoon features. The required frequency of monitoring will largely depend on the sensitivity of the type of lagoon and/or the species present, the importance of the site, which attributes are being measured and the site-specific factors (e.g. is it exposed to a factor to which it is sensitive).

For details of assessment techniques see Section 2 and Davies *et al*. 2001.

Table 1. UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Lagoons

Equivalent Phase 1 category: G1.6 Standing water - brackish

Includes the following NVC types: Various SM and S types

Includes the Habitats Directive Annex I habitat types: Coastal Lagoons

Reporting category: Inshore sublittoral sediment

NOTE: The attributes apply to all sites with lagoon features except those with asterisks which may not be applicable to all sites, and should be selected only where they reflect the conservation interest of the individual site.

It is essential that the section in the marine introductory text entitled *Setting objectives and judging favourable condition* is read in conjunction with this table when selecting the attributes to judge the condition of the feature.

Attribute	Target	Method of assessment	Comments
Extent of basin	No reduction in extent of saline lagoon area	Extent should be assessed periodically against a baseline map/aerial image or through the review of any known activities that may have caused an alteration in extent. In most cases the area will be derived by referral to aerial photographs of the site. Broadscale biotope maps at the Phase 1 scale may also be of benefit, showing distribution and extent of major habitats. For details of assessment techniques see Section 2 and Davies *et al*., 2001.	In many cases[10] where changes in extent are clearly attributable to natural processes, then the target value should accommodate this variability. A declining value may be established where sufficient information is available to predict a trend. Where the field assessment judges the extent to be unfavourable, and subsequent investigation reveals that the cause is clearly attributable to natural processes, the final assessment will require expert judgement to determine the reported condition of the feature. The feature's condition could be declared favourable where the officer is certain that the conservation interest of the feature is not compromised by the failure of this attribute to meet its target condition. Where there is a change outside the expected variation or a loss of the conservation interest of the site, (e.g. due to anthropogenic activities or unrecoverable natural losses) then condition should be considered unfavourable. Such natural changes may be attributable to infilling or coastal erosion processes and might be observed in isolated or percolation lagoons which are often transient features. For created and actively managed lagoons, natural processes leading to loss of extent may cause the site to

[10] Applicable when lagoons are being managed within a wider coastal geomorphological context and are therefore expected to appear in some areas as they disappear elsewhere.

Attribute	Target	Method of assessment	Comments
			become unfavourable and management action can be taken. In all cases, changes in extent would be considered unfavourable if attributable to the following: loss or damage to a sluice or other flow control mechanism; anthropogenic alterations to the separating barrier; infilling, land claim or other developments.
Isolating barrier – presence and nature	No change in measure(s) from established baseline. In many cases the horizontal level of the inlet bed should be a little below high water neaps. However the level of the inlet in naturally occurring lagoonal systems will be highly site specific.	For details of assessment techniques see Section 2 and Davies *et al*., 2001.	The key factor determining input and output of seawater is the height of the bottom of the inlet bed relative to ambient low water levels. Retention of the majority of the lagoonal water at low tide depends on this[10]. Where changes in the isolating barrier are attributable to natural processes (e.g. infilling or coastal erosion) also when restorative measures are not viable, the final assessment will require expert judgement to determine the reported condition of the feature. The feature's condition could be declared favourable where the officer is certain that the conservation interest of the feature is not compromised by the failure of this attribute to meet its target condition. Where there is a change outside the expected variation or a loss of the conservation interest of the site, (e.g. due to anthropogenic activities or unrecoverable natural losses) then condition should be considered unfavourable. Changes in presence, nature and integrity of the isolating barrier would be considered unfavourable if attributable to loss or damage of a sluice or other flow control mechanism or due

Attribute	Target	Method of assessment	Comments
			to alterations in structure arising from anthropogenic activities.
Salinity regime	Average seasonal salinity, and seasonal maxima and minima, should not deviate significantly from an established baseline. In cases where reliable baseline data are unavailable the presence and abundance of lagoonal species/biotopes may act as a proxy measure of salinity. Changes in the biota that indicate sustained change in the salinity regime should act as a trigger for more intensive salinity surveillance surveys. Average salinity throughout a site would be expected to lie within a range of between 15ppt and 40ppt. Sustained levels of <10ppt and >50ppt should trigger management action in many cases, but a good understanding of local ranges and periodic variability's is essential to individual site management.[11]	Seasonal averages (ppt) to be assessed periodically (preferably in late winter/early spring and later summer to determine seasonal lows and highs). Depending on the size and shape of the lagoon, it may be necessary to measure along a salinity gradient. In complex lagoonal systems salinity gradients may occur on more than one horizontal axis and may also include vertical stratification. For details of assessment techniques see Section 2 and Davies *et al.*, 2001.	Where the field assessment judges the salinity change to be unfavourable, and subsequent investigation reveals the cause is clearly attributable to natural processes, the final assessment will require expert judgement to determine the reported condition of the feature. Where changes in salinity are attributable to wider geomorphological processes, where lagoons are expected to appear and disappear, then this will be considered to be a normal change to the feature and should be reflected in the target. The feature's condition could be declared favourable where the officer is certain that the conservation interest of the feature is not compromised by the failure of this attribute to meet its target condition. Where there is a change outside the expected variation or a loss of the conservation interest of the site (e.g. due to anthropogenic activities or unrecoverable natural losses) then condition should be considered unfavourable. Isolated or percolation lagoons are most likely to be degraded this way. Changes in salinity would be considered unfavourable if attributable

Attribute	Target	Method of assessment	Comments
			to the following: loss or damage to a sluice or other flow control mechanism; water abstraction or discharge altering the freshwater input; anthropogenic alterations to the isolating barrier.
Biotope composition of lagoon	Maintain the variety of biotopes identified for the site, allowing for succession/ known cyclical change.	Repeated assessment of overall biotope composition or a subset of biotopes identified for the site. For details of assessment techniques see Section 2 and Davies *et al.*, 2001.	Where the field assessment judges the biotope composition to be unfavourable, and subsequent investigation reveals the cause is clearly attributable to cyclical natural processes, the final assessment will require expert judgement to determine the reported condition of the feature. The feature's condition could be declared favourable where the officer is certain that the conservation interest of the feature is not compromised by the failure of this attribute to meet its target condition. Where there is a change outside the expected variation or a loss of the conservation interest of the site, (e.g. due to anthropogenic activities or unrecoverable natural losses) then condition should be considered unfavourable.
*Extent of sub-feature or representative/ notable biotopes	No change in extent of the biotope(s) identified for the site, allowing for succession/known cyclical change.	Assessment of the extent of (a) biotope(s) identified for the site because of their nature conservation importance. For details of assessment techniques see Section 2 and Davies *et al.*, 2001.	The advice concerning judgement of the feature condition provided under Extent (*Section 2.1.1 Background to the attribute)* equally applies to this section and should be consulted.
*Extent of water	At least 60% of the water of the lagoon persisting at all times of year and states of tide.	Area of water occupying the basin should be assessed periodically, at the same time of year (preferably in late winter /early spring and late summer).	In most cases the area recorded in past surveys is extent of water. Extent of water in late winter/spring may be taken as the likely extent

Attribute	Target	Method of assessment	Comments
		This may be assessed by direct measurement of the position of the waterline by dGPS or in relation to fixed surface features. For details of assessment techniques see Section 2 and Davies *et al.*, 2001.	of the lagoon basin. Extent of water in late summer in lagoons with a shallow basin is likely to be less than the extent of the basin.
*Distribution of biotopes	Maintain the distribution of biotopes, allowing for succession/known cyclical change.	Assessment of the distribution of (a) biotope(s) identified for the site. For details of assessment techniques see Section 2 and Davies *et al.*, 2001.	Where a field assessment judges the condition of this attribute to be unfavourable and subsequent investigation indicates the cause is due to natural factors, the final assessment will require expert judgement to determine the reported condition of the feature. The feature's condition could be declared favourable where the officer is certain that the conservation interest of the feature is not compromised by the failure of this attribute to meet its target condition. Where there is a change in biotope distribution outside the expected variation or a loss of the conservation interest of the site, then condition should be considered unfavourable.
* Species composition of representative or notable biotopes	No decline in biotope quality due to changes in species composition or loss of notable species, allowing for natural succession/known cyclical change.	Assessment of biotope quality through assessing species composition where the biotope is representative of the site or contains a number of species of conservation importance. Assessing this attribute will require specialist taxonomic expertise.	Where the field assessment judges the species composition to be unfavourable, and subsequent investigation reveals the cause is clearly attributable to cyclical natural processes such as mass recruitment and dieback of characterising species, the final assessment will require expert judgement to determine the reported condition of the feature. The feature's condition could be declared favourable where the officer is certain that the conservation interest of the feature is not compromised by the failure of this attribute to meet its target condition. Where there is a

Attribute	Target	Method of assessment	Comments
			change in species composition outside the expected variation or a loss of the conservation interest of the site (e.g. due to anthropogenic activities or unrecoverable natural losses) then condition should be considered unfavourable.
*Species population measures - Population structure of a species	Maintain age/size class structure of a (named) species.	Population structure should be assessed in terms of viability of the named species identified for the feature. For details of assessment techniques see Section 2 and Davies *et al*., 2001	Where there is a sizeable shift in the age/size class structure (i.e. loss of mature adults or recruitment failure) or if disturbance causes a species of nature conservation importance to be lost, or if there is a significant reduction in abundance, then condition would be considered unfavourable.
- Presence or abundance of specified species	Maintain presence and/or abundance of the specified species. Absence of the specified species (such as an undesirable non-native species)	Assessment of the presence/absence or abundance of a specified species identified for the feature. For details of assessment techniques see Section 2 and Davies *et al*., 2001	Species selected should reflect the specific biological characteristics of the lagoon. Species should be used from the list of lagoonal specialists (Appendix A) The advice concerning judgement of the feature condition provided under *species composition* equally applies to this section and should be consulted.
*Water Depth	Average water depth should not deviate significantly from an established baseline, subject to natural change.	Average water depth within the lagoon basin (metres) at low tide, assessed at the same time of year each time (preferably in late winter/early spring and late summer).	In many cases[12] where changes in depth are attributable to natural processes (sedimentation) then the target should reflect this variation. Where the field assessment judges the change to be unfavourable and subsequent investigation

[12] Applicable when lagoons are being managed within a wider coastal geomorphological context and are therefore expected to appear in some areas as they disappear elsewhere.

Attribute	Target	Method of assessment	Comments
		Possible methods for measuring water depth are: • bathymetric survey or • stick/gauge measurements.	indicates the cause is due to natural factors, the final assessment will require expert judgement to determine the reported condition of the feature. The feature's condition could be declared favourable where the officer is certain that the conservation interest of the feature is not compromised by the failure of this attribute to meet its target condition. Where there is a change outside the expected variation or a loss of the conservation interest of the site (e.g. due to anthropogenic activities or unrecoverable natural losses) then condition should be considered unfavourable. Elsewhere, in created and actively managed lagoons, natural processes leading to loss of water depth may cause the site to become unfavourable. In all cases condition would be considered unfavourable if changes in depth are attributable to anthropogenic activities (e.g. infilling, land claim/development or increased run-off/ sedimentation arising from adjacent developments).

7 Appendix A: Specialist (within the UK) lagoonal plant and animal species

Table 1: Species distinctly more characteristic of lagoons and lagoon-like habitats than of other habitats

Plants	
Lamprothamnium papulosum	Foxtail stonewort
Tolypella nidifica	Bird's nest stonewort
Ruppia maritima	Beaked tasselweed
Ruppia cirrosa	Spiral tasselweed
?Chaetomorpha linum?[13]	
Cnidaria	
Clavopsella navis	a hydroid (sea-fir)
Edwardsia ivelli	Ivell's sea anemone
Nematostella vectensis	Starlet sea anemone
Bryozoa	
Conopeum seurati	Lagoon sea mat
Victorella pavida	Trembling sea mat
Annelida	
Armandia cirrhosa	Lagoon sandworm
Mollusca	
Hydrobia ventrosa	Lagoon mud snail
Hydrobia acuta	'Southern' lagoon mud snail
Onoba aculeus	a rissoid snail
Haminoea navicula	a sea slug
Cerastoderma glaucum	Lagoon cockle
Caecum armoricum	De Folin's snail
Crustacea	
Cyprideis torosa	an ostracod
Idotea chelipes	Lagoon slater
Lekanosphaera hookeri	an isopod (slater)
Gammarus insensibilis	Lagoon sand shrimp
Gammarus chevreuxi	a sand shrimp

[13] The species itself is not restricted to saline lagoons and occurs widely around the coast. However, a distinct form is found in sheltered water bodies such as saline lagoons and it is this which might be considered a lagoonal specialist. Clarification of the taxonomic status of *C. linum* is required to confirm its listing here.

Corophium insidiosum	an amphipod (Corophium shrimp)
Insecta	
Geranomyia bezzia	a cranefly
Glyptotendipes barbipes	a chironomid midge
Aves	
Recurvirostra avocetta	Avocet

Table 2: those species in addition to table 1 whose UK population would be unsustainable without the presence of saline lagoons, ie >30% of current sites are lagoonal

Plants	
Chara baltica	Baltic stonewort
Chara canescens	Bearded stonewort
Annelida	
Alkmaria romijni	Tentacled lagoon worm
Ficopomatus enigmaticus	a serpulid worm
Mollusca	
Tenellia adspersa	Lagoon sea slug
Insecta[14]	
Paracymus aeneus	Bembridge water beetle
Agabus conspersus	a diving beetle
Berosus fulvus	a hydrophilid water beetle
Atylotus latistriatus	a horse fly
Stratiomys longicornis	a soldier fly
Aves	
Platalea leucorodia	Spoonbill

[14] See text (2.5.2) qualifying basis on which species other than *Paracymus aeneus* are included

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