Appendix 15. Environmental factors and their benchmarks

Sensitivity and recoverability ranks for species are indicative. Ranks are assessed against the same intensity of change in environmental factor or 'benchmark'. The following table standardises the magnitude of each factor in order for effects to be normalised across species.

Physical factors

Substratum loss:

The physical removal of the substratum inhabited or required by the species or community in question. Newell *et al.* (1998) reviewed the environmental effects of dredging in coastal waters. They reported that trailer suction hopper dredging could result in dredged tracks 2-3m wide and 0.5m deep but up to 2m deep in some cases. In comparison, anchored dredging may result in pits of up to 75m in diameter and 20m deep. In the Baltic dredged tracks may still be detectable 12 months later. The time taken for pits to fill in the Dutch Wadden Sea was between 1year in high currents, 5-10 years in lower currents and up to 15 years on tidal flats (Newell *et al.*, 1998). Hall (1994) reports pits 3.5m wide and 0.6m deep as a result of suction dredging for *Ensis* in a Scottish sea loch. Newell *et al.* (1998) states that removal of 0.5m of sediment was likely to eliminate benthos from the affected area.

The chosen benchmark is representative of localised impacts on a specific area of substratum. This benchmark also includes the removal of other species that provide substrata for the species or community of interest, for example macroalgae. The time taken for the substratum to 'recover' within the habitat preferences of the species or community under consideration is not addressed.

	The level of effect against which sensitivity is rated.
Substratum loss	All of substratum occupied by the species or biotope under consideration is removed. A single event is assumed for sensitivity assessment. Once the activity or event has stopped (or between regular events) suitable substratum remains or is deposited. Species or community recovery assumes that the substratum within the habitat preferences of the original species or community is present.

Smothering:

The physical covering of the species or community and its substratum with additional sediment (silt), spoil, detritus, litter, oil or man-made objects. Overgrowth by other species such as encrusting ascidians is also included here. Major storms may deposit a layer of additional material of several centimetres at 20m depth and several millimetres at 40m (Hall, 1994). For example, storms were reported to deposit 4-10cm of sand at 28m in the Helgoland in German Bight and up to 11cm of sand off the Schleswig-Holstein coast (Hall, 1994). In a study of the impact of mill tailings, discharged into a Canadian silled fjord, Ellis & Heim (1985) observed layers of tailings of 0.5cm, 5cm and greater than 5cm (up to 60cm in one location).

The chosen benchmark represents the likely level of smothering resulting from natural events and comparable to the effects of maritime activities. [The definition does not include land claim. The habitat and its resident species would be destroyed by land claim. Recovery would not be possible, as the effect is permanent].

	The level of effect against which sensitivity is rated.
Smothering	All of the population of a species or an area of a biotope is smothered by sediment to a depth of 5 cm above the substratum for one month. **Impermeable** materials, such as concrete, oil, or tar, are likely to have a greater effect.

Changes in suspended sediment:

The concentration of suspended matter in the water column. The rate of siltation is dependent on the availability of suspended sediment, its particle size range and the water flow rate. In estuarine environments, siltation is increased by the flocculation of inorganic and organic substances due to mixing of fresh and saltwater. Floods are likely to increase the availability of sediment entering coastal waters from rivers. Storms may re-suspend sediment and transport it to other areas. Coastal erosion is a primary source of sediment. Activities that alter sediment availability (e.g., coastal quarries, de-forestation, coastal forestry, construction and dredging) or that change the water flow rate (e.g., coastal engineering such as channelization and breakwater construction) are likely to change the concentration of suspended sediment and hence siltation. Suspended sediment concentration varies around the UK, from 1-327 mg/l around the English coast and 1-227 mg/l around the Welsh coast but annual mean values are typically 1-110 mg/l (Parr *et al.* 1998; Cole *et al*. 1999). However, suspended sediment concentrations in estuaries may be much higher; measured in g/l.

Churchill (1989) reported a plume of suspended material behind a shrimp trawl, up to 50m behind the trawl with a concentration of 100-550mg/l suspended material. Newell *et al.* (1998) report a plume of suspended material behind a dredger reaching 75-150 mg/l, although this had dropped to 20-30 mg/l within 30 min. Similarly, they reported another dredger plume containing 2500 mg/l of suspended sand (<30 mg/l mud) which reduced to background levels with 200-500m.

'Suspended sediment' is included as a factor for those species likely to be sensitive to clogging of respiratory or feeding apparatus by silt or species that require a supply of sediment for tube construction such as *Sabellaria sp.* The resultant effects on light attenuation are addressed under turbidity, and the effects of rapid settling out of suspended sediment are addressed under smothering. Therefore, an arbitrary, short term, acute benchmark was chosen to represent a change in the availability of suspended sediment resulting from maritime activities or natural events, such as storm runoff.

	The level of effect against which sensitivity is rated.
Changes in suspended sediment.	An arbitrary short term, acute change in background suspended sediment concentration e.g., a change of 100mg/l for 1 month. The resultant light attenuation effects are addressed under turbidity, and the effects of rapid settling out of suspended sediment are addressed under smothering.

Desiccation:

The removal of water or drying. Desiccation rate during emersion is dependent on sunlight (and hence temperature), air movement (wind) and humidity. Intertidal organisms exhibit a number of physiological or behavioural adaptations to avoid or reduce desiccation. Two benchmarks for desiccation are given.

- The first desiccation benchmark represents stranding on the shore or the sudden exposure of an organism or community to desiccation, for example, by turning over rocks on the shore to expose undersurface communities.
- The second benchmark represents changes in the desiccation rate due to changes the wave exposure of the shore (hence humidity), prolonged periods of sunlight and higher temperatures, due to especially hot summers, hot winds, or a change in the emergence regime (see 'change in emergence regime' below).

	The level of effect against which sensitivity is rated.
Desiccation	1). A normally subtidal, demersal or pelagic species including intertidal migratory or under-boulder species is continuously exposed to air and sunshine for 1 hour. 2). A normally intertidal species or community is exposed to a change in desiccation equivalent to a change in position of one vertical biological zone on the shore, e.g., from upper eulittoral to the mid eulittoral or from sublittoral fringe to lower eulittoral.

Changes in emergence:

The time spent emersed and exposed to air. Intertidal species are regularly emersed with the falling tide; the percentage of time emersed is dependent on their position or height on the shore relative to the tide. There are seven sub-zones recognized in the intertidal. This benchmark also includes organisms in the splash zone (supralittoral) where the wetness regime is also dependent on the wave energy (wave height) reaching the shore. This factor is distinguished from desiccation, which while dependent on emergence, can change (due to changes in wind speed, air temperature and humidity) without changes in emersion.

	The level of effect against which sensitivity is rated.
Changes in emergence	A 1 hour change in the time covered or not covered by the sea for a period of 1 year.

Changes in water flow rate:

The movement of water associated with the rise and fall of the tide (tidal streams), prevailing winds and ocean currents. Strong tidal streams result in areas where water is forced through or over restrictions (e.g. gullies or narrows) or around offshore rocks. Currents are dependent on the meteorology, oceanography, and hydrography of the location.

Maritime activities, for example coastal engineering, are likely to cause changes in water flow rate at least as large as the benchmark level. In addition, many species and biotopes occur under a range of water flow conditions and a change of two categories is more likely to affect a range of species than is a change of one category.

	The level of effect against which sensitivity is rated.
Changes in water flow rate	A change of two categories in water flow rate for one year (see glossary) for 1 year. For example from moderately strong (1-3 knots) to very weak (negligible).

Changes in temperature:

A change in the ambient temperature of seawater, or in air temperature during emersion. Intertidal marine organisms experience a wide range of temperatures. If emersed at low tides intertidal organisms may be exposed to the heat of summer or the cold frosts of winter. Sub-tidal, permanently immersed marine species, however, will be exposed to a narrower temperature range since seawater takes time to warm or cool, and therefore ‘buffers’ the effects of extreme temperatures. Marine organisms are likely to be more tolerant of slow temperature change than sudden change. For example, species are likely to be more sensitive to a temperature change of 5 °C if it occurs over a period of a few hours rather than a few days.

The ambient temperature of air or sea changes with season, the magnitude of the change varying from year to year. However, short or long term changes in temperature may also result from thermal discharges (e.g. power station cooling waters) or climate change.

Thermal discharges are likely to be between 2° C and 10° C above the ambient temperature (UNEP, 1984). UNEP (1984) recommend an impact assessment level for thermal discharge plumes of equal to or greater than 3 °C.

Crisp (1964) reported the effects of the severe winter of 1962/63. Mortalities were recorded for a wide range of marine species as a result of a temperature drop of 5-6° C below the long term average for the south, south west and west coast of England during a two month period.

Benchmark 1) represents single pulse events, such as occasional short term industrial discharges or accidental spillages. However, species or communities are likely to be more sensitive to discharges of longer duration. Benchmark 2) represents continuous discharges of lower magnitude. A year's duration was chosen to represent the probability that the temperature change would impinge on the larval forms and breeding cycle of most marine organisms.

NB: Long term change in the average mean or winter minima and summer maxima resulting from climate change are addressed in the rationale but are not assessed under sensitivity and recoverability. This is because any increase or decrease in distribution and abundance of a species, as a result of long term change, is dependant on factors other than temperature alone, such as adult longevity, reproductive type and the importance of barriers to distribution at the organisms current limits of distribution.

	The level of effect against which sensitivity is rated.
Changes in temperature	2) A short term, acute change in temperature; e.g., a 5 ° C change in the temperature range for 3 consecutive days. This definition includes 'short term' thermal discharges. 2) A long term, chronic change in temperature; e.g. a 2 ° C change in the temperature range for a year. This definition includes 'long term' thermal discharges. For intertidal species or communities, the range of temperatures includes the air temperature regime for that species or communities.

Changes in turbidity:

The turbidity (clarity or opacity) of water is dependent on the concentration of substances that absorb or scatter light; for example, inorganic or organic particulates (suspended matter), plankton and dissolved substances. Dissolved substances may include natural organic materials (e.g. humic acids) or discharged chemicals. The turbidity determines the depth of water that light can penetrate and therefore the amount of light available for primary production by phytoplankton, benthic microalgae and macroalgae. At high levels, the suspended sediment that causes turbidity may clog feeding apparatus but this effect is included in 'siltation'. Coastal waters are likely to absorb 10-60% of incident light per metre at a wavelength of 500nm (Kinne, 1970). Assuming that coastal waters absorb, on average, 30% of incident light, then this is approximately equivalent to a suspended sediment concentration of 10-50 mg /l (extrapolated from Clarke, 1996). Cole *et al.* (1999) report average mean levels of turbidity of 1-110 mg/l around the English and Welsh coasts.

The water clarity scale (see glossary) refers to the effect of changes in light penetration, essential for photoautotrophs, because of changes in turbidity. The scale refers to the depth at which the incident surface illumination is reduced to 1% of surface intensity and approximates to the lower limit of growth in photophilic algae. It should be noted that turbidity may vary with season and coastal waters are likely to have a higher turbidity at times as a result of winter storms and riverine runoff.

Changes in turbidity	2) A short term, acute change; e.g., two categories of the water clarity scale (see glossary) for one month, i.e. from medium to extreme turbidity. 2) A long term, chronic change; e.g., one category of the water clarity scale (see glossary) for one year, i.e. from low to medium turbidity.

Changes in wave exposure:

Exposure on an open shore is dependent upon the distance of open seawater over which wind may blow to generate waves (the fetch) and the strength and incidence of the winds. Wave exposure is expressed as an eight rank scale of exposure (see glossary). Wave exposure may be altered by coastal engineering developments such as breakwaters and artificial reefs and are likely to be permanent unless positioned to temporarily protect other activities. Many species and biotopes occur under a range of wave exposure conditions. A change of one category might be effective in altering the survival or abundance of a few species, however, placing the benchmark magnitude at two at ranks is more likely to encompass a significant number of species. The benchmark level is also representative of the likely effects of a number of relevant maritime activities, such as, the construction of breakwaters.

	The level of effect against which sensitivity is rated.
Changes in wave exposure	A change of two ranks on the wave exposure scale (see glossary) e.g., from Exposed to Extremely exposed for a period of 1 year.

Noise:

Generally defined as unwanted or disruptive sound**.** Noise can cause sensitivity in three ways:

- actual discomfort, damage or death;
- interference with the use of hearing for feeding or communication reducing viability;
- disturbance of breeding or other behaviours reducing viability.

The units of the benchmark are received sound pressure in decibels (dB) shown as a ratio of received pressure to a fixed reference pressure (re) of 1 µPa at 1 metre. A typical ambient coastal noise level in calm weather would be around 40 – 60 dB (Morris, 1995). Various maritime activities produce noise of various frequencies at pressures from 120 to 250 dB (Richardson *et al.*, 1995). A distance of 1 metre is not very applicable to the exposure of marine organisms to noise in the environment. A typical decrease in pressure (transmission loss) over 100 metres would be 40 dB (Richardson *et al.*, 1995). In setting the benchmark for underwater noise, this loss has been applied to the typical noise pressures resulting from various activities. Different activities tend to produce noise of different pressures at different frequencies. For example:

- drilling noise tends to be up to 160 dB re 1 µPa-m at frequencies below 300 Hz with a peak below 2 Hz;
- dredging tends to be up to 180 dB re 1 µPa-m and below 1kHz;
- boats and small ships produce sound up to 170 dB re 1 µPa-m with frequencies up to 10 kHz (outboards motors have peaks at frequencies above 1kHz and larger vessels peak below 1 kHz);
- the regular passing of a 30 metre trawler at 100 metres or a working cutter-suction transfer dredge at 100 metres approximates to 130 dB re 1 µPa (for broad spectrum noise 45 – 7070 Hz);
- the regular passing of a Boeing 737 passenger jet 300 metres overhead approximates to 98 dB re 1 µPa (for broad spectrum noise 45 – 7070 Hz) @ 300 metres below the source;
- sonar sound can be up to 230 dB re 1 µPa-m and range from 500 Hz to several hundred kHz; and
- seismic airguns at 250 dB re 1 µPa-m up to several kHz (strongest below 100Hz) (Richardson *et al.*, 1995).

In addition, atmospheric noise can affect marine animals at the water surface or, for example, hauled out on sandbanks. Conventionally aircraft noise is referred to at a distance of 300 metres from the source. In extreme cases, such as for military jets, noise produced can be up to 130 dB re 1 µPa at 300m

Noise duration varies with activity, ranging from several weeks (dredging) to a fraction of a second repeated regularly for several hours (seismic survey) to a few minutes (a passing ship or plane). The benchmark was set using a duration that could typically result from a variety of activities e.g. continuous daytime boat activity, dredging, construction or proximity to an airport. This benchmark does not deal with the transmission of atmospheric noise to the water

	The level of effect against which sensitivity is rated.
Noise	**Underwater noise levels:** e.g., the regular passing of a 30 metre trawler at 100 metres or a working cutter-suction transfer dredge at 100 metres for 1 month during important feeding or breeding periods. **Atmospheric noise levels:** e.g., the regular passing of a Boeing 737 passenger jet 300 metres overhead for 1 month during important feeding or breeding periods.

Visual presence:

This benchmark applies only to species that have sufficient visual acuity to resolve moving objects or at least differentiate between rapid changes in light intensity (as in a moving shadow). Response is likely to be immediate with the species moving out of range of the stimulus. The duration of the factor has been set in line with potential maritime activities (such as disturbance to seals by tourists) and at a level that could cause a measurable effect on the species.

	The level of effect against which sensitivity is rated.
Visual presence	The continuous presence for one month of moving objects not naturally found in the marine environment (e.g., boats, machinery, and humans) within the visual envelope of the species or community under consideration.

Abrasion or physical impact:

This factor includes mechanical interference, crushing, physical blows against, or rubbing and erosion of the organism of interest. Protrusive species may be crushed, and delicate organisms with a fragile skeleton or soft bodies may be physically damaged or broken (snapped). The benchmark was chosen to be representative of a common maritime activity, namely anchorage. The intertidal is also susceptible to abrasion and physical impact from trampling, however, no standard units have been identified (units such as number of footsteps per m² or number of persons per transect have been reported). Where trampling is relevant, the evidence and trampling intensity will be reported in the rationale.

	The level of effect against which sensitivity is rated.
Abrasion or physical impact	This factor includes mechanical interference, crushing, physical blows against, or rubbing and erosion of the organism or habitat of interest. Force equivalent to a standard boat anchor landing on or being dragged across the organism e.g., a 5 –10 kg anchor and its chain (used by a 7-8m boat). A single event is assumed for assessment. Where trampling is relevant, the evidence and trampling intensity will be reported in the rationale.

Displacement:

Physical removal or transportation of the species or community of interest. The community, colony, or organism may be removed from its natural habitat but remain in the vicinity. For example, an individual may be disturbed by a storm, or passing trawl, not killed but thrown into suspension. The definition of the factor used here assumes that a permanently attached species cannot re-attach and is likely to die whilst many burrowing species or sedentary species can re-burrow or re-attach. The benchmark was chosen to represent significant bioturbation as a result of pit digging by large epi-benthic predators such as Rays and Gray Whale (Hall, 1994; Table 2), or removal from hard substrata by wave action. Anthropogenic activities such as of suction dredging or beam trawling are likely to have an effect greater than the benchmark level.

	The level of effect against which sensitivity is rated.
Displacement	Removal of the organism from the substratum and displacement from its original position onto a suitable substratum.

Chemical factors

Chemical factors require a particular approach to assessing sensitivity. Laboratory or field experiments and observations provide a starting point for assessing if species are adversely affected by the sorts of concentrations of any chemical that occur as a result of human activities or in accidents. However, the behaviour of chemicals in the marine environment is extremely complex and it is difficult to quantify the most likely effect of an activity. For example, a contaminant concentration at discharge may differ significantly from that experienced by an organism, due to dilution, dissipation, adsorption, absorption, flocculation, sedimentation, chemical change or degradation (of the contaminant), or bioaccumulation.

Similarly, the environmental concentration of any given contaminant may be the result of several activities, including aerial deposition.

A very large number of chemicals might affect marine species. The effects of some, such as TBT, are well known. Environmental Quality Standards (EQSs) or Environmental Assessment Levels (EALs) or World Health Organisation Guidance values are available for many contaminants (Environment Agency, 1998) (see Cole *et al.*, 1999 for review). However, scientific knowledge is incomplete or insufficient for many marine species. Contaminants may also exhibit antagonistic or synergistic effects, which are difficult to predict and poorly studied, and no attempt is made to take these into account here. It is accepted that considerable extrapolation is required in our assessments and that our levels of evidence and confidence are likely to be low. Therefore, it is neither practical nor accurate to set quantified benchmark levels for contaminants and an evidence based approach has been adopted.

Sensitivity is assessed against the available evidence for the effects of contaminants on the species of interest (or closely related species at low confidence). For example:

- evidence of mass mortality of a population of the species or community of interest (either short or long term) in response to a contaminant will be ranked as high sensitivity;
- evidence of reduced abundance, or extent of a population of the species or community of interest (either short or long term) in response to a contaminant will be ranked as intermediate sensitivity;
- evidence of sub-lethal effects or reduced reproductive potential of a population of the species or community of interest will be assessed as low sensitivity.

The evidence used is stated in the rationale. Where the assessment can be based on a known activity then this is stated. The tolerance to contaminants of species of interest will be included in the rationale when available, together with relevant supporting material.

The available toxicological information will vary between species and a species may be assessed to have different sensitivities to different chemicals within each class (heavy metals, synthetic chemicals, hydrocarbons, radionuclides) for example Cu, Zn and Hg within heavy metals.

NOTE: Where sensitivities to different chemicals within each class result in different sensitivity assessments, the available information will be clearly stated and the **'worst case'** sensitivity reported.

Changes in levels of synthetic chemicals:

Synthetic chemicals are by definition man-made and include, for example, organotins (tributyl tin, triphenyl tin), pesticides (lindane, atrazine, dichlorvos, DDT), organochlorides, organophosphates, solvents (carbon tetrachloride, chloroform) and poly-chlorinated biphenyls (PCBs).

Changes in levels of heavy metals:

Heavy metals include, for example, Arsenic (As), Cadmium (Cd), Mercury (Hg), Lead (Pb), Zinc (Zn) and Copper (Cu).

Changes in levels of hydrocarbons:

Hydrocarbons include, for example, oils (crude and fuel oils) and poly aromatic hydrocarbons (PAHs).

Changes in levels of radionuclides:

Isotopes of elements that emit alpha, beta, or gamma radiation. Radionuclides in the environment result from nuclear weapons tests, nuclear fuel processing, nuclear power generation, and natural sources. The little information known on the biological effects of radionuclides was reviewed by Cole *et al.* (1999). Dose rates of 10 milli-Grays per hour (mGy/hr) are considered acceptable for the protection of aquatic populations. Lethal levels in invertebrates range between 0.2 and 500 Grays (Gy). However, environmental concentrations of radionuclides are measured in becquerels per litre (Bq/l). Dosage is dependent of the type and energy of the radiation emitted as well as characteristics of the target organism. MAFF (1998) report values of caesium-137 in filtered seawater typically 50-500 mBq/kg in the north eastern Irish Sea and 2-20 mBq/kg in the North Sea. Concentrations of tritium (^{3}H) in the Bristol Channel ranged between 0-12 Bq/kg (MAFF, 1998).

<table>
<tr><th></th><th>The level of effect against which sensitivity is rated.</th></tr>
<tr><td>Changes in levels of synthetic chemicals</td><td rowspan="4">Sensitivity is assessed against the available evidence for the effects of contaminants on the species (or closely related species at low confidence) or community of interest. For example:
evidence of mass mortality of a population of the species or community of interest (either short or long term) in response to a contaminant will be ranked as high sensitivity;
evidence of reduced abundance, or extent of a population of the species or community of interest (either short or long term) in response to a contaminant will be ranked as intermediate sensitivity;
evidence of sub-lethal effects or reduced reproductive potential of a population of the species or community of interest will be assessed as low sensitivity.
The evidence used is stated in the rationale. Where the assessment can be based on a known activity then this is stated. The tolerance to contaminants of species of interest will be included in the rationale when available, together with relevant supporting material.</td></tr>
<tr><td>Changes in levels of heavy metals</td></tr>
<tr><td>Changes in levels of hydrocarbons</td></tr>
<tr><td>Changes in levels of radionuclides</td></tr>
</table>

Changes in levels of nutrient:

Nutrients include substances required for growth, for example, nitrogen, phosphorus, silicon, and micro-nutrients (heavy metals and vitamins). Low nutrient availability often limits growth or primary production in the marine environment. Ecosystems may be affected by changes in nutrient availability. Mean nutrient concentrations in English and Welsh coastal waters range from 0.07-1.85 mg/l total inorganic nitrogen (TIN), whereas estuarine concentrations vary between 0.1 to 15 mg/l total inorganic nitrogen (TIN). However, there is considerable variation in response to storms, floods, and seasons. Estuary concentrations peak in autumn/ winter and coastal concentrations in winter. However, man-made input from, for example, livestock, fertilisers, and sewage treatment works, may exceed the assimilative capacity of the environment, and result in eutrophication.

The chosen benchmark represents a marked change in nitrogen concentration, comparable with the difference between the general quality assessment (GQA) categories for estuaries (Cole *et al.*, 1999). The benchmark for phosphorus (total reactive phosphorus) assumes total inorganic nitrogen: phosphorus ratio of 10:1.

	The level of effect against which sensitivity is rated.
Changes in levels of nutrient	A change in background nutrient concentrations, e.g., a change of total nitrogen of 3 mg/l and/or phosphorus of 0.3 mg/l as an annual average. Alternatively, a 50% change in of nutrient concentration as an annual average.

Changes in salinity:

The salinity scale used by the Marine Nature Conservation Review (Hiscock, 1996a) was developed to reflect the occurrence of significantly different species from one category to another. Therefore, a change of one category was chosen as an appropriate sensitivity assessment benchmark for longer term changes and two categories for short term changes.

	The level of effect against which sensitivity is rated.
Changes in salinity	2) A short term, acute change; e.g., a change of two categories from the MNCR salinity scale for one week (see glossary) i.e. from full to reduced. 2) A long term, chronic change; e.g., a change of one category from the MNCR salinity scale for one year (see glossary) i.e. from reduced to low.

Changes in oxygenation:

The majority of organisms require oxygen for respiration; the process by which organic molecules is broken down to provide energy for work and metabolism. Natural events such as plankton blooms may deplete the oxygen levels locally. For example, a planktonic bloom, in the presence of a thermocline (which prevented mixing on the water column), in the North Atlantic Bight resulted in reduction of dissolved oxygen below 2mg/l for several months and the subsequent deaths of fish and benthos. De-oxygenation may also result from the addition of organic material to the water column and subsequent bacterial activity that consumes available dissolved oxygen. Gray & Jensen (1993) reported <4 mg/l as the concentration chosen by as likely to affect marine life and, therefore, to trigger cessation of dredging operations. The chosen benchmark was based on the general quality assessment levels for estuaries (8 mg/l, 4mg/l and 2mg/l) reported by Cole *et al.* (1999). However, anaerobic species may be sensitive to increased oxygen levels.

	The level of effect against which sensitivity is rated.
Changes in oxygenation	Exposure to dissolved oxygen concentration of 2 mg/l for 1 week.

Biological factors

Introduction of microbial pathogens and parasites:

By definition, diseases and parasites cause a reduction in fitness of an organism so all affected species are automatically assessed as of 'intermediate' sensitivity to disease or parasitism.

	The level of effect against which sensitivity is rated.
Introduction of microbial pathogens and parasites	Sensitivity can only be assessed relative to a known, named disease, likely to cause partial loss of a species population or community. Sensitivity will be assessed as 'intermediate'.

Introduction of alien or non- native species:

Sensitivity is assessed against a specific non-native or alien species that already occurs in Britain and/or Ireland that is most likely to have an adverse effect. The relevant alien or non-native species and its likely effects will be detailed in the rationale.

	The level of effect against which sensitivity is rated.
Introduction of alien or non- native species	Sensitivity assessed against the likely effect of the introduction of alien or non-native species in Britain or Ireland.

Specific targeted extraction of this species:

If 50% of the population or biotope is removed then sensitivity is automatically assessed as intermediate. Potential for recovery after a very efficient extraction has been undertaken can also be assessed using this definition.

	The level of effect against which sensitivity is rated.
Specific targeted extraction of this species	Extraction removes 50% of the species or community from the area under consideration. Sensitivity will be assessed as ‘intermediate’. The habitat remains intact or recovers rapidly. Any effects of the extraction process on the habitat itself are addressed under other factors, e.g. displacement, abrasion and physical disturbance, and substratum loss.

Specific targeted extraction of other species:

A species that is a required host or prey for the species under consideration (and assuming that no alternative host exists) or a keystone species in a biotope is removed.

	The level of effect against which sensitivity is rated.
Specific targeted extraction of other species	A species that is a required host or prey for the species under consideration (and assuming that no alternative host exists) or a keystone species in a biotope is removed. Any effects of the extraction process on the habitat itself are addressed under other factors, e.g. displacement, abrasion and physical disturbance, and substratum loss.