JOINT NATURE CONSERVATION COMMITTEE

Marine Monitoring Handbook
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Large shallow inlets and bays

Definition

Large indentations of the coast where, in contrast to estuaries, the influence of freshwater is generally limited. These shallow indentations are generally sheltered from wave action and contain a great diversity of sediments and substrates with a well developed zonation of benthic communities. These communities generally have a high biodiversity. The limit of shallow water is sometimes defined by the distribution of the *Zosteretea* and *Potametea* associations.

Several physiographic types may be included under this category provided the water is shallow over a major part of the area: embayments, fjards, rias and voes.

Introduction to the feature's interest

Large shallow inlets and bays are large indentations of the coast, generally more sheltered from wave action than the open coast. They are relatively shallow, usually averaging less than 30m in depth across at least 75% of the site. They are often complex systems composed of an interdependent mosaic of subtidal and intertidal habitats. Several of these habitats form Annex I features in their own right. The physiographical character of Large shallow inlets and bays is similar to that of the Annex I feature Estuaries, but the influence of freshwater is reduced by comparison.

In the UK, three main physiographic types can be identified that meet the EC definition:

Open coast bay and embayment: a type of marine inlet typically where the line of the coast follows a concave sweep between rocky headlands, sometimes with only a narrow entrance to the embayment.

Fjardic sealoch: a series of shallow basins connected to the sea via shallow and often intertidal sills. Fjards are found in areas of low-lying ground, which have been subject to glacial roughening. They have a highly irregular outline, no main channel and lack the high relief and U-shaped cross-section of fjordic sealochs.

Ria: a drowned valley in an area of high relief; most have resulted from the post-glacial rise in relative sea level. This sub-type is known in Scotland as a Voe, where it is restricted to the Shetland Islands. (The type is distinguished from the Ria estuaries described in the Section Esturies by their relative lack of freshwater inflow and near full salinity conditions.)

This is a very variable habitat type. The different sub-types vary in their distribution and extent. While some are widespread in Europe, others are found mainly in the UK. The habitat type is widespread in the UK, but some sub-types are localised in their distribution. Sites have been chosen to represent the range of physiographic types, the geographical range and the ecological variation of this habitat type. Selection favoured larger sites, which tend to encompass the greatest variety of habitats.

There are only a few large embayments around the coast of the UK. Rias occur only in southern Wales and south-west England, while voes (which are similar in physical character to rias) occur only in Shetland and fjards occur in western Scotland and Northern Ireland. Rias are particularly well represented in the UK compared with other parts of northern Europe.

Large shallow inlets and bays vary widely in habitat and species diversity according to their geographic location, size, shape, form and geology, depending on whether they occur on hard (rocky) or soft (sedimentary) coasts. The degree of exposure is a critical factor in determining habitat and species diversity. This affects communities on the shore and in the sublittoral zone. The range of plants and animals associated with this habitat type is therefore very wide. Intertidal communities may be dominated by *Fucus* species, particularly in more sheltered locations. Extensive beds of mussels *Mytilus edulis* may be present on mixed substrata. Sediment shores may vary widely, depending on the degree of exposure. Very exposed conditions may result in shingle beaches, while less exposed shores may consist of clean sand. In sheltered conditions shores may consist of fine sand and mud. Very exposed sediment shores are unable to support animal populations. On less exposed shores, communities of crustaceans and polychaetes develop, while shores of fine sand and mud are characterised by polychaete and bivalve communities and beds of eelgrass *Zostera* spp. In the sheltered conditions of Scottish fjards, loose-lying mats of green algae and the unattached form *mackaii* of the wrack *Ascophyllum nodosum* may occur.

In the sublittoral zone, more exposed rocky coasts support forests of the kelp *Laminaria hyperborea,* with forests of sugar kelp *Laminaria saccharina* occurring in more sheltered conditions. Communities of ephemeral algae and maerl (including *Phymatolithon calcareum* and *Lithothamnion corallioides*) may be present on exposed or current-swept coasts, whilst sheltered shallow sediments may be covered by communities of filamentous red and brown algae, by loose-lying mats of algae or by beds of eelgrass *Zostera marina*.

Animal-dominated rocky communities in the sublittoral zone also vary according to local conditions of wave exposure and tidal streams. In more wave-exposed coasts, soft corals, anemones, sponges, seafans, feather stars and hydroids may be dominant, whilst more sheltered coasts support different species of sponges, hydroids, brachiopods and solitary ascidians. A particular feature of rias is the presence of sublittoral rock in conditions of strong tidal flow but negligible wave action. Particular growth forms of sponges and ascidians, as well as specific biotopes, occur in these unusual conditions. In tide-swept areas communities of hydroids and bryozoan turf or beds of brittle stars may be dominant. Beds of horse mussel *Modiolus modiolus* characterise some habitats. Animal-dominated sediment communities range from gravel and coarse sands dominated by burrowing sea cucumbers, large bivalve molluscs and heart urchins, through finer sediments supporting communities of polychaetes and small bivalves, to fine muds with beds of seapens, large burrowing crustaceans and bottom-dwelling fish.

Typical Attributes to define the feature's condition

Generic attributes

Table 3.6-1 lists the generic attributes for inlets and bays and presents examples of the measures proposed for some of the candidate SACs in the UK. This list is not exhaustive and will be further developed as our knowledge improves of the factors that determine the condition of inlet and bay ecosystems.

Table 3.6-1 A summary of attributes that may define favourable condition of large shallow inlets and bays

Attribute	*Measure*	*Comment*
Extent		
Extent of the feature	Overall area of the entire inlet or bay	It is likely that such measurements will be a cartographic exercise from existing maps although satellite remote sensing could be used. There are likely to be significant difficulties in defining the actual boundary, particularly for dynamic systems.
Extent of sub-feature or specific biotope	Measure the area of a sub-feature	Some sub-features will be Annex I habitats (reefs, subtidal sandbanks, sediment flats) and therefore subject to their own monitoring programme.
	Extent of characteristic biotopes	Often biogenic reefs will be included here, such as mussel beds and honeycomb worm (*Sabellaria* spp.) reefs.
Physical properties		
Habitat composition	Sediment character, structure of biogenic reefs	
Nutrient status	Average phytoplankton concentration in summer measured annually	This should only be measured if it is considered to have an effect on the biological structure of the feature.
Water clarity	Average light attenuation measured on a monthly basis from March to September, annually	This should only be measured if it is considered to have an effect on the biological structure of the feature.
Water density – salinity and temperature.	Derive mean annual salinity and mean annual water temperature from monthly measurements	These data should be derived for each year of the monitoring cycle.
Morphological equilibrium	Long-term trend in the horizontal boundary of the saltmarsh/mudflat interface, measured annually	This will only apply to an estuary included within the Large shallow inlets and bays.

Attribute	*Measure*	*Comment*
Biotic composition		
Species composition of characteristic biotopes	Frequency and occurrence of composite species from specific biotopes	The biotopes selected should reflect the biological character of the feature, and/or be particularly important for their nature conservation value: for example, rich and diverse mussel beds, maerl beds.
Species composition of characteristic habitats	Species composition of specific habitats	The habitats selected should reflect the biological character of the feature, and/or be particularly important for their nature conservation value: for example rich and diverse low-shore boulder communities, or lagoon communities.
Population status of characteristic species	Estimate the population size of species characteristic of the feature	The species selected should represent the character of the site and may include those at the limits of their geographical range, or which form an important structural aspect of the feature, e.g. kelp beds.
Biological structure		
Spatial distribution of sub-features	Area and pattern of all the sub-features within the SAC	The distribution of sub-features will be an important aspect to the overall character of the SAC and any change in their location and extent may act as a proxy to identify low-level, diffuse anthropogenic activities.
Spatial distribution of characteristic biotopes	Area and frequency of important biotopes throughout the feature	Examples include the relative distribution of intertidal rocky shore communities, distribution of maerl beds, tidal rapids.

Suggested techniques for monitoring attributes of inlets and bays

For each of the attributes likely to be selected to monitor the condition of a feature, there are many techniques available to measure its value. To help implement the UK's Common Standards for Monitoring programme, it is necessary to recommend a small number of techniques that are likely to provide comparable measures (Table 3.6-2). The UK Marine SACs project evaluated the inter-comparability of some of these techniques (recording biotope richness, species counts), but further work is required on other techniques (such as measuring extent with remote sensing techniques). The advice presented below will be updated when new information becomes available.

It is important to note that inlets and bays may include other Annex I habitats or Annex II species which will require their own monitoring programme. The relevant sections of this document should be consulted in addition to the advice provided in Table 3.6-2.

Table 3.6-2 Suggested techniques for measuring the attributes of inlets and bays. The terms under *Technique* appear under the heading *Summary title* in the procedural guidelines provided in Section 6. Guidance will be developed for the techniques in italics

Generic attribute	*Feature attribute*	*Technique*
Extent		*Air photo interpretation; Remote imaging; GIS analysis*
	Biotope extent	Intertidal resource mapping; Intertidal biotope ID; *Air photo interpretation; Remote imaging;* AGDS; side scan sonar (plus mosaicing); Point sample mapping
Physical properties	Water clarity	Measuring water quality; *Secchi disk; Water chemistry data loggers*
	Water chemistry (including salinity, temperature)	Measuring water quality; *Water chemistry data loggers; Sea surface measurements by satellite remote sensing*
	Nutrient status	Measuring water quality; *Water chemistry data loggers; Phytoplankton abundance using satellite remote sensing* (Biotope extent techniques for algal mats)
Biotic composition	Intertidal biotope richness	Intertidal resource mapping; Intertidal biotope ID; Intertidal ACE; Viewpoint photography
	Subtidal biotope richness	Subtidal biotope ID; Grab sampling; Drop-down video; ROV; Diver-operated video; Towed video (limited by topography and/or risk of damage)
	Intertidal species composition/richness	Intertidal ACE; Intertidal quadrat photography; Intertidal quadrat sampling (see Subtidal quadrat sampling); Intertidal core sampling; Fish in rockpools
	Subtidal species composition/richness	Subtidal quadrat sampling; Subtidal biotope ID; Subtidal core sampling; Grab sampling; Suction sampling; Fish in subtidal rock habitats; Fish on sediments; ROV; Drop-down video; Diver-operated video; *Epibenthic trawling*
	Intertidal characteristic species	Intertidal ACE; Intertidal quadrat photography; Intertidal quadrat sampling (see Subtidal quadrat sampling); Intertidal core sampling; Fish in rockpools
	Subtidal characteristic species	Subtidal quadrat sampling; Subtidal biotope ID; Subtidal core sampling; grab sampling; Subtidal photography; Suction sampling; Fish: in subtidal rocky habitats, in vegetative cover, on sediments; ROV ('large' conspicuous species only); Drop-down video ('large' conspicuous species only); Diver-operated video; Mollusc shell ageing
Biological structure	Intertidal zonation	Intertidal resource mapping; Intertidal biotope ID; Intertidal ACE; *Transect survey; Shore profiling*
	Subtidal zonation	Subtidal biotope ID; Diver-operated video; ROV; Towed video (limited by topography and/or risk of damage)
	Spatial pattern of intertidal biotopes	Intertidal resource mapping; Intertidal biotope ID; Viewpoint photography; *Air photo interpretation; Remote imaging*
	Spatial pattern of subtidal biotopes	AGDS; Side scan sonar (with mosaicing); Point sample mapping (from Grab sampling, ROV or Drop-down video data); Towed video

Specific issues affecting the monitoring of inlets and bays

Large shallow inlets and bays may include several other Annex I features in their own right, and support populations of Annex II species. The monitoring advice presented below is therefore generic in nature and specific advice is available for the individual features: *reefs*, *subtidal sandbanks*, *intertidal mudflats and sandflats*, and *sea caves*. Annex II species are covered under Chapter 4.

Seasonal effects

Marine communities show seasonal patterns that could significantly affect a monitoring programme in large shallow inlets and bays. Some of the more obvious visual changes occur in algal assemblages, and following massive settlements of juvenile animals such as mussels and barnacles. In Loch Maddy cSAC, the largest changes observed in shallow communities between autumn 1998 and summer 1999 were due to a increase in diversity and abundance of algae.[a] Banks of loose stones and gravel are often sufficiently seasonally stable to support dense assemblages of ephemeral algae. Sediment flats often support dense green algal mats during the summer months. Rapid growth of microscopic algae, and diatoms in particular, can change the appearance (colour) of intertidal flats.[b] Maerl beds support rich algal assemblages with distinct seasonal variation.

Many marine organisms have seasonal reproductive patterns that can significantly alter the number of individuals present at different times of the year. Some polychaete worms have semelparous or 'boom and bust' life history strategies where the mature adults spawn synchronously and then die. Clearly, the number of adults present in the sediment will depend on the stage in their lifecycle. Larval settlement and recruitment of juveniles to the population can result in a massive increase in the population size at certain times of the year. The presence and number of juveniles should be enumerated in all samples.

Seasonal effects are also prevalent in eelgrass communities. The blade density of the eelgrass itself will increase during the summer and then the decrease during the autumn and winter – a process known as die-back.[c] Eelgrass blades may support dense assemblages of epiphytic algae during the summer months, which then decline during the winter.

Seasonal patterns must be considered when planning a monitoring strategy. Sampling should be undertaken at the same time of year if seasonal variation is likely. It may be necessary to specify the duration of a sampling window – for example, to precede post-reproductive death in polychaete communities. Seasonal changes in seagrass have important consequences for the timing of remote sensing campaigns because the spectral signature[1] of the seagrass will change between summer and winter.

Meteorological changes

Prevailing weather conditions and tidal state will affect any monitoring study. Sites open to the prevailing wind and swell will require calm conditions for effective field survey. Periods of calm conditions will improve underwater visibility and improve sampling efficiency and reliability. For sediment habitats and adjacent areas, excessive water movement will mobilise fine sediment into the water column, thereby reducing underwater visibility. Conversely, calm conditions will cause suspended sediment to deposit out of the water column, and visibility will improve, but reef assemblages may then become smothered with sediment, obscuring some species from view. For any areas subject to strong tidal streams (for instance, the tidal rapids in Loch Maddy cSAC), sampling must take place at slack water, avoiding the equinoctial tides when the duration of slack water will be at its shortest.

Freshwater input to large shallow inlets and bays is not as marked as to estuaries, although it may be locally important in parts of these systems. In such circumstances, monitoring events should avoid periods of heavy rainfall if changes in ambient salinity are likely to influence the results.

Ambient atmospheric pressure affects the height and time of low and high tide: high pressure decreases the height of high and low tide, and the time of the highest and lowest water is later than predicted. Low pressure has the opposite effect.

Weather cycles can result in changes in the biotic assemblages. Changes in perennial algae on Loch Maddy maerl beds were possibly due to an unusually warm preceding summer.[d] Periods of extreme cold coinciding with low water can result in mass mortality of kelp plants.[e] Storm events can result in the mass displacement of sediment communities – for example, populations of the long-armed brittlestar *Amphiura filiformis* in Galway Bay, Ireland.[f]

When establishing a monitoring strategy, meteorological effects must be integrated with seasonal effects to ensure that sites can be monitored reliably through time.

1 See Section 5 for an explanation

Access

There are no specific issues associated with gaining access to inlets and bays. Access to intertidal habitats will be gained from the land, except for islands and offshore banks or remote sites where boat access will be necessary. Most subtidal habitats would require boat access although land access would be possible for those habitats immediately adjacent to the shore.

Further information is provided under the advice for individual features: *reefs*, *estuaries*, *subtidal sandbanks*, *intertidal mudflats and sandflats*, and *sea caves*. Annex II species are covered under Section 4.

Sampling issues

A monitoring programme must consider the whole feature, even where it may contain other Annex 1 features; these features should have their own dedicated monitoring programme. A monitoring programme for a large shallow inlet and bay may therefore, be an aggregation of both monitoring for Annex 1 (sub) features in their own right, and specific sampling of attributes for the entire feature (such as extent).

Measuring the extent of a large shallow inlet and bay requires the careful definition of boundary in relation to the seaward limit and the high water limit. For those sites bounded by rocky shores or solid anthropogenic boundaries such as harbour walls or seawalls, measuring the extent may be a straightforward cartographic exercise using the most up-to-date maps of the area. Sites with 'soft' boundaries such as saltmarsh may require a more sophisticated mapping exercise such as remote sensing, particularly in dynamic systems where tidal currents result in erosion and/or accretion of these 'soft' habitats. The positions of channels and offshore banks may move considerably during a monitoring cycle, although the impact of such a change on the overall extent of the large shallow inlet and bay may be negligible.

Monitoring physical and biological attributes to assess the condition of the entire feature will require careful consideration of the overall sampling strategy. A comprehensive sampling programme throughout the entire feature may be prohibitively expensive and time-consuming. It would be necessary to devise a tiered sampling programme at different spatial scales aiming to cover key physical attributes and characteristic biota. That is, a programme would be structured in such a manner that detailed sampling in a number of small areas would allow an assessment over the whole feature.

Site marking and relocation

Marking and relocating the *feature* itself is unlikely to present any problems, although the precise location of the boundary may be difficult where the edge of the feature has 'soft' habitats. Clear guidance is necessary to define the high water limit and the position of the entrance boundary to ensure consistent monitoring.

Permanent marking of sampling stations is very difficult in dynamic environments where the substrata are mobile. Site relocation will rely on dGPS,[2] particularly on extensive intertidal flats (Morecambe Bay and the Wash) or open sea areas (Wash). For less dynamic habitats, sites may be marked with acoustic transponders[8] or curly whirlies.[3] Detailed site drawings (Figure 3-2) with transits (Figure 3-5) may be necessary to relocate sampling stations in complex sites.

Additional information is provided under the guidance for *reefs*, *mudflats and sandflats*, *subtidal sandbanks* and *caves*.

Health and Safety

All fieldwork must follow approved codes of practice to ensure the health and safety of all staff. See the comments on health and safety for the individual features: *reefs*, *subtidal sandbanks*, *mudflats* and *caves*. There are considerable health and safety issues associated with:

- fast moving tidal streams, particularly in shallow rapids (Loch Maddy);
- heavy wave action particularly at the mouth and/or habitats exposed to the prevailing wind;
- poor visibility caused by high turbidity (mostly in sedimentary areas) or freshwater inflow;
- boat traffic near harbours or ports;
- contaminated waters and sediments at sites with a history of anthropogenic inputs and/or adjacent

2 See Procedural Guideline 6-1 on dGPS guidance.

3 Plastic corkscrews that are screwed down into the sediment: see Fowler, S L (1992) *Marine Monitoring in the Isles of Scilly 1991*. English Nature Research Report No. 9. English Nature, Peterborough.

to industrial or military installations: appropriate protective clothing must be worn.

Some sampling in inlets and bays will involve SCUBA diving techniques. All diving operations are subject to the procedures described in the Diving at Work Regulations 1997[4] (see: **http://www.hse.gov.uk/spd/spddivex.htm**) and must follow the Scientific and Archaeological Approved Code of Practice[5] (**http://www.hse.gov.uk/spd/spdacop.htm - a**).

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

5 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.