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REVISED LIST OF DEFINITIONS OF PRESSURES AND BENCHMARKS FOR SENSITIVITY ASSESSMENT

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REVISED LIST OF DEFINITIONS OF PRESSURES AND BENCHMARKS FOR SENSITIVITY ASSESSMENT

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REVISED LIST OF DEFINITONS OF PRESSURES AND BENCHMARKS FOR SENSITIVITY ASSESSMENT

1 Introduction

The list of pressures (resultant from human activities) used to advise management and monitoring for marine conservation and planning were revised by the ICG-C, a sub-committee of the ICG-C COBAM group of OSPAR. Subsequent application to the process of sensitivity assessment was undertaken by adoption of the benchmarks devised for the MB0102 project (Tillin *et al.*, 2010). Recent development have required further revision of the benchmarks and pressures to ensure that they are applicable to the proposed next generation of sensitivity assessments.

The project brief for MB0102 specified that three benchmarks were set for each pressure, where the benchmarks were to describe the breakpoints between high/medium and medium/low pressure intensity and the mid-point between these two benchmarks (defined as medium pressure). The mid-point or medium benchmark was then used for assessing the sensitivity score within the overall sensitivity matrix. It should therefore be noted that the benchmarks were explicitly not defined on the basis of the highest pressure intensities exerted by activities.

2 Review of pressure benchmarks

The authors were asked to examine the existing benchmarks, based on comments received from the SNCBs in December 2014 (Appendix 1), and suggest a final list of benchmarks for use in sensitivity assessment. The review process used the following attributes to determine the suitability of each pressure benchmark to sensitivity assessment.

The definition of benchmarks should:

- represent the likely result from a defined suite of activities;
- qualify, or where possible, quantify the magnitude, extent or duration of the pressure;
- represent the likely result in quantifiable or qualifiable effects on marine species, communities and habitats; and
- be able to discriminate different levels of sensitivity.

The duration of a pressure is included where 'duration' is an essential component of the effect of the pressure and required for assessment. Otherwise, the intensity of the pressures defined in terms of frequency or duration of exposure to the pressure are not included in the benchmark definition.

3 Suggested pressure benchmarks

In the revision we have referred to the original MarLIN benchmarks (Tyler-Walters & Jackson, 1999, Tyler-Walters *et al.*, 2001), the development of the MB01020 benchmarks (Tillin *et al.*, 2010), and recent experience of the application of the benchmarks to marine species and habitats using the MB0102 Plus approach (d'Avack *et al.*, 2014, Gibb *et al.*, 2014, Mainwaring *et al.*, 2014, Tillin & Tyler-Walters, 2014a, Tillin & Tyler-Walters, 2014b).

The suggested pressure benchmarks and recommendations are shown in Table 3.1 together with any revised pressure descriptions. Recommendations and changes suggested by Natural England and APEM for mobile species (fish, birds, and mammals) are included. The detailed discussion and supporting evidence is given in Appendix 1. The table of SNCB revisions and comments on the ICG-C pressure and benchmarks is given in Appendix 2.

Table 3.1 Suggested pressure benchmarks and revised pressure descriptions

Pressure theme	ICG-C Pressure	MB0102 benchmark	ICG-C description
Hydrological changes (inshore/local)	Emergence regime changes - local, including tidal level change considerations	*1) Intertidal species* and habitats not uniquely defined by intertidal zone): A 1 hour change in the time covered or not covered by the sea for a period of 1 year. *2) Habitats and landscapes defined by intertidal zone:* An increase in relative sea level or decrease in high water level of 1mm for one year over a shoreline length >1km.	Changes in water levels reducing the intertidal zone (and the associated/dependant habitats). The pressure relates to changes in both the spatial area and duration that intertidal species are immersed and exposed during tidal cycles (the percentage of immersion is dependent on the position or height on the shore relative to the tide). The spatial and temporal extent of the pressure will be dependent on the causal activities but can be delineated. This relates to anthropogenic causes that may directly influence the temporal and spatial extent of tidal immersion, e.g. upstream and downstream of a tidal barrage the emergence would be respectively reduced and increased, beach re-profiling could change gradients and therefore exposure times, capital dredging may change the natural tidal range, managed realignment, saltmarsh creation. Such alteration may be of importance in estuaries because of their influence on tidal flushing and potential wave propagation. Changes in tidal flushing can change the sediment dynamics and may lead to changing patterns of deposition and erosion. Changes in tidal levels will only affect the emergence regime in areas that are inundated for only part of the time. The effects that tidal level changes may have on sediment transport are not restricted to these areas, so a very large construction could significantly affect the tidal level at a deep site without changing the emergence regime. Such a change could still have a serious impact. This excludes pressure from sea level rise.
		Suggested benchmark	**Revised description / comment**
		A change in the time covered or not covered by the sea for a period of ≥ 1 year. OR An increase in relative sea level or decrease in high water level for ≥ 1 year.	**T**he benchmark is only relevant to the intertidal, excluding habitats below Chart Datum (CD). The pressure benchmark does not expressly identify the role of 'desiccation' but sensitivity to desiccation will be discussed where known or relevant. In application, the majority of intertidal communities are sensitivity to changes in emergence, whether it is for one or more hours, or a due to changes in sea level and coastal squeeze. Therefore, we have removed that part of the MB0102 benchmark. However, we've retained the duration on the assumption that the effects on most communities would probably take a year to become apparent.

Pressure theme	ICG-C Pressure	MB0102 benchmark	ICG-C description
Hydrological changes (inshore/local)	Salinity changes - local	Increase from 35 to 38 units for one year. OR Decrease in Salinity by 4-10 units a year	Events or activities increasing or decreasing local salinity. This relates to anthropogenic sources/causes that have the potential to be controlled, e.g. freshwater discharges from pipelines that reduce salinity, or brine discharges from salt caverns washings that may increase salinity. This could also include hydromorphological modification, e.g. capital navigation dredging if this alters the halocline, or erection of barrages or weirs that alter freshwater/seawater flow/exchange rates. The pressure may be temporally and spatially delineated derived from the causal event/activity and local environment.
		Suggested benchmark	**Revised description / comment**
		1) Increase from 35 to 38 units for one year. 2) Decrease in salinity by 4-10 units one year	Assess increase and decrease in salinity separately.
Pressure theme	**ICG-C Pressure**	**MB0102 benchmark**	**ICG-C description**
Hydrological changes (inshore/local)	Temperature changes - local	A 5°C change in temp for one month period, or 2°C for one year	Events or activities increasing or decreasing local water temperature. This is most likely from thermal discharges, e.g. the release of cooling waters from power stations. This could also relate to temperature changes in the vicinity of operational sub sea power cables. This pressure only applies within the thermal plume generated by the pressure source. It excludes temperature changes from global warming which will be at a regional scale (and as such are addressed under the climate change pressures).
		Suggested benchmark	**Revised description / comment**
		A 5°C **increase** in temp for one month period, or 2°C for one year	Assess only the increase in temperature as managed human activities do not lead to decreases in temperature.

Pressure theme	ICG-C Pressure	MB0102 benchmark	ICG-C description
Hydrological changes (inshore/local)	Water flow (tidal current) changes - local, including sediment transport considerations	A change in peak mean spring tide flow speed of between 0.1m/s to 0.2m/s over an areas > 1km2 or 50% if width of water body for more than 1 year.	Changes in water movement associated with tidal streams (the rise and fall of the tide, riverine flows), prevailing winds and ocean currents. The pressure is therefore associated with activities that have the potential to modify hydrological energy flows, e.g. Tidal energy generation devices remove (convert) energy and such pressures could be manifested leeward of the device, capital dredging may deepen and widen a channel and therefore decrease the water flow, canalisation &/or structures may alter flow speed and direction; managed realignment (e.g. Wallasea, England). The pressure will be spatially delineated. The pressure extremes are a shift from a high to a low energy environment (or vice versa). The biota associated with these extremes will be markedly different as will the substrate, sediment supply/transport and associated seabed elevation changes. The potential exists for profound changes (e.g. coastal erosion/deposition) to occur at long distances from the construction itself if an important sediment transport pathway was disrupted. As such these pressures could have multiple and complex impacts associated with them.
		Suggested benchmark	**Revised description / comment**
		A change in peak mean spring bed flow velocity of between 0.1m/s to 0.2m/s for more than 1 year	Adopt SNCB amendment
Pressure theme	**ICG-C Pressure**	**MB0102 benchmark**	**ICG-C description**
Hydrological changes (inshore/local)	Wave exposure changes - local	A change in nearshore significant wave height >3% but <5%	Local changes in wave length, height and frequency. 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 winds. Anthropogenic sources of this pressure include artificial reefs, breakwaters, barrages, wrecks that can directly influence wave action or activities that may locally affect the incidence of winds, e.g. a dense network of wind turbines may have the potential to influence wave exposure, depending upon their location relative to the coastline.
		Suggested benchmark	**Revised description / comment**
		A change in nearshore significant wave height >3% but <5%	Retain existing benchmark. Research correlation between significant wave height and wave exposure scales.

Pressure theme	ICG-C Pressure	MB0102 benchmark	ICG-C description
Physical damage (Reversible Change)	Changes in suspended solids (water clarity)	A change in one Water Framework Directive (WFD) ecological status class for one year	Changes in water clarity from sediment & organic particulate matter concentrations. It is related to activities disturbing sediment and/or organic particulate matter and mobilising it into the water column. Could be 'natural' land run-off and riverine discharges or from anthropogenic activities such as all forms of dredging, disposal at sea, cable and pipeline burial, secondary effects of construction works, e.g. breakwaters. Particle size, hydrological energy (current speed & direction) and tidal excursion are all influencing factors on the spatial extent and temporal duration. This pressure also relates to changes in turbidity from suspended solids of organic origin (as such it excludes sediments - see the "changes in suspended sediment" pressure type). Salinity, turbulence, pH and temperature may result in flocculation of suspended organic matter. Anthropogenic sources mostly short lived and over relatively small spatial extents.
		Suggested benchmark	**Revised description / comment**
		A change in one rank on the WFD (Water Framework Directive) scale e.g. from clear to intermediate for one year.	Changes water clarity (or turbidity) due to changes in sediment & organic particulate matter and chemical concentrations. It is related to activities disturbing sediment and/or organic particulate matter and mobilising it into the water column. It could be 'natural' land run-off and riverine discharges or from anthropogenic activities such as all forms of dredging, disposal at sea, cable and pipeline burial, secondary effects of construction works, e.g. breakwaters. Particle size, hydrological energy (current speed & direction) and tidal excursion are all influencing factors on the spatial extent and temporal duration. Salinity, turbulence, pH and temperature may result in flocculation of suspended organic matter. Anthropogenic sources are mostly short lived and over relatively small spatial extents. Changes in suspended sediment loads can also alter the scour experienced by species and habitats. Therefore, the effects of scour are also addressed here.
Pressure theme	**ICG-C Pressure**	**MB0102 benchmark**	**ICG-C description**
Physical damage (Reversible Change)	Habitat structure changes - removal of substratum (extraction)	Extraction of sediment to 30cm	Unlike the "physical change" pressure type where there is a permanent change in sea bed type (e.g. sand to gravel, sediment to a hard artificial substrate) the "habitat structure change" pressure type relates to temporary and/or reversible change, e.g. from marine mineral extraction where a proportion of seabed sands or gravels are removed but a residual layer of seabed is similar to the pre-dredge structure and as such biological communities could re-colonize; navigation dredging to maintain channels where the silts or sands removed are replaced by non-anthropogenic mechanisms so the sediment typology is not changed.
		Suggested benchmark	**Revised description / comment**
		Extraction of substratum to 30cm (where substratum includes sediments and soft rocks but excludes hard bedrock)	Adopt SCNB benchmark revision, with amendment

Pressure theme	ICG-C Pressure	MB0102 benchmark	ICG-C description
Physical damage (Reversible Change)	Abrasion/disturbance of the substrate on the surface of the seabed	Damage to seabed surface features	The disturbance of sediments where there is limited or no loss of substrate from the system. This pressure is associated with activities such as anchoring, taking of sediment/geological cores, cone penetration tests, cable burial (ploughing or jetting), propeller wash from vessels, certain fishing activities, e.g. scallop dredging, beam trawling. Agitation dredging, where sediments are deliberately disturbed by and by gravity & hydraulic dredging where sediments are deliberately disturbed and moved by currents could also be associated with this pressure type. Compression of sediments, e.g. from the legs of a jack-up barge could also fit into this pressure type. Abrasion relates to the damage of the sea bed surface layers (typically up to 50cm depth). Activities associated with abrasion can cover relatively large spatial areas and include: fishing with towed demersal trawls (fish & shellfish); bio-prospecting such as harvesting of biogenic features such as maerl beds where, after extraction, conditions for recolonisation remain suitable or relatively localized activities including: seaweed harvesting, recreation, potting, aquaculture. Change from gravel to silt substrate would adversely affect herring spawning grounds.
		Suggested benchmark	**Revised description / comment**
		Benthic species /habitats: Damage to seabed surface features (species and habitats) **Fish/Bird/Mammal:** Structural damage of >10% area/volume of biologically relevant structures (including biogenic forming structures) within site	Physical disturbance or abrasion of the surface of the substratum in sedimentary or rocky habitats. The effects are relevant to epiflora and epifauna living on the surface of the substratum. In intertidal and sublittoral fringe habitats, abrasion is likely to result from recreational access and trampling (inc. climbing) by human or livestock, vehicular access, moorings (ropes, chains), activities that increase scour and grounding of vessels (deliberate or accidental). In the sublittoral, surface abrasion is likely to result from pots or creels, cables and chains associated with fixed gears and moorings, anchoring of recreational vessels, objects placed on the seabed such as the legs of jack-up barges, and harvesting of seaweeds (e.g. kelps) or other intertidal species (trampling) or of epifaunal species (e.g. oysters). In sublittoral habitats, passing bottom gear (e.g. rock hopper gear) may also cause abrasion to epifaunal and epifloral communities, including epifaunal biogenic reef communities. Activities associated with abrasion can cover relatively large spatial areas e.g. bottom trawls or bio-prospecting or be relatively localized activities e.g. seaweed harvesting, recreation, potting, and aquaculture.

Pressure theme	ICG-C Pressure	MB0102 benchmark	ICG-C description
Physical damage (Reversible Change)	Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion	Damage to sub-surface seabed	The disturbance of sediments where there is limited or no loss of substrate from the system. This pressure is associated with activities such as anchoring, taking of sediment/geological cores, cone penetration tests, cable burial (ploughing or jetting), propeller wash from vessels, certain fishing activities, e.g. scallop dredging, beam trawling. Agitation dredging, where sediments are deliberately disturbed by and by gravity & hydraulic dredging where sediments are deliberately disturbed and moved by currents could also be associated with this pressure type. Compression of sediments, e.g. from the legs of a jack-up barge could also fit into this pressure type. Abrasion relates to the damage of the sea bed surface layers (typically up to 50cm depth). Activities associated with abrasion can cover relatively large spatial areas and include: fishing with towed demersal trawls (fish & shellfish); bio-prospecting such as harvesting of biogenic features such as maerl beds where, after extraction, conditions for recolonisation remain suitable or relatively localized activities including: seaweed harvesting, recreation, potting, aquaculture. Change from gravel to silt substrate would adversely affect herring spawning grounds.
		Suggested benchmark	**Revised description / comment**
		Benthic species /habitats: • Damage to seabed surface physical disturbance of the substratum to a depth of ≤5 cm • physical disturbance of the substratum to a depth of >5 cm **Fish/Bird/Mammal:** Structural damage of >10% area/volume of biologically relevant structures (including biogenic forming structures) within site	Physical disturbance of the substratum by activities that penetrate the surface of the seabed, where there is limited or no loss of substratum from the system. This pressure is associated with activities such as taking of sediment/geological cores, cone penetration tests, cable burial (ploughing or jetting), propeller wash from vessels, certain fishing activities, e.g. scallop dredging, beam trawling. Agitation dredging, where sediments are deliberately disturbed by gravity and hydraulic dredging where sediments are deliberately disturbed and moved by currents could also be associated with this pressure type. Compression of sediments, e.g. from the legs of a jack-up barge could also fit into this pressure type. Penetration relates to the damage of the sea bed surface layers (typically up to 50cm depth). Activities such as fishing with towed demersal trawls (fish and shellfish); bio-prospecting such as harvesting of biogenic features such as maerl beds can cover large spatial areas. Loss, removal or modification of the substratum is not included within this pressure (see the physical loss pressure theme). Penetration and damage to the soft rock substrata are considered, however the penetration into hard bedrock is deemed unlikely.

Pressure theme	ICG-C Pressure	MB0102 benchmark	ICG-C description
Physical damage (Reversible Change)	Smothering and siltation rate changes(depth of vertical sediment overburden)	Light - 5cm of fine material added to the seabed in a single event Heavy -up to 30cm of fine material added to the seabed in a single event	When the natural rates of siltation are altered (increased or decreased). Siltation (or sedimentation) is the settling out of silt/sediments suspended in the water column. Activities associated with this pressure type include mariculture, land claim, navigation dredging, disposal at sea, marine mineral extraction, cable and pipeline laying and various construction activities. It can result in short lived sediment concentration gradients and the accumulation of sediments on the sea floor. This accumulation of sediments is synonymous with "light" smothering, which relates to the depth of vertical overburden. "Light" smothering relates to the deposition of layers of sediment on the seabed. It is associated with activities such as sea disposal of dredged materials where sediments are deliberately deposited on the sea bed. For "light" smothering most benthic biota may be able to adapt, i.e. vertically migrate through the deposited sediment. "Heavy" smothering also relates to the deposition of layers of sediment on the seabed but is associated with activities such as sea disposal of dredged materials where sediments are deliberately deposited on the sea bed. This accumulation of sediments relates to the depth of vertical overburden where the sediment type of the existing and deposited sediment has similar physical characteristics because, although most species of marine biota are unable to adapt, e.g. sessile organisms unable to make their way to the surface, a similar biota could, with time, re-establish. If the sediments were physically different this would fall under L2.
		Suggested benchmark	**Revised description / comment**
		Benthic species/habitat: • 'Light' deposition of up to 5 cm of fine material added to the seabed in a single event • 'Heavy' deposition of up to 30 cm of fine material added to the seabed in a single event **Fish/Bird/Mammal:** • up to 5 cm of fine material added to the seabed in a single event within site • up to 30 cm of fine material added to the seabed in a single event within site	Adopt MB0102 and SNCB benchmarks. Assess 'Light' and 'Heavy' smothering separately.

Pressure theme	ICG-C Pressure	MB0102 benchmark	ICG-C description
Physical loss (Permanent Change)	Physical change (to another seabed type)	Change in 1 folk class for 2 years	The permanent change of one marine habitat type to another marine habitat type, through the change in substratum, including to artificial (e.g. concrete). This therefore involves the permanent loss of one marine habitat type but has an equal creation of a different marine habitat type. Associated activities include the installation of infrastructure (e.g. surface of platforms or wind farm foundations, marinas, coastal defences, pipelines and cables), the placement of scour protection where soft sediment habitats are replaced by hard/coarse substrate habitats, removal of coarse substrate (marine mineral extraction) in those instances where surficial finer sediments are lost, capital dredging where the residual sedimentary habitat differs structurally from the pre-dredge state, creation of artificial reefs, mariculture i.e. mussel beds. Protection of pipes and cables using rock dumping and mattressing techniques. Placement of cuttings piles from oil & gas activities could fit this pressure type, however, there may be an additional pressures, e.g. "pollution and other chemical changes" theme. This pressure excludes navigation dredging where the depth of sediment is changes locally but the sediment typology is not changed.
		Suggested benchmark	**Revised description / comment**
		Benthic species/habitat: • Change in 1 folk class • Change from sedimentary or soft rock substrata to hard rock or artificial substrata **Fish/Birds/Mammals:** >10% habitat type change within site	Tillin & Tyler-Walters (2014) did not consider the change in one Folk class benchmark applicable to hard rock biotopes, but did assess the sensitivity of biotopes occurring on softer substrata, including chalk, peat, mud rock, and clay. The new benchmark (change from sediment to hard rock or vice versa) would affect all types of substratum, and all habitats would be assessed as highly sensitive. This pressure assumes a permanent change, while short term smothering of substrata with sediment is addressed under smothering (siltation).
Pressure theme	**ICG-C Pressure**	**MB0102 benchmark**	**ICG-C description**
Physical loss (Permanent Change)	Physical loss (to land or freshwater habitat)	Permanent loss of existing saline habitat	The permanent loss of marine habitats. Associated activities are land claim, new coastal defences that encroach on and move the Mean High Water Springs mark seawards, the footprint of a wind turbine on the seabed, dredging if it alters the position of the halocline. This excludes changes from one marine habitat type to another marine habitat type.
		Suggested benchmark	**Revised description / comment**
		Permanent loss of existing saline habitat within site	Adopt SNCB rephrasing

Pressure theme	ICG-C Pressure	MB0102 benchmark	ICG-C description
Physical pressure (other)	Barrier to species movement	10% change in tidal excursion, or temporary barrier to species movement over ≥50% of water body width	The physical obstruction of species movements and including local movements (within & between roosting, breeding, feeding areas) and regional/global migrations (e.g. birds, eels, salmon, and whales). Both include up-river movements (where tidal barrages & devices or dams could obstruct movements) or movements across open waters (offshore wind farm, wave or tidal device arrays, mariculture infrastructure or fixed fishing gears). Species affected are mostly highly mobile birds, fish, and mammals.
		Suggested benchmark	**Revised description / comment**
		Benthic species: permanent or temporary barrier to species movement over ≥50% of water body width or a 10% change in tidal excursion **Fish/birds:** >10% of local population of a migratory feature affected by permanent or temporary lack of continuity of parts of the migration corridor **Mammals:** Introduction of a permanent physical barrier in areas used by the feature	The pressure is clearly relevant to mobile species such as fish, birds, reptiles and mammals . However, it should also be considered relevant to species or macrofauna such as crabs that undertake migrations to over-winter or to breed, and where populations are dependent on larval or other propagule supply from outside the site.
Pressure theme	**ICG-C Pressure**	**MB0102 benchmark**	**ICG-C description**
Physical pressure (other)	Electromagnetic changes	Local electric field of 1V m-1. Local magnetic field of 10μT	Localized electric and magnetic fields associated with operational power cables and telecommunication cables (if equipped with power relays). Such cables may generate electric and magnetic fields that could alter behaviour and migration patterns of sensitive species (e.g. sharks and rays).
		Suggested benchmark	**Revised description / comment**
		As above	The evidence to assess these effects against the pressure benchmark is very limited and the impact of this pressure could not be assessed for benthic species or habitats (Tillin & Tyler-Walters, 2014).

Pressure theme	ICG-C Pressure	MB0102 benchmark	ICG-C description
Physical pressure (other)	Death or injury by collision	0.1% of tidal volume on average tide, passing through artificial structure	Injury or mortality from collisions of biota with both static &/or moving structures. Examples include: collision with rigs (e.g. birds) or screens in intake pipes (e.g. fish at power stations) (static) or collisions with wind turbine blades, fish & mammal collisions with tidal devices and shipping (moving). Activities increasing number of vessels transiting areas, e.g. new port development or construction works will influence the scale and intensity of this pressure.
		Suggested benchmark	**Revised description / comment**
		Benthic species: 0.1% of tidal volume on average tide, passing through artificial structure **Birds/Mammals:** Above water collision - introduction of aerial structures or devices that introduce collision risk in areas used by features **Fish/Birds** Below water collision - 0.1% of tidal volume on average tide, passing through artificial structure **Mammals:** Presence of propellered vessels (particularly ducted propellered vessels) and/or tidal power devices, OR 0.1% of tidal volume on average tide, passing through artificial structure	Adopt SNCB revised benchmarks. The benthic species benchmark is only relevant to larvae. Collison with benthic habitats due to grounding by vessels is addressed under 'abrasion'.

Pressure theme	ICG-C Pressure	MB0102 benchmark	ICG-C description
Physical pressure (other)	Introduction of light	None proposed	Direct inputs of light from anthropogenic activities, i.e. lighting on structures during construction or operation to allow 24 hour working; new tourist facilities, e.g. promenade or pier lighting, lighting on oil & gas facilities etc. Ecological effects may be the diversion of bird species from migration routes if they are disorientated by or attracted to the lights. It is also possible that continuous lighting may lead to increased algal growth.
		Suggested benchmark	**Revised description / comment**
		Benthic species / Fish / Birds / Mammals: 0.1 Lux change in diffuse irradiation during period of site occupancy by the feature; OR >3 distant strobe & point light sources visible over a 90° azimuth arc	The introduction of light is unlikely to be relevant for most benthic invertebrates, excect where it is possible to interfere with spawning cues. But we are not aware of evidence to that effect. The introduction of light could potentially be beneficial for immersed plants, but again, we are not aware of any relevant evidence.
Pressure theme	**ICG-C Pressure**	**MB0102 benchmark**	**ICG-C description**
Physical pressure (other)	Litter	**MB0102 Pressure benchmark**: None **Fish/Birds/Mammals:** Introduction of man-made objects able to cause physical harm (surface, water column, sea floor and/or strandline)	Marine litter is any manufactured or processed solid material from anthropogenic activities discarded, disposed or abandoned (excluding legitimate disposal) once it enters the marine and coastal environment including: plastics, metals, timber, rope, fishing gear etc. and their degraded components, e.g. microplastic particles. Ecological effects can be physical (smothering), biological (ingestion, including uptake of microplastics; entangling; physical damage; accumulation of chemicals) and/or chemical (leaching, contamination).
		Suggested benchmark	**Revised description / comment**
		Benthic species / Fish / Birds / Mammals: Introduction of man-made objects able to cause physical harm (surface, water column, sea floor and/or strandline)	We are not aware of any evidence on the effects of 'litter' on benthic marine species. While there is documented evidence of the accumulation of micro-plastics in some species, no ecological effects have been shown to date. The only exception is the effect of ghost fishing on large crustaceans (crabs etc.). Therefore, the sensitivity to litter was not assessed for habitats and was scored 'No evidence' by Tillin & Tyler-Walters (2014). Clearly it is relevant for large macrofauna such as fish, birds and mammals.

Pressure theme	ICG-C Pressure	MB0102 benchmark	ICG-C description
Physical pressure (other)	Noise changes	**Above water noise:** None **Underwater noise:** MSFD indicator levels (SEL or peak SPL) exceeded for 20% of days in calendar year	Increases over and above background noise levels (consisting of environmental noise (ambient) and incidental man-made/anthropogenic noise (apparent)) at a particular location. Species known to be affected are marine mammals and fish. The theoretical zones of noise influence (Richardson et al 1995) are temporary or permanent hearing loss, discomfort & injury; response; masking and detection. In extreme cases noise pressures may lead to death. The physical or behavioural effects are dependent on a number of variables, including the sound pressure, loudness, sound exposure level and frequency. High amplitude low and mid-frequency impulsive sounds and low frequency continuous sound are of greatest concern for effects on marine mammals and fish. Some species may be responsive to the associated particle motion rather than the usual concept of noise. Noise propagation can be over large distances (tens of kilometres) but transmission losses can be attributable to factors such as water depth and sea bed topography. Noise levels associated with construction activities, such as pile-driving, are typically significantly greater than operational phases (i.e. shipping, operation of a wind farm).
		Suggested benchmark	**Revised description / comment**
		Underwater noise: **Benthic species/habitat:** MSFD indicator levels (SEL or peak SPL) exceeded for 20% of days in calendar year **Fish/Birds/Mammals:** MSFD indicator levels (SEL or peak SPL) exceeded in areas used by features **Above water noise:** **Birds/Mammals:** Introduction of airborne noise above background levels during periods of site occupancy by the feature	**Underwater noise** – description and benchmarks remain the same. **Above water noise** **Pressure description:** Any loud noise made onshore or offshore by construction, vehicles, vessels, tourism, mining etc. that may disturb birds and reduce time spent in feeding or breeding area. Only relevant to birds and sea mammals that spend time on land for breeding purposes (haul-outs). It is unlikely to be relevant to habitat sensitivity assessments. **NB:** MSFD indicator (2010) states "the proportion of days within a calendar year, over areas of 15'N x 15'E/W in which anthropogenic sound sources exceed either of two levels, 183 dB re 1µPa2.s (i.e. measured as Sound Exposure Level, SEL) or 224 dB re 1µPa peak (i.e. measured as peak sound pressure level) when extrapolated to one metre, measured over the frequency band 10 Hz to 10 kHz"

Pressure theme	ICG-C Pressure	MB0102 benchmark	ICG-C description
Physical pressure (other)	Vibration	None	None
		Suggested benchmark	**Revised description / comment**
		Fish/Birds/Mammals: Particle motion equivalent for MSFD indicator levels (SEL or peak SPL) exceeded in areas used by features	**Pressure description** – none available The above pressure was introduced in the sensitivity assessment of mobile species. No equivalent has been proposed for benthic species or habitats.
Pressure theme	**ICG-C Pressure**	**MB0102 benchmark**	**ICG-C description**
Physical pressure (other)	Visual disturbance	None proposed	The disturbance of biota by anthropogenic activities, e.g. increased vessel movements, such as during construction phases for new infrastructure (bridges, cranes, port buildings etc.), increased personnel movements, increased tourism, increased vehicular movements on shore etc. disturbing bird roosting areas, seal haul out areas etc.
		Suggested benchmark	**Revised description / comment**
		Benthic species/Fish/Birds: daily duration of transient visual cues exceeds 10% of the period of site occupancy by the feature **Mammals:** Presence of activity within visual range of the feature	Visual disturbance is only relevant to species that respond to visual cues, for hunting, behavioural responses or predator avoidance, and that have the visual range to perceive cues at distance. It is particularly relevant to fish, birds, reptiles and mammals that depend on sight but less relevant to benthic invertebrates. The cephalopods are an exception but they are only likely to response to visual disturbance at close range (from e.g. divers). Sea horses are disturbed by photographic flash units but again at close range. It is unlikely to be relevant to habitat sensitivity assessments.
Pressure theme	**ICG-C Pressure**	**MB0102 benchmark**	**ICG-C description**
Pollution and other chemical changes	Organic enrichment	A deposit of 100gC/m^2/yr	Resulting from the degraded remains of dead biota & microbiota (land & sea); faecal matter from marine animals; flocculated colloidal organic matter and the degraded remains of: sewage material, domestic wastes, industrial wastes etc. Organic matter can enter marine waters from sewage discharges, aquaculture or terrestrial/agricultural runoff. Black carbon comes from the products of incomplete combustion (PIC) of fossil fuels and vegetation. Organic enrichment may lead to eutrophication (see also nutrient enrichment). Adverse environmental effects include deoxygenation, algal blooms, changes in community structure of benthos and macrophytes.
		Suggested benchmark	**Revised description / comment**
		As above	Direct evidence on the effect of organic enrichment was used to make sensitivity assessments by Tillin & Tyler-Walters (2014). In the absence of direct evidence, reference was made to the AMBI index, supplemented by any other relevant evidence on the effects of organic enrichment on habitats.

Pressure theme	ICG-C Pressure	MB0102 benchmark	ICG-C description
Pollution and other chemical changes	De-oxygenation	**MB0102 benchmark:** compliance with WFD criteria for good status **Fish/Birds/Mammals:** Compliance with WFD criteria for good status within site. "Note: Although compliance with established WFD criteria for good ecological status (GES) or good ecological potential (GEP) is likely to result in no direct effects on the features, local acute anoxic events on designated sites could have direct effect on water breathing features (fishes, molluscs, etc.)"	Any deoxygenation that is not directly associated with nutrient or organic enrichment. The lowering, temporarily or more permanently, of oxygen levels in the water or substrate due to anthropogenic causes (some areas may naturally be deoxygenated due to stagnation of water masses, e.g. inner basins of fjords). This is typically associated with nutrient and organic enrichment, but it can also derive from the release of ballast water or other stagnant waters (where organic or nutrient enrichment may be absent). Ballast waters may be deliberately deoxygenated via treatment with inert gases to kill non-indigenous species.
		Suggested benchmark	**Revised description / comment**
		Benthic species/habitat, fish: exposure to dissolved oxygen concentration of less than or equal to 2mg/l for 1 week.	Adopt a cut off of 2mg/l for one week, based on the WFD status of 'poor' to 'bad' in marine waters and the 'action levels' for transitional waters (UKTAG, 2014). The benchmark was originally used in MarLIN sensitivity assessments. Dissolved oxygen levels less relevant air breathing birds, reptiles and mammals.

Pressure theme	ICG-C Pressure	MB0102 benchmark	ICG-C description
Pollution and other chemical changes	Introduction of other substances (solid, liquid or gas)	None proposed	The 'systematic or intentional release of liquids, gases …' (from MSFD Annex III Table 2) is being considered e.g. in relation to produced water from the oil industry. It should therefore be considered in parallel with P1, P2 and P3.
	Nutrient enrichment	Compliance with WFD criteria for good status	Increased levels of the elements nitrogen, phosphorus, silicon (and iron) in the marine environment compared to background concentrations. Nutrients can enter marine waters by natural processes (e.g. decomposition of detritus, riverine, direct and atmospheric inputs) or anthropogenic sources (e.g. waste water runoff, terrestrial/agricultural runoff, sewage discharges, aquaculture, atmospheric deposition). Nutrients can also enter marine regions from 'upstream' locations, e.g. via tidal currents to induce enrichment in the receiving area. Nutrient enrichment may lead to eutrophication (see also organic enrichment). Adverse environmental effects include deoxygenation, algal blooms, changes in community structure of benthos and macrophytes.
	Hydrocarbon & PAH contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC.	Compliance with all AA EQS, conformance with PELs, EACs/ER-Ls	Increases in the levels of these compounds compared with background concentrations. Naturally occurring compounds, complex mixtures of two basic molecular structures: - straight chained aliphatic hydrocarbons (relatively low toxicity and susceptible to degradation) - multiple ringed aromatic hydrocarbons (higher toxicity and more resistant to degradation) These fall into three categories based on source (includes both aliphatics and polyaromatic hydrocarbons): - petroleum hydrocarbons (from natural seeps, oil spills and surface water run-off) - pyrogenic hydrocarbons (from combustion of coal, woods and petroleum) - biogenic hydrocarbons (from plants & animals) Ecological consequences include tainting, some are acutely toxic, carcinomas, growth defects.
	Radionuclide contamination	An increase in 10µGy/h above background levels	Introduction of radionuclide material, raising levels above background concentrations. Such materials can come from nuclear installation discharges, and from land or sea-based operations (e.g. oil platforms, medical sources). The disposal of radioactive material at sea is prohibited unless it fulfils exemption criteria developed by the International Atomic Energy Agency (IAEA), namely that both the following radiological criteria are satisfied: (i) the effective dose expected to be incurred by any member of the public or ship's crew is 10 µSv or less in a year; (ii) the collective effective dose to the public or ship's crew is not more than 1 man Sv per annum, then the material is deemed to contain de minimis levels of radioactivity and may be disposed at sea pursuant to it fulfilling all the other provisions under the Convention. The individual dose criteria are placed in perspective (i.e. very low), given that the average background dose to the UK population is ~2700 µSv/a. Ports and coastal sediments can be affected by the authorised discharge of both current and historical low-level radioactive wastes from coastal nuclear establishments.

	Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals). Includes those priority substances listed in Annex II of Directive 2008/105/EC.	Compliance with all AA EQS, conformance with PELs, EACs, ER-Ls	Increases in the levels of these compounds compared with background concentrations. Synthesised from a variety of industrial processes and commercial applications. Chlorinated compounds include polychlorinated biphenols (PCBs), dichlor-diphenyl-trichloroethane (DDT) & 2,3,7,8-tetrachlorodibenzo(p)dioxin (2,3,7,8-TCDD) are persistent and often very toxic. Pesticides vary greatly in structure, composition, environmental persistence and toxicity to non-target organisms. Includes: insecticides, herbicides, rodenticides & fungicides. Pharmaceuticals and Personal Care Products originate from veterinary and human applications compiling a variety of products including, Over the counter medications, fungicides, chemotherapy drugs and animal therapeutics, such as growth hormones. Due to their biologically active nature, high levels of consumption, known combined effects, and their detection in most aquatic environments they have become an emerging concern. Ecological consequences include physiological changes (e.g. growth defects, carcinomas).
	Transition elements & organo-metal (e.g. TBT) contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC.	Compliance with all AA EQS, conformance with PELs, EACs, ER-Ls	The increase in transition elements levels compared with background concentrations, due to their input from land/riverine sources, by air or directly at sea. For marine sediments the main elements of concern are Arsenic, Cadmium, Chromium, Copper, Mercury, Nickel, Lead and Zinc Organo-metallic compounds such as the butyl tins (Tri butyl tin and its derivatives) can be highly persistent and chronic exposure to low levels has adverse biological effects, e.g. Imposex in molluscs.
		Suggested benchmark	**Revised description / comment**
		Pollutant pressure benchmark: Adopt the MarLIN, qualitative , evidence based approach (see section 4)	Therefore, 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 low resistance; • 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 moderate resistance; • evidence of sub-lethal effects or reduced reproductive potential of a population of the species or community of interest will be assessed as high resistance. The evidence used is stated in the review. Where the assessment can be based on a known activity or impact (e.g. accidental release) 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.

Pressure theme	ICG-C Pressure	MB0102 benchmark	ICG-C description
Biological pressures	Genetic modification & translocation of indigenous species	Translocation outside of a geographic areas; introduction of hatchery – reared juveniles outside of geographic area from which adult stick derives	Genetic modification can be either deliberate (e.g. introduction of farmed individuals to the wild, GM food production) or a by-product of other activities (e.g. mutations associated with radionuclide contamination). Former related to escapees or deliberate releases e.g. cultivated species such as farmed salmon, oysters, scallops if GM practices employed. Scale of pressure compounded if GM species "captured" and translocated in ballast water. Mutated organisms from the latter could be transferred on ships hulls, in ballast water, with imports for aquaculture, aquaria, live bait, species traded as live seafood or 'natural' migration.
		Suggested benchmark	**Revised description / comment**
		Benthic species / habitats, fish: Translocation of indigenous species and/or introduction of genetically modified or genetically different populations of indigenous species that may result in changes in genetic structure of local populations, hybridization, or change in community structure.	Genetic modification can be either deliberate (e.g. introduction of farmed individuals to the wild, GM food production) or a by-product of other activities (e.g. mutations associated with radionuclide contamination). The former is related to escapees or deliberate releases e.g. cultivated species such as farmed salmon, oysters, and scallops if GM practices or breeding programmes are employed. The scale of pressure is compounded if GM species "captured" and translocated in ballast water. GM species could be transferred on ships hulls, in ballast water, with imports for aquaculture, aquaria, live bait, species traded as live seafood or 'natural' migration. The pressure also relates to the translocation of indigenous species which may compete with local populations of species, alter the community of the receiving habitat, or provide the opportunity for hybridization between similar species (e.g. *Spartina* spp. and *Mytilus* spp.).

Pressure theme	ICG-C Pressure	MB0102 benchmark	ICG-C description
Biological pressures	Introduction of microbial pathogens	**SNCB Revised Benchmark:** the introduction of microbial pathogens *Bonamia* and *Martelia refringens* to an area where they are currently not present. **Bird/Fish/Mammal**: introduction of relevant microbial pathogens to an area where they are currently not present (e.g. Avian influenza virus, viral Haemorrhagic Septicaemia virus, etc.)	Untreated or insufficiently treated effluent discharges & run-off from terrestrial sources & vessels. It may also be a consequence of ballast water releases. In mussel or shellfisheries where seed stock is imported, 'infected' seed could be introduced, or it could be from accidental releases of effluvia. Escapees, e.g. farmed salmon could be infected and spread pathogens in the indigenous populations. Aquaculture could release contaminated faecal matter, from which pathogens could enter the food chain.
		Suggested benchmark	**Revised description / comment**
		Benthic species / habitats, Fish, Birds, Mammals: The introduction of relevant microbial pathogens or metazoan disease vectors to an area where they are currently not present (e.g. *Martelia refringens* and *Bonamia*, Avian influenza virus, viral Haemorrhagic Septicaemia virus).	Any significant pathogens or disease vectors relevant to species or the species that characterize biotopes/ habitats identified during the evidence review phase will be noted in the review text.

Pressure theme	ICG-C Pressure	MB0102 benchmark	ICG-C description
Biological pressures	Introduction or spread of non-indigenous species (NIS)	**MB0102 benchmark:** A significant pathway exists for introduction of one or more invasive non-indigenous species (NIS) (e.g. aquaculture of NIS, untreated ballast water exchange, local port, terminal harbour or marina); creation of new colonisation space >1ha. One or more NIS in Table C3 (Technical report) has been recorded in the relevant habitat. **Fish/Bird/Mammal:** A significant pathway exists for introduction or spread of one or more non indigenous invasive species; OR there is a potential for the introduction of highly invasive/impact species **SNCB revised benchmark:** the introduction of one of more invasive non-indigenous species (NIS)	The direct or indirect introduction of non-indigenous species, e.g. chinese mitten crabs, slipper limpets, Pacific oyster and their subsequent spreading and out-competing of native species. Ballast water, hull fouling, stepping stone effects (e.g. offshore wind farms) may facilitate the spread of such species. This pressure could be associated with aquaculture, mussel or shellfishery activities due to imported seed stock or from accidental releases.
		Suggested benchmark	**Revised description / comment**
		The introduction of one of more invasive non-indigenous species (NIS)	Adopt SNCB revision. Sensitivity assessment will be made against a prescribed list of NIS based on the GBNNSIP list of potential invasive species.

Pressure theme	ICG-C Pressure	MB0102 benchmark	ICG-C description
Biological pressures	Removal of non-target species	Removal of features through pursuit of a target fishery at a commercial scale	By-catch associated with all fishing activities. The physical effects of fishing gear on sea bed communities are addressed by the "abrasion" pressure type (D2) so B6 addresses the direct removal of individuals associated with fishing/ harvesting. Ecological consequences include food web dependencies, population dynamics of fish, marine mammals, turtles and sea birds (including survival threats in extreme cases, e.g. Harbour Porpoise in Central and Eastern Baltic).
		Suggested benchmark	**Revised description / comment**
		Removal of features or incidental non-targeted catch (by-catch) through targeted fishery, shellfishery or harvesting at a commercial or recreational scale.	By-catch associated with all fishing, harvesting and extraction activities. Ecological consequences include food web dependencies, population dynamics of fish, marine mammals, turtles and sea birds (including survival threats in extreme cases, e.g. Harbour Porpoise in Central and Eastern Baltic). The physical effects of fishing gear on sea bed communities are addressed by the "abrasion" pressure type so the pressure addresses the direct removal of individuals associated with fishing/ harvesting.

Pressure theme	ICG-C Pressure	MB0102 benchmark	ICG-C description
Biological pressures	Removal of target species	**MB0102 pressure benchmark:** Removal of target species that are features of conservation importance or sub-features of habitats of conservation importance at a commercial scale. **Fish:** Extraction of features as a target species removes 10% of the individuals from the population of the site under consideration **Birds:** Numbers of individuals of feature removed as target species equates to in excess of 10% of the rate of natural mortality of the population of the site under consideration e.g. increases annual mortality of that site's population of individuals from 10% to more than 11% **Mammals:** Removal of feature as a target species exceeds 10% of the rate of natural mortality	The commercial exploitation of fish & shellfish stocks, including smaller scale harvesting, angling and scientific sampling. The physical effects of fishing gear on sea bed communities are addressed by the "abrasion" pressure type D2, so B5 addresses the direct removal / harvesting of biota. Ecological consequences include the sustainability of stocks, impacting energy flows through food webs and the size and age composition within fish stocks.
		Suggested benchmark	**Revised description / comment**
		Benthic species and habitats: removal of species targeted by fishery, shellfishery or harvesting at a commercial or recreational scale. **Fish, birds, and mammals:** as above.	As above, this pressure addresses only the ecological effects of removal of species and not the effects of the removal process on the species, community or habitat itself. In application, sensitivity will be assessed against the effects documented in the evidence base. Where a targeted species is characteristic of the biotope or habitat, then assessment will be made against the hypothetical removal of >25% of the population, where >25% represented the cut off between high and moderate resistance.

4 Suggestions and recommendations

The setting of pressure benchmarks is not an exact process. The following points are highlighted for clarification. Several points remain for discussion within the SNCBs and MarLIN steering Committee.

1. Benchmarks are either qualitative or quantitative.

The quantitative benchmarks describe a value for magnitude, extent and in some cases duration. These values are derived from literature review of the effects of activities that result in the pressure under consideration. In the sensitivity assessment process, these values can be compared with values in the evidence base, for example temperature, salinity and oxygen level tolerances, in order to assess resistance and hence sensitivity.

However, many benchmarks remain qualitative, that is, they describe a pressure or process, e.g. 'removal of non-target species', 'introduction of non-indigenous species', where the level of resistance is determined by the levels of damage or disturbance documented in the evidence base. In these cases, there is the danger that the sensitivity assessments do not compare 'like' with 'like' but care is taken to record the evidence used in detail.

In qualitative benchmarks, resistance (and hence sensitivity) is assessed against the available evidence for the effects of the pressure on the species 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 pressure benchmark will be ranked as low resistance;
- 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 pressure benchmark will be ranked as moderate resistance;
- evidence of sub-lethal effects or reduced reproductive potential of a population of the species or community of interest will be assessed as high resistance.

The evidence used is stated and cited in the review. Where the assessment can be based on a known activity or impact (e.g. accidental release) then this is stated.

2. We have assumed that the sensitivity to pressures from human activities alone is assessed.

For example, we have suggested that we only assess the effect of 'increases in temperature' as we cannot describe any human activities that would result in a decrease in temperature. Severe winters cause significant reductions in temperature but this is a natural event.

We need to confirm that the emphasis is on management of human activities rather than on information for site management, where knowledge of natural processes is also required.

3. We have assumed that 'change' refers to an increase and decrease in pressure, unless otherwise stated.

Therefore, for 'emergence', wave exposure', and 'water flow' we will assess the sensitivity to both an increase and a decrease in the pressure (and document the relevant evidence). For temperature, we suggest only assessing the effect of an increase (see point 2 above) and for 'salinity' to assess decrease and increase separately, as they have different magnitudes.

4. The physical pressures assume a single event, unless otherwise specified.
5. We have reintroduced two depths of penetration for sub-surface penetration, to better represent difference in gear types, and the sensitivity of deep-burrowing species.
6. We have divided 'change in substratum type' to include the change from hard or soft substrata when artificial hard substrata are introduced or hard, substrata are removed.

7. The ‘wave exposure’ benchmark will require further attention.

The current benchmark (a change in significant wave height) is based on the likely effects of artificial structures in the marine environment and their effects on wave climate. Significant wave height is dependent on the wind climate and fetch, seabed depth and slope. However the majority of the data available on the distribution of habitat types and their wave energy climate is based on the MNCR ‘wave exposure’ classification. This classification is a qualitative scale that synthesizes information on the wave climate (fetch, aspect, slope and depth) and substratum based on the dominant communities present. While ‘wave exposure’ is dependent on ‘wave climate’ the two measures are not directly comparable. We need further research to determine a ‘rule of thumb’ by which to compare the two types of information.

8. It is difficult to define meaningful benchmarks for the pollutant pressures,

It has always proved difficult to define practical benchmarks for the pollutant pressures (Tyler-Walters & Jackson, 1999; Tyler-Walters *et al.*, 20001). The range of chemicals is large and their effects are highly variable between species and moderated by the physicochemical conditions at the site of impact. In addition, the scale of effects vary between long term low level pollution, bioaccumulation, and short term high level pollution from spills and accidental releases. Also detailed ecotoxicology is limited to standard test species or easy to study species, while the effects of spills and accidental releases are documented for many species and habitats, together with long term effects on community recovery. As a result, the evidence base is diverse. Ideally, we could assess the sensitivity to species (and hence communities and habitats) to every potential chemical contaminant, but that would be impractical.

To date there are two main strategies to assess sensitivity.

A) In the MarLIN approach, the effects of a particular set of chemical contaminants (e.g. hydrocarbons) were reviewed, based on specific papers, and review articles, together with the effects of know spills/accidents.

This a qualitative approach. Therefore, 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 low resistance;
- 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 moderate resistance;
- evidence of sub-lethal effects or reduced reproductive potential of a population of the species or community of interest will be assessed as high resistance.

The evidence used is stated in the review. Where the assessment can be based on a known activity or impact (e.g. accidental release) 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 disadvantage of this approach is that it does not necessarily compare ‘like’ with ‘like’, since the effects vary with contaminant, and that the review process can be lengthy, unless carefully managed. The lack of benchmark means that sensitivity assessments between habitats are not comparable.

B) The MB0102 project decided to use compliance with the EQS or MAA levels (developed for WFD and IPC) as the basis for assessment. The EQS is set below observed levels of contaminant exposure know to have an ecological effect (see section 6.5.3). The EQSs’ are, therefore, precautionary. This is a practical approach as many of the contaminants (or classes of contaminants) associated with human activities have an EQS. But, the

benchmark does not 'discriminate' between species or habitats, as all species and habitats are 'not sensitive' by definition where the EQS's are met (compliance) and by inference 'sensitive' where compliance is not met.

C) MSFD Annex III – define the pressure as the 'introduction of a contaminant' but it is unclear how that definition is used to assess sensitivity.

Therefore, we suggest that we adopt the MarLIN approach, and document reported effects of a range of contaminants under each pressure as the basis for assessment.

We believe that the resultant suggested list of pressure benchmark (Table 3.1 below) are practical and can be applied to the exiting evidence base in a systematic manner. However, we realize that they need confirmation by the SNCBs and MarLIN Steering Committee.

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6 Appendix 1. Review and discussion

6.1 Hydrological changes (inshore/local)

6.1.1 Emergence regime changes - local, including tidal level change considerations

MB0102 benchmark:

- *Intertidal species* (and habitats not uniquely defined by intertidal zone): A 1 hour change in the time covered or not covered by the sea for a period of 1 year.
- *Habitats and landscapes defined by intertidal zone:* An increase in relative sea level or decrease in high water level of 1mm for one year over a shoreline length >1km.

ICG-C Pressure description: Changes in water levels reducing the intertidal zone (and the associated/dependant habitats). The pressure relates to changes in both the spatial area and duration that intertidal species are immersed and exposed during tidal cycles (the percentage of immersion is dependent on the position or height on the shore relative to the tide). The spatial and temporal extent of the pressure will be dependent on the causal activities but can be delineated. This relates to anthropogenic causes that may directly influence the temporal and spatial extent of tidal immersion, e.g. upstream and downstream of a tidal barrage the emergence would be respectively reduced and increased, beach re-profiling could change gradients and therefore exposure times, capital dredging may change the natural tidal range, managed realignment, saltmarsh creation. Such alteration may be of importance in estuaries because of their influence on tidal flushing and potential wave propagation. Changes in tidal flushing can change the sediment dynamics and may lead to changing patterns of deposition and erosion. Changes in tidal levels will only affect the emergence regime in areas that are inundated for only part of the time. The effects that tidal level changes may have on sediment transport are not restricted to these areas, so a very large construction could significantly affect the tidal level at a deep site without changing the emergence regime. Such a change could still have a serious impact. This excludes pressure from sea level rise which is considered under the climate change pressures.

Suggested pressure benchmark:

A change in the time covered or not covered by the sea for a period of ≥ 1 year **OR** an increase in relative sea level or decrease in high water level for ≥ 1 year.

Discussion & application: the benchmark is only relevant to the intertidal, excluding habitats below Chart Datum (CD). The pressure benchmark does not expressly identify the role of 'desiccation' but sensitivity to desiccation will be discussed where known or relevant. In application, the majority of intertidal communities are sensitivity to changes in emergence, whether it is for one or more hours, or a due to changes in sea level and coastal squeeze. Therefore, we have removed that part of the MB0102 benchmark. However, we've retained the duration on the assumption that the effects on most communities would probably take a year to become apparent.

6.1.2 Salinity changes- local

MB0102 benchmark:

- Increase in salinity from 35 to 38 units for one year
- Decrease in salinity by 4-10 units one year

ICG-C Pressure description: Events or activities increasing or decreasing local salinity. This relates to anthropogenic sources/causes that have the potential to be controlled, e.g. freshwater discharges from pipelines that reduce salinity, or brine discharges from salt caverns washings that may increase salinity. This could also include hydromorphological modification, e.g. capital navigation dredging if this alters the halocline, or erection of barrages

or weirs that alter freshwater/seawater flow/exchange rates. The pressure may be temporally and spatially delineated derived from the causal event/activity and local environment.

No changes are suggested to the benchmark or pressure description, however it would be useful when developing and presenting future assessments to **separate the two assessments**.

Application: There is little empirical evidence available to assess sensitivity of marine habitats to the increase benchmark except some extrapolated data from the impacts of desalination plants abroad and inferences from exposure to natural increases where enclosed water bodies are exposed to high levels of evaporation.

6.1.3 Temperature changes-local

MB0102 Benchmark: A 5°C change in temp for one month period, or 2°C for one year

ICG-C Pressure description: Events or activities increasing or decreasing local water temperature. This is most likely from thermal discharges, e.g. the release of cooling waters from power stations. This could also relate to temperature changes in the vicinity of operational sub-sea power cables. This pressure only applies within the thermal plume generated by the pressure source. It excludes temperature changes from global warming which will be at a regional scale (and as such are addressed under the climate change pressures).

Although human activities such as the abstraction of water as a coolant and subsequent discharge may generate plumes of heated water it is not clear that any human activities result in a decrease in water temperature.

If we are only assessing the effects of human activities, and not natural events (e.g. unusually cold winters, ice melt) it is therefore suggested that future sensitivity assessments only consider an increase in temperature.

Suggested revised benchmark: a 5°C increase in temp for one month period, or 2°C for one year

6.1.4 Water flow (tidal current) changes - local, including sediment transport considerations

MB0102 benchmark: benchmark changed from: A change in peak mean spring tide flow speed of between 0.1m/s to 0.2m/s over an area > 1km2 or 50% if width of water body for more than 1 year.

SNCB revised benchmark: a change in peak mean spring bed flow velocity of between 0.1m/s to 0.2m/s for more than 1 year.

ICG-C Pressure description: changes in water movement associated with tidal streams (the rise and fall of the tide, riverine flows), prevailing winds and ocean currents. The pressure is therefore associated with activities that have the potential to modify hydrological energy flows, e.g. tidal energy generation devices remove (convert) energy and such pressures could be manifested leeward of the device, capital dredging may deepen and widen a channel and therefore decrease the water flow, canalisation &/or structures may alter flow speed and direction; managed realignment (e.g. Wallasea, England). The pressure will be spatially delineated. The pressure extremes are a shift from a high to a low energy environment (or vice versa). The biota associated with these extremes will be markedly different as will the substrate, sediment supply/transport and associated seabed elevation changes. The potential exists for profound changes (e.g. coastal erosion/deposition) to occur at long distances from the construction itself if an important sediment transport pathway was disrupted. As such these pressures could have multiple and complex impacts associated with them.

Discussion

The MB0102 benchmark was selected on the basis that it was relevant to impact assessments where permitting and licensing would be informed by modelled predictions of changes in hydrography. However the mismatch between the activity information and available ecological evidence has meant the application of this benchmark has been challenging and largely reliant on proxies, such as the MNCR categories of water flow.

The MNCR categories for tidal regime are: very strong: >3m/sec; strong: 1.5-3m/sec; moderately strong: 0.5-1.5m/sec; weak: <0.5m/sec; very weak – negligible. The MarLIN benchmark was based on a change of two categories in water flow rate (view glossary) for 1 year; for example, from moderately strong (1-3 knots e.g. 0.5-1.5 m/s) to very weak (negligible). The magnitude of this benchmark is therefore far greater than the one adopted by Project MB0102.

No changes are suggested to the benchmark or pressure description.

Application: the evidence base for impacts of changes in water flows is limited. The water flow tolerances of relatively few species have been studied and most evidence is based on their habitat preferences, that is, tidal stream regime where the species is recorded. Most readily available information on habitats comes from the MNCR. As a proxy indicator of sensitivity evidence from biotope records (Connor *et al.*, 2004) for tidal stream categories was used to address gaps in assessments. For example, where a biotope occurs in two categories the natural variability in tidal stream experienced is a greater magnitude than the MB0102 pressure benchmark and the biotope was considered 'Not sensitive at the pressure benchmark' (Tillin & Tyler-Walters, 2014b).

Also, where a biotope occurs only in weak –negligible tidal streams it was considered potentially sensitive as the categories refer to a restricted range of flow speeds. However, where biotopes were recorded occur only in strong or moderately strong flow rates, the range of flow speeds is greater than the benchmark and the biotope was considered 'Not sensitive at the benchmark'.

Both a decrease and an increase in water flow were considered. However, at high water flow rates (e.g. strong tidal streams 1.5-3m/s) a change of 0.1-0.2m/s is probably not significant.

Evidence on the effects of change in water flow on the physical habitat (e.g. the erosion / accretion rates associated with sediments), or on characteristic species was taken into account, together with information on wave mediated water flow (e.g. in wave exposed conditions) was also taken into account. Habitats structured by wave action rather than water flow were considered not sensitive to changes in water flow at the MB0102 benchmark.

6.1.5 Wave exposure changes - local

MB0102 benchmark: A change in nearshore significant wave height >3% but <5%

ICG-C Pressure description: Local changes in wave length, height and frequency. 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 winds. Anthropogenic sources of this pressure include artificial reefs, breakwaters, barrages, wrecks that can directly influence wave action or activities that may locally affect the incidence of winds, e.g. a dense network of wind turbines may have the potential to influence wave exposure, depending upon their location relative to the coastline.

Discussion

Previous sensitivity assessments made by Project MB0102 (Tillin *et al.*, 2010) and for biogenic habitats (Gibb *et al.*, 2014, Mainwaring *et al.*, 2014) considered this pressure at the benchmark. The MarLIN biotope assessments also assessed this pressure at a different pressure benchmark: A change of two ranks on the wave exposure scale e.g., from exposed to

extremely exposed for a period of 1 year'. The magnitude of this benchmark is therefore far greater than the one adopted by Project MB0102.

The MB0102 benchmark was selected on the basis that it was relevant to impact assessments where permitting and licensing would be informed by modelled predictions of changes in hydrography. It is a process or activity based benchmark. The MarLIN benchmark was based on a level of change in wave exposure expected to result in changes in communities / biotopes.

The MNCR wave exposure scale is qualitative, based on prior work to describe wave exposure, and synthesizes the effects of aspect, fetch, profile and depth, tidal range and dominant communities into a single scale. Recent work by Burrows and co-workers (Burrows *et al.*, 2008, Burrows, 2012) has developed a GIS model for wave fetch, which has been used to demonstrate changes in community structure with increased exposure where exposure was defined by fetch and depth.

The difficulty for sensitivity assessment is that the MNCR habitat classification can provide a range of wave exposure for most of the biotope in the classification but that evidence in literature on changes communities to wave exposure is rarely expressed against the same scale. Similarly, wave height correlates with shore profile (reflective vs dissipative) and sediment type on beaches, but that little evidence relates changes in significant wave height to changes in communities. The MNCR wave exposure scale and measures of wave height are not directly comparable.

Suggested pressure benchmark: none suggested. Retain existing.

Application: clearly wave exposure increases with increasing significant/average wave height. In practice, we will refer to relevant oceanographic texts to develop a 'rule' of thumb' to compare wave height to the wave exposure scale and make assessments based on 'expert judgement'. Further research and case work examples are required.

6.2 Physical damage (Reversible change)

6.2.1 Changes in suspended solids & water clarity

MB0102 benchmark: A change in one Water Framework Directive (WFD) ecological status class for one year

SNCB revised benchmark: A change in one rank on the WFD (Water Framework Directive) scale e.g. from clear to turbid for one year

Fish/Bird/Mammal benchmark: a change in one Water Framework Directive (WFD) ecological status class for one year within site

ICG-C Pressure description: changes in water clarity from sediment & organic particulate matter concentrations. It is related to activities disturbing sediment and/or organic particulate matter and mobilising it into the water column. Could be 'natural' land run-off and riverine discharges or from anthropogenic activities such as all forms of dredging, disposal at sea, cable and pipeline burial, secondary effects of construction works, e.g. breakwaters. Particle size, hydrological energy (current speed & direction) and tidal excursion are all influencing factors on the spatial extent and temporal duration. This pressure also relates to changes in turbidity from suspended solids of organic origin (as such it excludes sediments - see the "changes in suspended sediment" pressure type). Salinity, turbulence, pH and temperature may result in flocculation of suspended organic matter. Anthropogenic sources are mostly short lived and over relatively small spatial extents.

Discussion

The WFD water turbidity ranks are shown in Table 6.1. The WFD scale describes turbidity in terms of mg/l suspended sediment but does not refer to changes in terms of light penetration

Table 6.1. Water turbidity ranks UKTAG, 2014 based on mean concentration of suspended particulate matter mg/l.

Water Turbidity	Definition
>300 mg/l	Very turbid
100-300 mg/l	Medium turbidity
10-100 mg/l	Intermediate
<10 mg/l	Clear

The ICG-C pressure description is unclear, since it is defined in terms of suspended sediment load, but goes on to say that turbidity from suspended sediment of organic origin, excludes suspended sediment.

The turbidity (clarity or opacity) of sea water is dependent on the concentration of substances that absorb or scatter light, including inorganic and organic particulates and dissolved coloured substances (Jerlov, 1976). Light penetration is vital to algal growth and the depth range of macroalgae and flowering plant communities. Recent work demonstrated a close relationship between light attenuation and suspended particulate levels (Devlin *et al.*, 2008).

Suggest pressure benchmark: adopt SNCB revised benchmarks **with minor revision.**

A change in one rank on the WFD (Water Framework Directive) scale e.g. from clear to intermediate for one year.

Suggested pressure description: changes water clarity (or turbidity) due to changes in sediment & organic particulate matter and chemical concentrations. It is related to activities disturbing sediment and/or organic particulate matter and mobilising it into the water column. It could be 'natural' land run-off and riverine discharges or from anthropogenic activities such as all forms of dredging, disposal at sea, cable and pipeline burial, secondary effects of construction works, e.g. breakwaters. Particle size, hydrological energy (current speed & direction) and tidal excursion are all influencing factors on the spatial extent and temporal duration. Salinity, turbulence, pH and temperature may result in flocculation of suspended organic matter. Anthropogenic sources are mostly short lived and over relatively small spatial extents. Changes in suspended sediment loads can also alter the scour experienced by species and habitats. Therefore, the effects of scour are also addressed here.

Application: in assessment evidence on the direct effects of light attenuation or suspended sediment loads on of characteristic species are taken into account, together with information on the habitat preferences of the community or biotope. Such evidence is usually derived from review articles for a wide range of species or from recent work on the effects of aggregate dragging. In general the magnitude and duration of changes in suspended solids associated with acute, sediment disturbing activities are well understood. For example, Churchill (1989) reported a plume of suspended material behind a shrimp trawl, up to 50 m behind the trawl with a concentration of 100-550 mg/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 200-500 m. However, the impacts on species and habitats at the pressure benchmark, which refers to a chronic level of exposure (a year) associated with changes in hydrodynamics and sediment transport that can arise with large scale barrage schemes and other infrastructure, are less well understood.

Habitat preferences based on the distribution of the biotope or community can be used to support a decision regarding sensitivity. For example, 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; cited in Cole *et*

al., 1999). However, suspended sediment concentrations in estuaries may be much higher; measured in grammes per litre. Coastal waters are likely to absorb 10-60% of incident light per metre at a wavelength of 500 nm (Kinne, 1970). If 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. Species or habitats found in estuarine waters are therefore inferred to have greater tolerances to increased suspended sediment.

In addition, information on any likely effects of scour resulting from increased suspended sediment in the water column is considered under this pressure.

6.2.2 Habitat structure changes - removal of substratum (extraction)

MB0102 benchmark: Extraction of sediment to 30 cm

SNCB revised benchmark: Extraction of substratum to 30 cm

Fish/Bird/Mammal: Extraction of sediment to 30cm; OR removal of >10% area/volume of biologically relevant structures (including water column habitat and biogenic forming structures) within site

ICG-C Pressure description: unlike the "physical change" pressure type where there is a permanent change in sea bed type (e.g. sand to gravel, sediment to a hard artificial substratum) the "habitat structure change" pressure type relates to temporary and/or reversible change, e.g. from marine mineral extraction where a proportion of seabed sands or gravels are removed but a residual layer of seabed is similar to the pre-dredge structure and as such biological communities could re-colonize; navigation dredging to maintain channels where the silts or sands removed are replaced by non-anthropogenic mechanisms so the sediment typology is not changed.

Discussion

Extraction of 30 cm sedimentary substrata is relatively straightforward to assess. For example, the dredging process actively removes the surface layer of sediment from the seabed. Two principal dredging methods are currently used in the UK – static dredging and trailer hopper suction dredging, which create different footprints in the seabed. Static dredging tends to create depressions in the seabed, which may reach 5-10m in depth. These coalesce over time to form an irregular bed topography. Trailer hopper suction dredging creates shallow furrows that may extend for several kilometres in length. The depressions are generally 2-3m wide and initially only around 0.5m deep. Over time however, the seabed may be lowered by up to 3m.

The pressure benchmark describes a process by which the sediment is removed, and the sensitivity assessment is made by reference to documented evidence of the effects of extraction or similar activities on the habitat.

Extraction of hard substrata poses another problem. In recent work for Natural England (Tillin & Tyler-Walters, 2014b), we assumed that it was possible to remove soft rock substrata (clays, peats, chalks) but that it was very unlikely that hard bedrock would be removed or subject to extraction. We do not know of any situations in which hard bedrock would be removed to a depth of 30cm, as coastal quarries tend to be coastal rather than truly marine. Therefore, we would include soft rock but exclude hard rock from the assessment.

The mobile species benchmark refer to removal of >10% of 'relevant habitat' or 'biologically relevant structures'. We believe that this is not relevant under this pressure. For benthic species the extraction of substratum is a direct physical impact. For mobile species, the extraction result in a loss of available substratum and the impact is indirect. Therefore, the

indirect impact of extraction of substratum is better dealt with under 'physical change' to or 'physical loss' of habitat, rather than under this pressure.

Suggested pressure benchmark: Extraction of substratum to 30cm (where substratum included sediments and soft rocks but excludes hard bedrock)

6.2.3 Abrasion/disturbance of the surface of the substratum or seabed

MB0102 Benchmark: Damage to seabed surface features

Fish/Bird/Mammal: Structural damage of >10% area/volume of biologically relevant structures (including biogenic forming structures) within site

ICG-C Pressure description: the disturbance of sediments where there is limited or no loss of substratum from the system. This pressure is associated with activities such as anchoring, taking of sediment/geological cores, cone penetration tests, cable burial (ploughing or jetting), propeller wash from vessels, certain fishing activities, e.g. scallop dredging, beam trawling. Agitation dredging, where sediments are deliberately disturbed by and by gravity and hydraulic dredging where sediments are deliberately disturbed and moved by currents could also be associated with this pressure type. Compression of sediments, e.g. from the legs of a jack-up barge could also fit into this pressure type. Abrasion relates to the damage of the sea bed surface layers (typically up to 50cm depth). Activities associated with abrasion can cover relatively large spatial areas and include: fishing with towed demersal trawls (fish and shellfish); bio-prospecting such as harvesting of biogenic features such as maerl beds where, after extraction, conditions for recolonization remain suitable or relatively localized activities including: seaweed harvesting, recreation, potting, aquaculture. Change from gravel to silt substratum would adversely affect herring spawning grounds.

Suggested pressure description: physical disturbance or abrasion of the surface of the substratum in sedimentary or rocky habitats. The effects are relevant to epiflora and epifauna living on the surface of the substratum. In intertidal and sublittoral fringe habitats, abrasion is likely to result from recreational access and trampling (inc. climbing) by human or livestock, vehicular access, moorings (ropes, chains), activities that increase scour and grounding of vessels (deliberate or accidental). In the sublittoral, surface abrasion is likely to result from pots or creels, cables and chains associated with fixed gears and moorings, anchoring of recreational vessels, objects placed on the seabed such as the legs of jack-up barges, and harvesting of seaweeds (e.g. kelps) or other intertidal species (trampling) or of epifaunal species (e.g. oysters). In sublittoral habitats, passing bottom gear (e.g. rock hopper gear) may also cause abrasion to epifaunal and epifloral communities, including epifaunal biogenic reef communities. Activities associated with abrasion can cover relatively large spatial areas e.g. bottom trawls or bio-prospecting or be relatively localized activities e.g. seaweed harvesting, recreation, potting, and aquaculture.

Application: the majority of the evidence on physical disturbance to sedimentary habitats is based on reports on the impacts of shellfisheries and fisheries. This evidence relates to penetrative activities. However, there is evidence on the effects of trampling, vehicular access, potting, creeling, and crab tiling, depending on habitat and species. The benchmark is qualitative and the sensitivity assessment is based on the likely level of damage determined by the evidence base.

6.2.4 Penetration and/or disturbance of the substratum below the surface of the seabed

MB0102 Benchmark: Damage to sub-surface seabed

Fish/Bird/Mammal: Structural damage of >10% area/volume of biologically relevant structures (including biogenic forming structures) within site

ICG-C Pressure description: (as 6.2.3 above).

Suggested pressure description: physical disturbance of the substratum by activities that penetrate the surface of the seabed, where there is limited or no loss of substratum from the system. This pressure is associated with activities such as taking of sediment/geological cores, cone penetration tests, cable burial (ploughing or jetting), propeller wash from vessels, certain fishing activities, e.g. scallop dredging, beam trawling. Agitation dredging, where sediments are deliberately disturbed by gravity and hydraulic dredging where sediments are deliberately disturbed and moved by currents could also be associated with this pressure type. Compression of sediments, e.g. from the legs of a jack-up barge could also fit into this pressure type. Penetration relates to the damage of the sea bed surface layers (typically up to 50cm depth). Activities such as fishing with towed demersal trawls (fish and shellfish); bio-prospecting such as harvesting of biogenic features such as maerl beds can cover large spatial areas.

Loss, removal or modification of the substratum is not included within this pressure (see the physical loss pressure theme). Penetration and damage to the soft rock substrata are considered, however the penetration into hard bedrock is deemed unlikely.

Discussion

The majority of the evidence on which to base sensitivity assessment comes from literature on the effects of fishing (fin-fish and shellfish). However, it may be sensible to divide this benchmark to distinguish between the effects of bottom gears that penetrate the surface of the substratum (otter, beam trawls) rather than those that penetrate deeply (e.g. suction or hydraulic dredging). The depth of penetration also affects the sensitivity of species that live in deep rather than shallow burrows.

The original MB0102 benchmarks distinguished two depths of penetration; <2.5 cm and >2.5 cm. we need to confirm that these cut-off points match defined gear types. Surface disturbance, can create tracks on the seabed, re-suspend sediments and reduce habitat complexity by smoothing out structures and displacing and overturning any larger cobbles or boulders present as well as flattening biogenic structures. Fishing gear may penetrate deeper in mud sediments than in other coarser habitat types, beam trawls have been reported to penetrate to 1 cm in sandy ground and 3 cm in muds (De Groot, 1995). Tracks from otter trawls may still be visible in muddy sediments in sheltered areas after 18 months (Lindeboom & De Groot, 1998). Scallop dredging can disturb the top 10 cm of sediment. Disturbance by scallop dredging flattens the surface as pits and depressions are filled in and mounds are removed (Currie & Parry, 1996). These physical changes as well as the track marks may still be present months later depending on the conditions at the site. Where there is little current movement the tracks may be visible for a long time and even a relatively minor fishery may have a significant cumulative effect on bottom microtopography (Caddy, 1973).

In general, the macrofauna and near-surface infauna of subtidal muds are susceptible to physical disturbance from bottom fishing gears (i.e. beam trawls, scallop dredges, otter trawls, seine netting, hydraulic suction dredges) (Hall *et al.*, 2008 and references therein; see also reviews by Kaiser *et al.*, 2002, Kaiser *et al.*, 2006; Johnson, 2002, and Thrush & Dayton, 2002).

Otter boards plough a groove in the seabed, which can vary from a few cm to 30 cm deep (Jones, 1992, references therein). The trawl may remove or damage sedentary organisms and displace stones. Bobbins and chains can also leave tracks (Krost *et al.*, 1990) and remove surface sediment. The disturbance depth depends on board weight, angle of tow and the nature of the substrate (Jones 1992). Sediment recovery time and infilling will depend on local hydrodynamics and the substratum. Beam trawls leave detectable marks on the seabed. The duration that the beam trawl marks remain visible depends on the upper sediment layer and on the hydrographic conditions. On the seabed consisting of medium to coarse sand, tracks have been observed to remain visible for up to 6 days. On sediments with mainly finer particles a corresponding figure of 37 hours was observed.

Suggested pressure benchmarks:

- physical disturbance of the substratum to a depth of ≤5 cm
- physical disturbance of the substratum to a depth of >5 cm

Application: the degree of damage due penetrative activates described in the evidence dbase is used to determine the sensitivity assessment. The activities resulting in damage are clearly described in the summary of evidence presented in support of the assessment.

6.2.5 Smothering and siltation rate changes (depth of vertical sediment overburden)

MB0102 Benchmark:

- 'Light' deposition of up to 5 cm of fine material added to the seabed in a single event
- 'Heavy' deposition of up to 30 cm of fine material added to the seabed in a single event

Fish/Bird/Mammal:

- up to 5 cm of fine material added to the seabed in a single event within site
- up to 30 cm of fine material added to the seabed in a single event within site

ICG-C Pressure description: when the natural rates of siltation are altered (increased or decreased). Siltation (or sedimentation) is the settling out of silt/sediments suspended in the water column. Activities associated with this pressure type include mariculture, land claim, navigation dredging, disposal at sea, marine mineral extraction, cable and pipeline laying and various construction activities. It can result in short lived sediment concentration gradients and the accumulation of sediments on the sea floor. This accumulation of sediments is synonymous with "light" smothering, which relates to the depth of vertical overburden.

"Light" smothering relates to the deposition of layers of sediment on the seabed. It is associated with activities such as sea disposal of dredged materials where sediments are deliberately deposited on the sea bed. For "light" smothering most benthic biota may be able to adapt, i.e. vertically migrate through the deposited sediment.

"Heavy" smothering also relates to the deposition of layers of sediment on the seabed but is associated with activities such as sea disposal of dredged materials where sediments are deliberately deposited on the sea bed. This accumulation of sediments relates to the depth of vertical overburden where the sediment type of the existing and deposited sediment has similar physical characteristics because, although most species of marine biota are unable to adapt, e.g. sessile organisms unable to make their way to the surface, a similar biota could, with time, re-establish. If the sediments were physically different this would fall under physical change.

Discussion

Most benthic organisms live in the top 10cm of the seabed and must maintain some connection to the sediment-water interface for ventilation and feeding Miller *et al.*, 2002. Organisms have various capabilities for moving upward through newly deposited sediments, such as dredged material, to reoccupy positions relative to the sediment-water interface that are similar to those maintained prior to burial by the disposal activity. The depth of sediment overburden that benthic biota can tolerate is both trophic group and particle size/sediment type dependant Bolam *et al.*, 2010. The level of effect is system specific as natural adaptations can determine sensitivity to smothering effects. The depth of siltation at the benchmark level for 'High' siltation is relatively high. Many species are adapted to re-surface from thin deposits but 30cm is a substantial deposit.

In high energy systems, the effects are relatively small as many of the species are capable of migrating up through the deposited sediments (Bijkerk, 1988 cited in Essink, 1999, Wilber *et al.*, 2007) as they are adapted to natural, high levels of background erosion and deposition.

Relocation/disposal in high energy systems like tidal estuaries or coasts has less effect than relocation/disposal in low energy systems, for example lagoons. The effects are also mediated by the thickness of deposition and the intensity and frequency of deposition events, slower addition of thin layers has been shown to be better tolerated than the same thickness of sediment deposited in a single event. An analysis of data from 18 disposal sites (intertidal and subtidal), confirmed that long-term impacts were disposal site specific and varied according to the prevailing hydrodynamic regime, ecological condition and the disposal activity (mode, timing, quantity, frequency and type of material) (Bolam *et al.*, 2006). This variability means that it is difficult to predict generalised impacts (Bolam *et al.*, 2006).

Bijkerk (1988, cited in Essink, 1999) compared results obtained at higher and lower temperatures (cf. summer and winter). At lower temperatures mortality among macrozoobenthos was lower and there was a higher tolerance of low oxygen conditions. The percentage of animals escaping from burial by crawling upward through the deposited sediment, however, was always lower at lower temperatures. These results are related to seasonal differences in metabolic activity.

Suggested pressure benchmark: split benchmark adopt to original MB0102 benchmarks (above)

Application: there is a reasonable evidence base on which to base assessment. Recent work by Last *et al.* (2011) has augmented the evidence base. Duration, is a vital component, but as shown above is related to the hydrography of the site. Therefore, in the assessment process the energy of the habitat (wave and tidal regimes) is taken into account. It is assumed therefore that smothering does not persist in areas of high energy but may be retained for significant periods in areas of low energy.

Dredging may contain contaminants although levels will be monitored as part of licensing stages. This effect is not considered in this review. Similarly, sediments removed by dredging and subsequently deposited may be anoxic and this effect is also not considered within this section.

The benchmark refers to a single event and it is therefore assumed that the siltation event is a discrete, pulse event where fine sediments are added in a short period of time so that the receiving habitat experiences burial to a depth of five or 30 cm. This contrasts with low levels of chronic siltation from activities, where accumulation is prevented by removal over tidal cycles, or the rate of accretion is so low that animals can continually reposition within sediments.

6.3 Physical loss (permanent change)

6.3.1 Physical loss (to land or freshwater habitat)

MB0102 benchmark: permanent loss of existing saline habitat

Fish/Birds/Mammals: permanent loss of existing saline habitat within site

ICG-C Pressure description: the permanent loss of marine habitats. Associated activities are land claim, new coastal defences that encroach on and move the Mean High Water Springs mark seawards, the footprint of a wind turbine on the seabed, dredging if it alters the position of the halocline. This excludes changes from one marine habitat type to another marine habitat type.

Suggested pressure benchmark: No change

All marine habitats and benthic species are considered to have a resistance of 'None' to this pressure and to be unable to recover from a permanent loss of habitat (resilience is 'Very Low'). All habitats would therefore be considered sensitive to this pressure.

6.3.2 Physical change (to another seabed type)

MB0102 benchmark: Change in 1 folk class for 2 years

Fish/Birds/Mammals: >10% habitat type change within site

ICG- C Pressure description: the permanent change of one marine habitat type to another marine habitat type, through the change in substratum, including to artificial (e.g. concrete). This therefore involves the permanent loss of one marine habitat type but has an equal creation of a different marine habitat type. Associated activities include the installation of infrastructure (e.g. surface of platforms or wind farm foundations, marinas, coastal defences, pipelines and cables), the placement of scour protection where soft sediment habitats are replaced by hard/coarse substrata habitats, removal of coarse substrata (marine mineral extraction) in those instances where surficial finer sediments are lost, capital dredging where the residual sedimentary habitat differs structurally from the pre-dredge state, creation of artificial reefs, mariculture i.e. mussel beds; and protection of pipes and cables using rock dumping and mattressing techniques. Placement of cuttings piles from oil & gas activities could fit this pressure type, however, there may be an additional pressures, e.g. "pollution and other chemical changes" theme. This pressure excludes navigation dredging where the depth of sediment is changes locally but the sediment typology is not changed (see 'extraction of sediment).

Discussion

The current benchmark for this pressure refers to a change in one Folk class in sediment type. The pressure benchmark originally developed by Tillin *et al.* (2010) used the modified Folk triangle developed by Long (2006) which simplified sediment types into four categories: mud and sandy mud, sand and muddy sand, mixed sediments and coarse sediments. The change referred to is therefore a change in sediment classification rather than a change in the finer-scale original Folk categories (Folk, 1954).

The change in one Folk class was considered by Tillin & Tyler-Walters (2014a) to relate to a change in classification only to adjacent categories in the modified Folk triangle. For habitats classified as mixed sediments or sand and muddy sand, a change in one folk class may therefore refer to a change to any of the sediment categories. However, for coarse sediment habitats resistance is assessed based on a change to either mixed sediments or sand and muddy sands but not mud and sandy muds. Similarly, muds and sandy muds are assessed based on a change to either mixed sediments or sand and muddy sand but not coarse sediment.

Where biotopes were described as 'muddy', for example, EUNIS biotope A5.325 '[*Capitella capitata*] and [*Tubificoides*] spp. in reduced salinity infralittoral muddy sediment' the benchmark was interpreted as referring to a change to mixed sediments, mud and sandy mud and sand and muddy sand but not to coarse sediments coarse sediments is not assessed this biotope would be considered to be 'Not sensitive' at the pressure benchmark.

While the pressure assessment considers sensitivity to a change in sediment type, it does not consider sensitivity to the pathways by which this change may occur. Changes in sediment or substratum type may occur through physical damage e.g. penetration and disturbance of the sediment and extraction which can remove relatively soft substratum such as chalk, peat or clay, lead to re-suspension of fine sediments which are removed by water currents resulting in coarser sediments or expose different types of substratum. Siltation may alter the character of the sediment or substratum through the addition of fine sediments.

However, the pressure description refers to a change to artificial substrata, so a new benchmark is required to address a significant change, e.g. the overlaying of sedimentary habitats by concrete, gabions, boulders etc. The latter benchmark is clearly significant and affected sedimentary habitat would be sensitive. .

Suggested pressure benchmark

- Change in 1 folk class
- Change from sedimentary or soft rock substrata to hard rock or artificial substrata

Application: Tillin & Tyler-Walters (2014) did not consider the change in one Folk class benchmark applicable to hard rock biotopes, but did assess the sensitivity of biotopes occurring on softer substrata, including chalk, peat, mud rock, and clay.

The new benchmark (change from sediment to hard rock or vice versa) would affect all types of substratum, and all habitats would be assessed as highly sensitive. This pressure assumes a permanent change, while short term smothering of substrata with sediment is addressed under smothering (siltation).

6.4 Physical pressures (other)

6.4.1 Barrier to species movement

MB0102 benchmark: 10% change in tidal excursion, or temporary barrier to species movement over ≥50% of water body width

Fish/birds: >10% of local population of a migratory feature affected by permanent or temporary lack of continuity of parts of the migration corridor

Mammals: Introduction of a permanent physical barrier in areas used by the feature

ICG-C Pressure description: The physical obstruction of species movements, including local movements (within & between roosting, breeding, feeding areas) and regional/global migrations (e.g. birds, eels, salmon, whales). Both include up-river movements (where tidal barrages & devices or dams could obstruct movements) or movements across open waters (offshore wind farm, wave or tidal device arrays, mariculture infrastructure or fixed fishing gears). Species affected are mostly birds, fish, mammals.

Discussion & application

Tidal excursion refers to the distance travelled by a water particle during a single tidal cycle (ebb and flow tide). The degree of tidal excursion may be reduced by barrages.

The habitat benchmark was initially developed by Project MB0102 and represents the medium pressure benchmark (see Introduction), the higher pressure benchmark referred to greater changes in tidal excursion and permanent barriers. It is suggested that the pressure benchmark currently in use is updated to refer to 'temporary or permanent barriers to species movement' to represent managed human activities and to be in line with the species benchmarks for fish, birds and mammals.

Suggested pressure benchmark: permanent or temporary barrier to species movement over ≥50% of water body width or a 10% change in tidal excursion.

The pressure is clearly relevant to mobile species such as fish, birds, reptiles and mammals . However, it should also be considered relevant to species or macrofauna such as crabs that undertake migrations to over-winter or to breed, and where populations are dependent on larval or other propagule supply from outside the site.

6.4.2 Death or injury by collision

MB0102 benchmark: 0.1% of tidal volume on average tide, passing through artificial structure

Birds/Mammals: Above water collision - introduction of aerial structures or devices that introduce collision risk in areas used by features

Fish/Birds Below water collision - 0.1% of tidal volume on average tide, passing through artificial structure

Mammals: Presence of propellered vessels (particularly ducted propellered vessels) and/or tidal power devices, OR 0.1% of tidal volume on average tide, passing through artificial structure

ICG-C Pressure description: Injury or mortality from collisions of biota with both static &/or moving structures. Examples include: collision with rigs (e.g. birds) or screens in intake pipes (e.g. fish at power stations) (static) or collisions with wind turbine blades, fish & mammal collisions with tidal devices and shipping (moving). Activities increasing number of vessels transiting areas, e.g. new port development or construction works will influence the scale and intensity of this pressure.

Suggested pressure benchmarks: – as above

Application: the benchmark relates to passage through an artificial structure and is therefore only relevant to mobile species and the mobile stages of benthic species, that is, larvae. Therefore, in assessment reference will be made to evidence on the effects of know barrage or turbine installations (e.g. Oosterschelde estuary). Collision with hard substrata caused by the grounding (accidental or deliberate) of vessels is assessed under physical damage.

6.4.3 Electromagnetic changes

MB0102 Benchmark: Local electric field of 1V m-1. Local magnetic field of 10μT within site

Fish/Bird/Mammals: Local electric field of 1V m-1. Local magnetic field of 10μT within site

ICG-C Pressure description: Localized electric and magnetic fields associated with operational power cables and telecommunication cables (if equipped with power relays). Such cables may generate electric and magnetic fields that could alter behaviour and migration patterns of sensitive species (e.g. sharks and rays).

Species sensitivity depends on the ability of the species to sense the electromagnetic field (EMF) and the degree to which this affects the species. Most work to date has concentrated on fish species although the evidence to assess likely impacts is limited and effects are therefore poorly understood (Gill & Bartlett, 2010). Arthropods are considered to demonstrate sensitivity to magnetic fields. Spiny lobsters (*Palinurus argus*) have been show experimentally to orient by the Earth's magnetic field when relocated from home habitat (Boles & Lohmann, 2003). No magneto or electro reception has so far been demonstrated in cephalopods (Williamson, 1995). In talitrids, different populations show different magnetic sensitivities, with Atlantic and Equatorial populations showing evidence of magnetic orientation but Mediterranean ones either weak or no response (Scapini & Quochi, 1992). In molluscs, magnetic orientation has been demonstrated for the opisthobranch *Tritonia diomedea* (Lohmann & Willows, 1987)

In general sessile species or those with low mobility may not have evolved sensitive electro or magneto receptors and may be unaffected by changes in these fields in terms of navigation and prey location. However these fields may have some physiological effects and some life stages e.g. larvae may be more sensitive than adults. Deleterious effects of super-high and low frequency electromagnetic radiation have been recorded for sea urchins (Shkuratov *et al.*, 1998, Ravera *et al.*, 2006). Ravera *et al.* (2006) found that threshold for formation of anomalous embryos was about 0.75 ± 0.01mT – which is lower than the pressure benchmark. Other physiological effects in animals exposed to magnetic fields include the induction of heat shock proteins in mussels (Malagoli *et al.*, 2004), and altered limb regeneration rates in fiddler crab (Lee & Weis, 1980).

Application: the evidence to assess these effects against the pressure benchmark is very limited and the impact of this pressure could not be assessed for benthic species or habitats (Tillin & Tyler-Walters, 2014a).

6.4.4 Introduction of light

MB0102 Benchmark: None

Fish/Birds/Mammals: 0.1 Lux change in diffuse irradiation during period of site occupancy by the feature; OR >3 distant strobe & point light sources visible over a 90° azimuth arc

ICG-C Pressure description: Direct inputs of light from anthropogenic activities, i.e. lighting on structures during construction or operation to allow 24 hour working; new tourist facilities, e.g. promenade or pier lighting, lighting on oil & gas facilities etc. Ecological effects may be the diversion of bird species from migration routes if they are disorientated by or attracted to the lights. It is also possible that continuous lighting may lead to increased algal growth.

Suggest pressure benchmark: adopt fish/bird/mammal benchmark for mobile species.

Application: the introduction of light is unlikely to be relevant for most benthic invertebrates, expect where it is possible to interfere with spawning cues. But we are not aware of evidence to that effect. The introduction of light could potentially be beneficial for immersed plants, but again we are not aware of any relevant evidence.

6.4.5 Litter

MB0102 Pressure benchmark: None

Fish/Birds/Mammals: Introduction of man-made objects able to cause physical harm (surface, water column, sea floor and/or strandline)

ICG-C Pressure description: Marine litter is any manufactured or processed solid material from anthropogenic activities discarded, disposed or abandoned (excluding legitimate disposal) once it enters the marine and coastal environment including: plastics, metals, timber, rope, fishing gear etc. and their degraded components, e.g. micro-plastic particles. Ecological effects can be physical (smothering), biological (ingestion, including uptake of micro-plastics; entangling; physical damage; accumulation of chemicals) and/or chemical (leaching, contamination).

Suggested pressure benchmark: introduction of man-made objects able to cause physical harm (surface, water column, sea floor and/or strandline).

Application: we are not aware of any evidence on the effects of 'litter' on benthic marine species. While there is documented evidence of the accumulation of micro-plastics in some species, no ecological effects have been shown to date. The only exception is the effect of ghost fishing on large crustaceans (crabs etc.). Therefore, the sensitivity to litter was not assessed for habitats and was scored 'No evidence' by Tillin & Tyler-Walters (2014a). Clearly it is relevant for large macrofauna such as fish, birds and mammals.

6.4.6 Underwater noise

MB0102 Pressure benchmark: MSFD indicator levels (SEL or peak SPL) exceeded for 20% of days in calendar year

Fish/Birds/Mammals: MSFD indicator levels (SEL or peak SPL) exceeded in areas used by features

ICG-C Pressure description: increases over and above background noise levels (consisting of environmental noise (ambient) and incidental man-made/anthropogenic noise (apparent)) at a particular location. Species known to be affected are marine mammals and fish. The theoretical zones of noise influence (Richardson *et al.*, 1995) are temporary or permanent hearing loss, discomfort & injury; response; masking and detection. In extreme cases noise pressures may lead to death. The physical or behavioural effects are dependent on a number of variables, including the sound pressure, loudness, sound exposure level and frequency.

High amplitude low and mid-frequency impulsive sounds and low frequency continuous sound are of greatest concern for effects on marine mammals and fish. Some species may be responsive to the associated particle motion rather than the usual concept of noise. Noise propagation can be over large distances (tens of kilometres) but transmission losses can be attributable to factors such as water depth and sea bed topography. Noise levels associated with construction activities, such as pile-driving, are typically significantly greater than operational phases (i.e. shipping, operation of a wind farm).

NB: MSFD indicator (2010) states "the proportion of days within a calendar year, over areas of 15'N x 15'E/W in which anthropogenic sound sources exceed either of two levels, 183 dB re 1µPa2.s (i.e. measured as Sound Exposure Level, SEL) or 224 dB re 1µPa peak (i.e. measured as peak sound pressure level) when extrapolated to one metre, measured over the frequency band 10 Hz to 10 kHz"

Suggested pressure benchmark: – no change

6.4.7 Above water noise

MB0102 Pressure benchmark: none

Birds/Mammals: Introduction of airborne noise above background levels during periods of site occupancy by the feature

SNCB Pressure description: Any loud noise made onshore or offshore by construction, vehicles, vessels, tourism, mining etc. that may disturb birds and reduce time spent in feeding or breeding area.

Suggested pressure benchmark: adopt above

Application: only relevant to birds and sea mammals that spend time on land for breeding purposes (haul-outs). It is unlikely to be relevant to habitat sensitivity assessments.

6.4.8 Vibration

MB0102 Pressure benchmark: none

Fish/Birds/Mammals: Particle motion equivalent for MSFD indicator levels (SEL or peak SPL) exceeded in areas used by features

Pressure description – none available

The above pressure was introduced in the sensitivity assessment of mobile species. No equivalent has been proposed for benthic species or habitats.

6.4.9 Visual disturbance

MB0102 Pressure benchmark: none

Fish/Birds: daily duration of transient visual cues exceeds 10% of the period of site occupancy by the feature

Mammals: Presence of activity within visual range of the feature

ICG-C Pressure description: The disturbance of biota by anthropogenic activities, e.g. increased vessel movements, such as during construction phases for new infrastructure (bridges, cranes, port buildings etc.), increased personnel movements, increased tourism, increased vehicular movements on shore etc. disturbing bird roosting areas, seal haul out areas etc.

Suggested pressure benchmark: adopt above for fish/birds and mammals.

Application: visual disturbance is only relevant to species that respond to visual cues, for hunting, behavioural responses or predator avoidance, and that have the visual range to perceive cues at distance. It is particularly relevant to fish, birds, reptiles and mammals that

depend on sight but less relevant to benthic invertebrates. The cephalopods are an exception but they are only likely to response to visual disturbance at close range (from e.g. divers). Sea horses are disturbed by photographic flash units but again a close range. It is unlikely to be relevant to habitat sensitivity assessments.

6.5 Pollution and other chemical changes

6.5.1 Organic enrichment

MB0102 Pressure benchmark: A deposit of 100gC/m^2/yr.

ICG-C Pressure description: Resulting from the degraded remains of dead biota and microbiota (land and sea); faecal matter from marine animals; flocculated colloidal organic matter and the degraded remains of: sewage material, domestic wastes, industrial wastes etc. Organic enrichment may lead to eutrophication. Adverse environmental effects include deoxygenation, algal blooms, changes in community structure of benthos and macrophytes.

MSFD Annex III: inputs of organic matter (e.g. sewers, mariculture, riverine inputs).

Discussion

The impacts of this pressure will be altered by the magnitude and frequency of exposure. Adding 100gC in a single event may also lead to siltation impacts whereas chronic addition of smaller amounts may be readily absorbed by the habitat.

The response of benthic invertebrate communities to increasing inputs of organic material has been characterized by Pearson and Rosenberg (1978). There are two distinct phases in the response often referred to as organic enrichment and organic pollution.

Organic enrichment encourages the productivity of suspension and deposit feeding detritivores and allows other species to colonize the affected area to take advantage of the enhanced food supply. The benthic invertebrate community response is characterised by increasing numbers of species, total number of individuals and total biomass.

Organic pollution occurs when the rate of input of organic matter exceeds the capacity of the environment to process it, and leads to other pressures being exerted on the habitat. Commonly, there is an accumulation of organic matter on the sediment surface that smothers organisms, depletes the oxygen concentrations in the sediment and sometimes the overlying water which in turn changes the sediment geochemistry and increases the exposure of organisms to toxic substances associated with organic matter. The benthic invertebrate community response is characterized by decreasing numbers of species, total number of individuals and total biomass and dominance by a few pollution tolerant annelids (Pearson and Rosenberg 1978).

It was not clear how the pressure benchmark may compare to natural levels of sedimentation and thresholds for effect. Therefore, evidence was sought on background levels of organic carbon input in the environment and any potential effect thresholds identified directly from habitat exposed to this pressure or experimentally.

The Marine Ecosystems Research Laboratory studied the fate and effects of sewage solids added to mesocosms. Organic loading rates less than 36gC m^2/yr. had little effect, rates between 36 and 365gC m^2/yr. enriched the sediment community, and a loading over 548gC m^2/yr. produced degraded conditions (Kelly and Nixon 1984, Frithsen et al 1987, Oviatt et al 1987, Maughanand Oviatt 1993, cited from Cromey *et al.*, 1998).

Eleftheriou *et al.* (1982) showed that the addition of 767gC m^2/yr. to an unpolluted sea loch enriched the sediment dwelling fauna whereas addition of 1498gC m^2/yr. caused degraded conditions. These values are higher than the mesocosm values as it is likely that more organic matter was lost in the open water system.

Observations and applications of a depositional, particle tracking model called DEPOMOD around salmon farms in Scotland and British Columbia have also shown that proportions of benthic fauna feeding groups based on the infaunal trophic index (ITI) changed significantly when organic sedimentation rates increased above specific thresholds Cromey *et al.*, 2002, Chamberlain & Stucchi, 2007. ITI values >50 (which correspond to little effect) were associated with predicted organic carbon fluxes <1gC m^2/day (i.e. 365 gC m^2/yr.) but ITI values decreased rapidly (<30, corresponding to an enriched community) as fluxes increased from 1 to 10gC m^2 /yr. (i.e. 365-3650gC m^2/yr.). The impact of adding organic matter will depend on the state of enrichment or pollution of the receiving environment and whether the additional loading leads to a tipping point. The results reported in Cromey et al (2002) and Eletheriou et al (1982) suggest that the addition of organic matter at the pressure benchmark may lead to slight enrichment effects, rather than gross organic pollution. For some ecological groups and species the AZTI Marine Biotic Index (AMBI) classification of disturbance effects, developed by Borja et al (2000) has been used as the basis for the assessment. There was greater confidence in assigning assessments of sensitivity for species that were indicated to be tolerant of organic enrichment. However, the evidence underlying the AMBI assessment was not clear and less confidence was given to sensitivity assessment based on the indicated intolerance to organic enrichment according to the AMBI index at the pressure benchmark.

Suggested pressure benchmark – no change

Application: direct evidence on the effect of organic enrichment was used to make sensitivity assessments by Tillin & Tyler-Walters (2014a). In the absence of direct evidence, the AMBI index was used, supplemented by any other relevant evidence on the effects of organic enrichment on habitats.

6.5.2 De-oxygenation

MB0102 Pressure benchmark: compliance with WFD criteria for good status

Fish/Birds/Mammals: Compliance with WFD criteria for good status within site. "Note: Although compliance with established WFD criteria for good ecological status (GES) or good ecological potential (GEP) is likely to result in no direct effects on the features, local acute anoxic events on designated sites could have direct effect on water breathing features (fishes, molluscs, etc.)"

ICG-C Pressure description: any deoxygenation that is not directly associated with nutrient or organic enrichment. The lowering, temporarily or more permanently, of oxygen levels in the water or substrate due to anthropogenic causes (some areas may naturally be deoxygenated due to stagnation of water masses, e.g. inner basins of fjords). This is typically associated with nutrient and organic enrichment, but it can also derive from the release of ballast water or other stagnant waters (where organic or nutrient enrichment may be absent). Ballast waters may be deliberately deoxygenated via treatment with inert gases to kill non-indigenous species.

Discussion & application:

Gray and 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. 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 2 mg/l for several months and the subsequent deaths of fish and benthos. Cole *et al.* (1999) suggested that he general quality assessment levels for estuaries were 8 mg/l, 4 mg/l and 2 mg/l). The WFD provides scores freshwater and marine water bodies as High to bad status based on oxygen levels, as shown in Table 6.2

Table 6.2 Dissolved oxygen standards for transitional and coastal waters (5-percentile, mg/l) UKTAG 2008.

	Freshwater	Marine	Description
High	7	5.7	Protects all life-stages of salmonid fish
Good	5-7	4.0 – 5.7	Resident salmonid fish
Moderate	3 - 5	2.4 – 4.0	Protects most life-stages of Non-salmonid adults
Poor	2 - 3	1.6 – 2.4	Resident non-salmonid fish, poor survival of salmonid fish
Bad	2	1.6	No salmonid fish. Marginal survival of resident species

UKTAG (2008) goes on to state that the dissolved oxygen levels at the freshwater end (of a transitional water body) should not fall below 2 mg/l for more than one 6 hours tidal cycle over a six year period.

There is considerable evidence on the effects on de-oxygenation in the marine environment due to ongoing work and reviews by Diaz and Rosenberg (refs). Therefore, we suggest a return to the MarLIN benchmark of a reduction in oxygen to ≤2mg/l for one week.

Suggested pressure benchmark: exposure to dissolved oxygen concentration of less than or equal to 2mg/l for 1 week.

6.5.3 Pollutants

General discussion

MB0102 decide to adopt compliance with the WFD and/or EQS levels for pollutants as the mid-point benchmarks used for the assessment. No benchmark was suggested for a low magnitude of pressure, the high-level was set as exceedance of EQS< 150% and compliance with a median environment effect range (ER-M). This type of benchmark was applied to:

synthetic and non-synthetic compounds (the benchmarks were subsequently separated further into Hydrocarbons and PAHs and transition elements and organo-metals after project MB0102 had reported);Alignment of pressure benchmarks with compliance standards used for environmental management (WFD) was also suggested for the pressures;

- deoxygenation, and
- nutrient enrichment.

The pollution pressures present particular challenges relating to the setting of a benchmark for several reasons:

i) the number of substances that marine species and habitats are potentially exposed to;
ii) the lack of biological effect data for many of these substances;
iii) dose, response curves being available for only a tiny proportion of invertebrate species;
iv) the lack of toxicity data for most species groups; and
v) that the evidence base for impacts is largely based on single species laboratory studies rather than ecological effects at the habitat level (although the effects of acute and chronic gross pollution events have been recorded for some substances).

The current benchmarks as used in MB0102 for the pollution pressures are based on compliance with existing standards as shown below in Table 6.3.

Table 6.3 Types of contaminant benchmark referred to within the pressure benchmarks, description and relevant directives or programmes.

Pollution targets	Description	Relevant directives / programmes
AA	Annual Average- protects against chronic (long-term effects). It is derived by analysing data from chronic (long term) toxicity tests and, in some cases, from field data.	EQSD, WFD
EAC	Environmental assessment criteria (EACs) are assessment tools used by OSPAR that are intended to represent the contaminant concentration in sediment and biota below which no chronic effects are expected to occur in marine species, including the most sensitive species.	OSPAR
EQS	Environmental Quality Standards- provide high levels of protection for all living organisms. EQS derived for the WFD may refer to long-term values- Annual Averages and short-term standards-Maximum Allowable Concentrations The short-term standard aims to protect against intermittent or short-lived periods of exposure and are often used in the assessments associated with particular incidents. They are not normally used in the context of routine monitoring and compliance assessment because, for most chemicals, the short-term risk is managed sufficiently through the achievement of the Annual Average.	EQSD
ER-L	Effects range low (ER-L) and effects range median (ERM) are concentrations derived from compiled biological toxicity assays and synoptic sampling of marine sediment. These values are used as sediment quality guidelines to help categorize the range of concentrations in sediment which effects are scarcely observed or predicted (below the ER-L)	N/A
MAC	Maximum Allowable Concentration- protects against short-term effects and is based on analysis of data on acute (short-term) toxicity.	EQSD, WFD
PNEC	Predicted no effects concentration- precautionary, derived value, below a concentration that will have an effect.	WFD
PEL	Probable effect level (PEL), defines the level above which adverse effects are expected to occur frequently.	Canadian Sediment Quality Guidelines

The monitoring and regulatory framework for pollutants in UK waters is largely based on the Water Framework Directive (WFD -Directive 2000/60/EC), the Environmental Quality Standard Directive (EQSD-Directive 2008/105/EC) and OSPAR. The Water Framework Directive 2000/60/EC establishes limits, Environmental Quality Standards, (EQS) for 33 priority substances (including 13 priority hazardous substances) and an additional 8 substances regulated under previous legislation. Two types of EQS are set annual average concentrations (AA) and Maximum Allowable Concentrations (MAC). The chemical status assessment is used alongside the ecological status assessment to determine the overall quality of a water body. In addition, EQSs are used to set discharge permits to water bodies, so that chemical emissions do not lead to EQS exceedance within the receiving water.

Adopting an approach to benchmarking based on pre-existing standards meant that the benchmarks were quantitative and integrated with management and policy. The approach taken was considered useful to support case work as it was set within the regulatory framework, and based on meaningful, evidence derived benchmarks, developed and reviewed by experts. The steering group, however, has raised concerns that, as the benchmarks are set as 'compliance' with existing standards that the sensitivity assessments, by default, are 'Not

Sensitive'. The sections below outline a number of options for revising the benchmark and the sensitivity scores that are likely to result.

The number of substances that are recognised as contaminants means that a single generic benchmark concentration would not be appropriate for use. For example, approximately 97 compounds or broad classes of compounds are prioritised by OSPAR, HELCOM and WFD.

Setting substance specific benchmarks would be possible but the basis for these would need to be decided, e.g. whether the benchmark level refers to the minimum levels where impacts have been observed, or levels from reported spills etc. As the evidence base regarding biological effects for most priority substances is laid out in reports detailing the derivation of standards for permitting and regulatory frameworks, indicator development and monitoring it would be possible to utilise these sources. This would however, be time-consuming and direct effort away from other pressure assessments.

Although a minimum detectable level has been suggested as a benchmark it should be noted that this would be lower than the compliance benchmark and therefore most, if not all, assessments made on this basis would be 'Not Sensitive'.

The steering group have also suggested that benchmarks could be set as non-compliance, although the level of non-compliance that should be considered was not indicated. It should be noted that levels for standards, such as the water column annual averages, are developed using an Assessment Factor to derive a predicted no effect concentration that is lower than the observed effects concentration to derive the EQS. The EQS is therefore precautionary, particularly where a high Assessment Factor has been used to scale the EQS where data is limited and based on the most sensitive organisms (UK TAG). For example, an assessment factor of 10 would mean that the EQS was set at one tenth of the value observed to produce an effect. To set the pressure benchmark at the observed effect level for the most sensitive organisms would therefore set the benchmarks at greater concentrations than are currently used. As this benchmark would relate to the most sensitive organisms, some groups would still be 'Not sensitive', based on toxicity evidence, at the pressure benchmark. If this benchmark was adopted the available evidence would be most likely to refer to, at most, a restricted number of species groups and deriving a sensitivity assessment for most biotopes, based on limited species evidence would be challenging.

Given the integration of EQS with policy, management (through permitting) and determination of ecological status and monitoring through WFD/EQSD, MSFD and OSPAR, it is unclear what value would be derived from revising the pollution benchmarks. It has been suggested that setting the pollution benchmarks at a compliance level does not reflect ecological effects. However, it should be recognised that the basis of these assessments are biological effects as they are set with regard to threshold levels determined largely from ecotoxicity testing or biomonitoring. We are concerned that re-setting these levels would challenge existing standards used to protect the environment, sending a message to operators that levels of contamination, exceeding current legislative targets would not lead to impacts.

An additional advantage of the current, unrevised current MB0102 benchmarks are their flexibility to include new contaminants with EQS where these are identified as significant. For example the anticipated revision to the EQSD in 2015 will require 15 additional substances to be considered.

6.5.4 Nutrient enrichment

MB0102 Pressure benchmark: compliance with WFD criteria for good status

MSFD Annex III: inputs of fertilisers and other nitrogen - and phosphorous-rich substances (e.g. from point and diffuse sources, including agriculture, aquaculture, atmospheric deposition)

Fish/Birds/Mammals: compliance with WFD criteria for good status within site. Note: Although compliance with established WFD criteria for good ecological status (GES) or good ecological potential (GEP) is likely to result in no effects on the features, the accidental introduction of large quantities of nutrients on designated sites could result in severe eutrophication and have indirect effects on features

ICG-C Pressure description: increased levels of the elements nitrogen, phosphorus, silicon (and iron) in the marine environment compared to background concentrations. Nutrients can enter marine waters by natural processes (e.g. decomposition of detritus, riverine, direct and atmospheric inputs) or anthropogenic sources (e.g. waste water runoff, terrestrial/agricultural runoff, sewage discharges, aquaculture, atmospheric deposition). Nutrients can also enter marine regions from 'upstream' locations, e.g. via tidal currents to induce enrichment in the receiving area. Nutrient enrichment may lead to eutrophication (see also organic enrichment). Adverse environmental effects include deoxygenation, algal blooms, changes in community structure of benthos and macrophytes.

Suggested pressure benchmark: see recommendations (section 4)

6.5.5 Hydrocarbon & PAH contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC.

MB0102 Pressure benchmark: compliance with all AA EQS, conformance with PELs, EACs/ER-Ls

Fish/Bird/Mammals: Compliance with all AA EQS, conformance with PELs, EACs/ER-Ls within site. Note: Although compliance with established EQSs is likely to result in no direct toxic effects, the accidental introduction of large quantities of petroleum hydrocarbons on designated sites could have direct effects on bird features.

ICG-C Pressure description: Increases in the levels of these compounds compared with background concentrations. Naturally occurring compounds, complex mixtures of two basic molecular structures:

- straight chained aliphatic hydrocarbons (relatively low toxicity and susceptible to degradation)
- multiple ringed aromatic hydrocarbons (higher toxicity and more resistant to degradation)

These fall into three categories based on source (includes both aliphatics and polyaromatic hydrocarbons):

- petroleum hydrocarbons (from natural seeps, oil spills and surface water run-off)
- pyrogenic hydrocarbons (from combustion of coal, woods and petroleum)
- biogenic hydrocarbons (from plants & animals)

Ecological consequences include tainting, some are acutely toxic, carcinomas, growth defects.

Suggested pressure benchmark: see recommendations (section 4)

6.5.6 Introduction of other substances (solids, liquids and gases)

MB0102 Pressure benchmark: None proposed

MSFD Annex III: Introduction of other substances, whether solid, liquid or gas, in marine waters resulting from their systematic and/or international release into the marine environment, as permitted in accordance with other Community legislation and/or international conventions

ICG-C pressure description: The 'systematic or intentional release of liquids, gases '(from MSFD Annex III Table 2) is being considered e.g. in relation to produced water from the oil industry

Discussion

This pressure was not assessed by MB0102. We understand that the intention is for this pressure to refer to all contaminants not covered by the other pollution pressures. Within the review timescale it has not been possible to draw up a list of candidate substances. To progress this pressure, examples perhaps based on casework would be useful.

Suggested pressure benchmark: see recommendations (section 4)

6.5.7 Radionuclide contamination.

MB0102 benchmark: An increase in 10µGy/h above background levels.

Precautionary dose rate 10 µGy/h (microGrays per hour) from OSPAR (2008). These levels not encountered in OSPAR area. Dose rates of 10 mGy/h (1000 µGy/h) are considered protective in the marine environment

ICG-C Pressure description: Introduction of radionuclide material, raising levels above background concentrations. Such materials can come from nuclear installation discharges, and from land or sea-based operations (e.g. oil platforms, medical sources). The disposal of radioactive material at sea is prohibited unless it fulfils exemption criteria developed by the International Atomic Energy Agency (IAEA), namely that both the following radiological criteria are satisfied: (i) the effective dose expected to be incurred by any member of the public or ship's crew is 10 µSv or less in a year; (ii) the collective effective dose to the public or ship's crew is not more than 1 man Sv per annum, then the material is deemed to contain *de minimis* levels of radioactivity and may be disposed at sea pursuant to it fulfilling all the other provisions under the Convention. The individual dose criteria are placed in perspective (i.e. very low), given that the average background dose to the UK population is ~2700 µSv/a. Ports and coastal sediments can be affected by the authorised discharge of both current and historical low-level radioactive wastes from coastal nuclear establishments.

Discussion

In the UK, the current legislative measures relevant to the protection of wildlife from radiation are the Water Framework Directive (WFD) and the Habitats Directive, Defra, the Scottish Government, Welsh Government and the Department of the Environment Northern Ireland have policy responsibility for implementing the WFD in the UK. As competent authorities, the environment agencies are largely responsible for implementing the WFD.

Under the Habitats Regulations, the Environment Agency and SEPA review new and existing authorisations/permits to ensure that they do not have an adverse effect on the integrity of Natura 2000 habitat sites. The Environment Agency has assessed the dose rates to reference organisms and feature species for authorised discharges under the Radioactive Substances Act 1993 and, since April 2010, the Environmental Permitting (England and Wales) Regulations 2010 (Environment Agency, 2009). Environmental concentrations are predicted using appropriate dispersion models and the data were used to calculate the dose rates. The assessment concluded that, for all but two of the habitat sites, dose rates to the worst affected organisms were less than the dose rate threshold of 40 µGy h-that the Environment Agency have agreed with Natural England to be protective of Natura 2000 sites National Dose Assessment Working Group (NDAWG), 2008,). Hence, there was no significant impact on the integrity of these habitat sites. The two habitat sites with the potential for dose rates to the worst affected organism to be greater than the agreed threshold were the Drigg coast and the Ribble and Alt Estuaries. A detailed assessment has been carried out for the Drigg coast using monitoring data and this confirmed there was no indication of significant impact from ionising radiation on the sand dune biota (Wood *et al.*, 2008, Wood *et al.*, 2009a, Wood *et al.*, 2009b). A detailed assessment was also carried out for the Ribble and Alt estuaries using monitoring data and taking into account new discharge limits for the Springfields site which came into force in 2008 (Environment Agency, 2009). This assessment concluded that the dose rate to

the worst affected organism was less than the agreed threshold and hence there was no significant impact on the integrity of this habitat site. When a new authorisation/permit to discharge or dispose of radioactive waste is issued, or one is varied, the applicant is required to make an assessment of the potential impact of the discharges on reference organisms that represent species which may be adversely affected.

SEPA has carried out a Pressures and Impacts Assessment from radioactive substances on Scotland's water environment. The study concluded that there was no adverse impact on the aquatic environment as a result of authorised discharges of radioactive substances, although it recognised that there may be a need for further data to support this conclusion. The benchmark proposed by Project MB0102 is more protective than currently accepted thresholds. There is no evidence to suggest that the assessment of 'Not Sensitive' is incorrect or, based on environmental exposure, that the benchmark should be raised.

Suggested pressure benchmark: see recommendations (section 4)

6.5.8 Synthetic compound contamination (incl. pesticides, anti-foulants, pharmaceuticals). Includes those priority substances listed in Annex II of Directive 2008/105/EC.

MB0102 benchmark: Compliance with all AA EQS, conformance with PELs, EACs, ER-Ls

Fish/Bird/Mammal Benchmark: Compliance with all AA EQS, conformance with PELs, EACs, ER-Ls within site. Note: Although compliance with established EQSs is likely to result in no direct toxic effects, the accidental introduction of large quantities of synthetic compounds on designated sites could have direct effects on marine fish/bird/mammal features.

ICG-C Pressure description: increases in the levels of these compounds compared with background concentrations. Includes chemical synthesised from a variety of industrial processes and commercial applications. Chlorinated compounds include polychlorinated biphenols (PCBs), dichlor-diphenyl-trichloroethane (DDT) & 2,3,7,8-tetrachlorodibenzo(p)dioxin (2,3,7,8-TCDD) are persistent and often very toxic. Pesticides (inc. insecticides, herbicides, rodenticides & fungicides) vary greatly in structure, composition, environmental persistence and toxicity to non-target organisms. Pharmaceuticals and Personal Care Products originate from veterinary and human applications compiling a variety of products including, over the counter medications, fungicides, chemotherapy drugs and animal therapeutics, such as growth hormones. Due to their biologically active nature, high levels of consumption, known combined effects, and their detection in most aquatic environments they have become an emerging concern. Ecological consequences include physiological changes (e.g. growth defects, carcinomas).

Suggested pressure benchmark: see recommendations (section 4)

6.5.9 Transition elements & organo-metal (e.g. TBT) contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC.

MB0102 Benchmark: None proposed (?)

Fish/Bird/Mammals: Introduction of non-synthetic substances and compounds (e.g. heavy metals resulting, for example, from pollution by ships and oil, gas and mineral exploration, atmospheric deposition, riverine inputs)

ICG-C Pressure description: The increase in transition elements levels compared with background concentrations, due to their input from land/riverine sources, by air or directly at sea. For marine sediments the main elements of concern are Arsenic, Cadmium, Chromium, Copper, Mercury, Nickel, Lead and Zinc Organo-metallic compounds such as the butyl tins (Tri butyl tin and its derivatives) can be highly persistent and chronic exposure to low levels has adverse biological effects, e.g. imposex in molluscs.

Suggested pressure benchmark: see recommendations (section 4)

6.6 Biological pressures

6.6.1 Genetic modification & translocation of indigenous species

MB0102 Pressure benchmark: Translocation outside of a geographic areas; introduction of hatchery –reared juveniles outside of geographic area from which adult stock derives

Fish/Bird/Mammals: as above

ICG-C Pressure description: Genetic modification can be either deliberate (e.g. introduction of farmed individuals to the wild, GM food production) or a by-product of other activities (e.g. mutations associated with radionuclide contamination). Former related to escapees or deliberate releases e.g. cultivated species such as farmed salmon, oysters, scallops if GM practices employed. Scale of pressure compounded if GM species "captured" and translocated in ballast water. Mutated organisms from the latter could be transferred on ships hulls, in ballast water, with imports for aquaculture, aquaria, live bait, species traded as live seafood or 'natural' migration.

Discussion

Previously, when developing sensitivity assessments (Tillin *et al.* 2010, Tillin & Tyler-Walters, 2014a&b), this pressure was considered relevant only to biotopes that are characterized by species which may be translocated or transplanted either for aquaculture or onward growing e.g. *Mytilus edulis*, *Ostrea edulis*, or for habitat creation e.g. seagrass and chord grass (*Spartina* spp.). The impact pathway considers the potential for genetic modification leading to changes in genetic structure of a population or hybridisation. The pressure description also refers to aquaculture escapees and hence would be relevant to fish species that are currently farmed and which also occur naturally in the wild.

The term genetic modification is slightly misleading. In current use, the term often refers to deliberate alteration of the genetic code of an individual using molecular genetic techniques. However, genetic modification of a species population has been achieved via selective breeding programmes in agriculture. Also, the genetic structure[1] of local populations may be altered by immigration from neighbouring populations or the deliberate translocation of individuals from another population of the same species with a different genetic structure.

Translocation or introduction of similar species that had not previously come into contact could provide the opportunity for hybridization (e.g. *Spartina*). Translocation could also potentially result in competition between the local species and the introduced species can change the community composition or structure of the receiving habitat.

Introduction of non-native species (whether genetically modified or not) is expressly considered under a separate pressure. Should the introduction of GM non-indigenous species become an identifiable problem then the pressure benchmarks for the two relevant pressures may need to be revisited. This pressure is not relevant to birds or mammals as aquaculture and agriculture are the only recognised activity.

Reintroductions for conservation purposes may be considered translocation of indigenous species. Species of conservation interest may be reintroduced into habitats as a conservation measure, however where there is no natural population, interbreeding effects will not arise although these may be a consideration in the future. We are not aware of any reintroductions of birds and mammals into the marine environment.

Crustaceans that are reared in hatcheries are not considered in assessments as these do not characterize biotopes and no negative ecological effects have been identified. The pressure

[1] Genetic structure defined in terms of the most common and least common alleles for any particular gene.

description refers to mutations associated with radionuclide contamination. Any evidence is considered under radionuclide pollution pressure theme. Currently no genetically modified organisms are licensed for aquaculture in the UK and therefore genetic modification from this source is not considered.

Suggested pressure description: Genetic modification can be either deliberate (e.g. introduction of farmed individuals to the wild, GM food production) or a by-product of other activities (e.g. mutations associated with radionuclide contamination). The former is related to escapees or deliberate releases e.g. cultivated species such as farmed salmon, oysters, scallops if GM practices or breeding programmes are employed. The scale of pressure is compounded if GM species "captured" and translocated in ballast water. GM species could be transferred on ships hulls, in ballast water, with imports for aquaculture, aquaria, live bait, species traded as live seafood or 'natural' migration.

The pressure also relates to the translocation of indigenous species which may compete with local populations of species, alter the community of the receiving habitat, or provide the opportunity for hybridization between similar species (e.g. *Spartina* spp. and *Mytilus* spp.).

Suggested revised benchmark: Translocation of indigenous species and/or introduction of genetically modified or genetically different populations of indigenous species that may result in changes in genetic structure of local populations, hybridization, or change in community structure.

Application: the sensitivity assessment will review evidence for the effects of translocation of indigenous species on community and genetic structure and assess reported effects against the resistance/resilience scales.

6.6.2 Introduction of microbial pathogens or diseases

MB0102 Benchmark: the introduction of microbial pathogens *Bonamia* and *Martelia refringens* to an area where they are currently not present.

NE Bird/Fish/Mammal: the introduction of relevant microbial pathogens to an area where they are currently not present (e.g. Avian influenza virus, viral Haemorrhagic Septicaemia virus, etc.)

ICG-C Pressure description: Untreated or insufficiently treated effluent discharges & run-off from terrestrial sources & vessels. It may also be a consequence of ballast water releases. In mussel or shellfisheries where seed stock are imported, 'infected' seed could be introduced, or it could be from accidental releases of effluvia. Escapees, e.g. farmed salmon could be infected and spread pathogens in the indigenous populations. Aquaculture could release contaminated faecal matter, from which pathogens could enter the food chain.

Discussion

Microbial pathogens include bacteria, viruses, protozoa and fungi. Human activities which may directly introduce microbial pathogens are the introduction of effluents and ballast water and the translocation of infected individuals. Microbial pathogens may also be introduced by human activities indirectly via land run-off particularly run-off from agricultural land. Microbial monitoring in UK waters is currently focussed on pathogens relevant to human health rather than potential negative impacts on the quality of marine habitats and species health.

Although many microbial pathogens have been identified in marine and coastal waters, the impacts of these are largely confined to impacts on the viability of individuals and small-scale population outbreaks. Few mass mortality events have been recorded that are directly linked to managed human activities. For example, neither the mass dieback of *Zostera marina* during the 1920s nor mid-1930s due to the wasting disease caused by Labyrnthula or Phocine

distemper virus (PDV) that resulted in the deaths of 21,700 seals, estimated to be 51% of the population along the North Sea coast are directly linked to human activities.

The pressure benchmark developed by MB0102 considered microbial pathogens that could potentially impact benthic habitats and species and which could be directly introduced by human activities and hence managed. Microbial pathogens that were relevant to human health but which do not negatively impact habitats and species were not assessed. The pressure benchmark developed refers expressly to two pathogens, *Martelia refringens* and *Bonamia* which have an impact on marine habitats and species and which are linked to a manageable human activity. The current pressure benchmark is only relevant to biotopes characterized by species subject to infection; *Mytilus* spp., *Ostrea edulis*, and some other shellfish as indicated by Bower *et al.* (1994).

The current benchmark also excludes other disease vectors such as fungal infections and metazoan parasites. Technically all species host parasites or microbial pathogens and are hence sensitive to disease causing organisms.

Therefore, we suggest that sensitivity assessment is focused on 'relevant' microbial pathogens or metazoan parasites that are 'relevant' because they are a) spread or introduced by human activities or humans themselves (e.g. via faeces), b) controllable by management and c) reported to cause a decline in the affected species population.

Suggested revised benchmark: the introduction of relevant microbial pathogens or metazoan disease vectors to an area where they are currently not present (e.g. *Martelia refringens* and *Bonamia*, Avian influenza virus, viral Haemorrhagic Septicaemia virus).

Application: any significant pathogens or disease vectors relevant to species or the species that characterize biotopes identified during the evidence review phase will be noted in the review text. Evidence of effects will be assessed against the resistance/resilience scales

6.6.3 Introduction or spread of non-indigenous species (NIS)

MB0102 benchmark: A significant pathway exists for introduction of one or more invasive non-indigenous species (NIS) (e.g. aquaculture of NIS, untreated ballast water exchange, local port, terminal harbour or marina); creation of new colonisation space >1ha. One or more NIS in Table C3 (Technical report) has been recorded in the relevant habitat.

Fish/Bird/Mammal benchmark: A significant pathway exists for introduction or spread of one or more non indigenous invasive species; OR there is a potential for the introduction of highly invasive/impact species

SNCB revised benchmark: the introduction of one of more invasive non-indigenous species (NIS)

The updated pressure benchmark proposed by the SNCBs removes the considerations of exposure to introduction pathways (e.g. ports and marinas) and creation of suitable habitat that were included within the Project MB0102 benchmark but were generally not able to be considered by the sensitivity assessment. The SNCB revision therefore brings the benchmark in line with assessments which are qualified on the basis of reported occurrence of NIS within habitats or impacting the receptor (NE bird mammal and fish benchmarks). If the proposed update to the physical change (to another seabed type) pressure is adopted to include consideration of artificial hard substratum the NIS pressure can be considered in conjunction with that pressure.

Suggested pressure benchmark: the introduction of one of more invasive non-indigenous species (NIS) (as SNCB revision)

Application: Sensitivity assessment in Tillin et al. (2014) were undertaken against a prescribed list of potentially invasive NIS, based on MB0102 list and updated based on the FEAST tool for subsequent sensitivity assessments based on Ecological Groups of species

(Tillin *et al.* 2014). FEAST added the tunicate *Styela clava*, the tube worm *Ficopomatus enigmaticus*, and Mink (for bird features). The current list is given in Table 6.4.

Table 6.4 Suggested list of potential invasive NIS that were considered in the MB0102 sensitivity assessments.

Species	Habitats in which species has occurred
Codium fragile subsp *tormentosoides*	May dominate algal cover in infralittoral rocky reefs
Sargassum muticum	May dominate algal cover on sheltered rocky and coarse substratum shores penetrating into estuaries
Undaria pinnatifida	May dominate algal cover on rocky shores from low tide down to 15m
Spartina anglica	May dominate lower saltmarsh
Marenzelleria viridis	May dominate faunal assemblage in low salinity shallow subtidal muds
Ficopomatus enigmaticus	May dominate substratum.
Eriocheir sinensis	Structuring component of high intertidal in upper estuaries
Crepidula fornicata	May smother subtidal muddy and sandy sea beds
Urosalpinx cinerea	Predator on oysters
Crassostrea gigas	May form oyster beds on coarse/hard substrata in estuaries
Perophora japonica	May cover up to 10% of seabed surface in lagoons
Didemnum vexillum	May encrust submerged structures but may also affect sheltered shallow subtidal hard substrata
Styela clava	May occupy space and dominate substratum (but also provide substratum)

We suggest that the list is augmented with potential invasive NIS listed under the GBNNSIP register (2014) where they are relevant to habitat sensitivity (Table 6.5). The list may be extended during the evidence review.

Table 6.5 List of possible additional invasive marine species relevant to habitats sensitivity assessment.

Species name	Common name
Asparagopsis armata	Harpoon weed
Asterocarpa humilis	A sea squirt
Austrominius modestus	Australasian barnacle
Bonnemaisonia hamifera	A red seaweed
Botrylloides diegensis	A sea squirt
Botrylloides violaceus	A sea squirt
Caprella mutica	Japanese skeleton shrimp
Codium fragile subsp.fragile	A green seaweed
Cordylophora caspia	A hydroid
Corella eumyota	A sea squirt
Monocorophium sextonae	Tube-dwelling mud shrimp
Ensis directus	Razor shell

Species name	Common name
Gammarus tigrinus	A sand shrimp
Grateloupia turuturu	A red algae
Hemigrapsus sanguineus	Asian shore crab
Hemigrapsus takanoi	Asian shore crab
Heterosiphonia japonica	A red seaweed
Hydroides elegans	Tube worm
Hydroides ezoensis	Tube worm
Mytilopsis leucophaeta	Dark false mussel
Dyspanopeus sayi	Say mud crab
Neosiphonia harveyi	A red seaweed
Rhithropanopeus harrisii	Harris mud crab
Schizoporella japonica	A bryozoan
Tricellaria inopinata	A bryozoan
Urosalpinx cinerea	American oyster drill
Watersipora subatra	A bryozoan

6.6.4 Removal of non-target species

MB0102 Pressure benchmark: removal of features through pursuit of a target fishery at a commercial scale

MSFD Annex III Table 2 equivalent: selective extraction of species, including incidental non-target catches (e.g. by commercial and recreational fishing)

ICG-C Pressure description: by-catch associated with all fishing activities. The physical effects of fishing gear on sea bed communities are addressed by the "abrasion" pressure type so the pressure addresses the direct removal of individuals associated with fishing/ harvesting. . Ecological consequences include food web dependencies, population dynamics of fish, marine mammals, turtles and sea birds (including survival threats in extreme cases, e.g. Harbour Porpoise in Central and Eastern Baltic).

Discussion and application

The definition of the pressure 'removal of non-target species' has proven to be problematic for sensitivity assessment. The pressure addresses only the biological effects of removal of species and not the effects of the removal process on the species, community or habitat itself, which results in confusion.

In general, the removal of species may result in changes to the biological structure (species richness and diversity) and where extreme may lead to biotope re-classification. The risk of this impact is captured through the physical damage pressures as those assessments are based on the likelihood of characterising species being killed or damaged within the direct footprint of the pressure. To avoid direct duplication of the physical damage assessments, the pressure benchmark for the removal of non-target species has been interpreted as specifically referring to the risk of ecological effects arising from the removal of species that are not directly targeted by fisheries. The basis of the assessment is intended to provide a meaningful risk assessment of an aspect of human activities that is not captured through other pressures.

When developing the assessments for this pressure we have attempted to assess where clear ecological or biological effects may arise as a result of by-catch. The assessment therefore firstly considers whether species present in the biotope are likely to be removed based on environmental position (rather than potential exposure to the activity). Secondly, the

assessment considers whether this removal is likely to result in measurable effects on biotope structure and function. Examples of biotopes that are sensitive to this pressure are therefore biogenic habitats that are created by species which may be removed by fishing activities, e.g. maerl beds and *Sabellaria* reefs and habitats not defined as biogenic where much of the physical structure is created by plants and animals e.g. hard substrata that are dominated by plant and animal assemblages. Within benthic biotopes some species, often referred to as ecosystem engineers, may strongly determine the rate of some ecological processes. For example dense aggregations of *Arenicola marina* alter sediment properties and influence the species assemblage. Removal of *A. marina* is therefore considered likely to alter biotope function and biotopes characterized by this species are considered sensitive to this pressure.

Where species are key characterizing species, for example named in the biotope description or identified as important by the biotope description and have been identified as likely to be removed or displaced as by-catch this has also been noted and the biotope assessed as sensitive. In many instances species that are likely to be removed as by-catch are epifauna or flora which also create much of the physical structure of benthic biotopes e.g. macroalgae, sea fans and erect sponges and the biotope is considered sensitive to their removal due to changes in biological structure (species richness and diversity) and physical structure (degree of habitat complexity).

It should be noted that the assessments on this basis largely identify biotopes with species identified as 'ecosystem engineers' where removal of species may have a significant effect on biotope structure and function. An assessment of 'Not relevant' does not mean that the species present are unimportant in terms of ecosystem processes and functions. Nor does 'Not relevant' mean that commercial harvesting activities will not remove or damage species that are present within the biotope. It is strongly advised that the physical damage pressures should be consulted alongside the removal of non-target species pressure to identify the sensitivity of biotopes to physical damage resulting from activities.

Suggested pressure benchmark: removal of features and incidental non-targeted catch (by-catch) through targeted fishery, shellfishery or harvesting at a commercial or recreational scale.

Suggested Pressure description: by-catch associated with all fishing harvesting and extraction activities. Ecological consequences include food web dependencies, population dynamics of fish, marine mammals, turtles and sea birds (including survival threats in extreme cases, e.g. Harbour Porpoise in Central and Eastern Baltic). The physical effects of fishing gear on sea bed communities are addressed by the "abrasion" pressure type so the pressure addresses the direct removal of individuals associated with fishing/ harvesting.

6.6.5 Removal of Target Species

MB0102 pressure benchmark: removal of target species that are features of conservation importance or sub-features of habitats of conservation importance at a commercial scale.

Fish: extraction of features as a target species removes 10% of the individuals from the population of the site under consideration.

Birds: numbers of individuals of feature removed as target species equates to in excess of 10% of the rate of natural mortality of the population of the site under consideration e.g. increases annual mortality of that site's population of individuals from 10% to more than 11%.

Mammals: removal of feature as a target species exceeds 10% of the rate of natural mortality.

ICG-C Pressure description: The commercial exploitation of fish & shellfish stocks, including smaller scale harvesting, angling and scientific sampling. The physical effects of fishing gear on sea bed communities are addressed by the "abrasion" pressure type D2, so B5 addresses the direct removal / harvesting of biota. Ecological consequences include the sustainability of

stocks, impacting energy flows through food webs and the size and age composition within fish stocks.

Discussion & application

As above, this pressure addresses only the biological effects of removal of species and not the effects of the removal process on the species, community or habitat itself, which results in confusion. The MB0102 benchmark is restricted to the removal of conservation features, but ecological effects on species and habitats of conservation concern could result from fishing or harvesting of species that are not themselves of conservation concern. For example, the removal of sea urchins predators from kelp beds may impact kelp bed dynamics; removal or limpets or other gastropod grazers may affect fucoid and barnacle dominated communities.

In some cases the effects are direct. For example, the removal of mussels from mussel beds or the harvesting of kelp from kelp beds has direct ecological consequences on these beds. Therefore, if a species that characterizes a biotope or habitat is targeted by commercial harvesting (or recreational harvesting that can be intensive) the biotope was judged to be sensitive to this pressure (Tillin & Tyler-Walters, 2014, Gibb *et al.*, 2014, Mainwaring *et al.*, 2014 and d'Avack *et al.*, 2014). The benchmarks for fish, birds and mammals, infer that the feature of interest (the fish, bird or mammal in question) is targeted, rather than address the ecological effects of a fishery. We assume that where there is clear evidence, (e.g. sand eels and kittiwake), the ecological effects are considered.

However, a targeted scallop fishery probably has very limited ecological consequences for a horse mussel bed or maerl bed, but the resultant physical damage may be significant, and it is the physical damage to which the beds are sensitive. The effects of scallop dredging on horse mussels or maerl are then assessed under the relevant physical pressures.

Suggested pressure benchmark:

- **benthic species and habitats:** removal of species targeted by fishery, shellfishery or harvesting at a commercial or recreational scale.
- **fish, birds, and mammals:** as above.

In application, sensitivity will be assessed against the effects documented in the evidence base. Where a targeted specie sis characteristic of the biotope or habitat, then assessment will be made against the hypothetical removal of >25% of the population, where >25% represented the cut off between high and moderate resistance.

7 Appendix 2. List of ICG-C pressures and benchmarks plus SNCB commentary Dec. 2014.

Pressure theme	ICG-C Pressure	ICG-C description	MB102 benchmark	MSFD Annex III Table 2	SNCB Changes made
Biological pressures	Genetic modification & translocation of indigenous species	Genetic modification can be either deliberate (e.g. introduction of farmed individuals to the wild, GM food production) or a by-product of other activities (e.g. mutations associated with radionuclide contamination). Former related to escapees or deliberate releases e.g. cultivated species such as farmed salmon, oysters, scallops if GM practices employed. Scale of pressure compounded if GM species "captured" and translocated in ballast water. Mutated organisms from the latter could be transferred on ships hulls, in ballast water, with imports for aquaculture, aquaria, live bait, species traded as live seafood or 'natural' migration.	Translocation outside of a geographic areas; introduction of hatchery – reared juveniles outside of geographic area from which adult stick derives	X	X
Biological pressures	Introduction of microbial pathogens	Untreated or insufficiently treated effluent discharges & run-off from terrestrial sources & vessels. It may also be a consequence of ballast water releases. In mussel or shellfisheries where seed stock are imported, 'infected' seed could be introduced, or it could be from accidental releases of effluvia. Escapees, e.g. farmed salmon could be infected and spread pathogens in the indigenous populations. Aquaculture could release contaminated faecal matter, from which pathogens could enter the food chain.	The introduction of relevant microbial pathogens to an area where they are currently not present	Introduction of microbial pathogens	Benchmark changed from: The introduction of microbial pathogens Bonamia and Martelia refringens to an area where they are currently not present.
Biological pressures	Introduction or spread of non-indigenous species (NIS)	The direct or indirect introduction of non-indigenous species, e.g. chinese mitten crabs, slipper limpets, Pacific oyster and their subsequent spreading and out-competing of native species. Ballast water, hull fouling, stepping stone effects (e.g. offshore wind farms) may facilitate the spread of such species. This pressure could be associated with aquaculture, mussel or shellfishery activities due to imported seed stock imported or from accidental releases.	The introduction of one of more invasive NIS	Introduction of non-indigenous species and translocations	Benchmark changed from: A significant pathway exists for introduction of one or more invasive non-indigenous species (NIS) (e.g aquaculture of NIS, untreated ballast water exchange, local port, terminal harbour or marina); creation of new

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					colonisation space >1ha. One or more NIS in Table C3 (Technical report) has been recorded in the relevant habitat.
Biological pressures	Removal of non-target species	By-catch associated with all fishing activities. The physical effects of fishing gear on sea bed communities are addressed by the "abrasion" pressure type (D2) so B6 addresses the direct removal of individuals associated with fishing/ harvesting. . Ecological consequences include food web dependencies, population dynamics of fish, marine mammals, turtles and sea birds (including survival threats in extreme cases, e.g. Harbour Porpoise in Central and Eastern Baltic).	Removal of features through pursuit of a target fishery at a commercial scale	Selective extraction of species, including incidental non-target catches (e.g. by commercial and recreational fishing)	Request MarLIN to provide clarification with regards to what is being assessed within the pressure, and how the "physcial effects of fishing gear on the seabed communities are addressed by the abrasion pressure type.
Biological pressures	Removal of target species	The commercial exploitation of fish & shellfish stocks, including smaller scale harvesting, angling and scientific sampling. The physical effects of fishing gear on sea bed communities are addressed by the "abrasion" pressure type D2, so B5 addresses the direct removal / harvesting of biota. Ecological consequences include the sustainability of stocks, impacting energy flows through food webs and the size and age composition within fish stocks.	Removal of target species that are features of conservation importance or sub-features of habitats of conservation importance at a commercial scale.	Selective extraction of species, … (e.g. by commercial and recreational fishing)	Request MarLIN to provide clarification with regards to what is being assessed within the pressure, and how the "physcial effects of fishing gear on the seabed communities are addressed by the abrasion pressure type.
Biological pressures	Visual disturbance	The disturbance of biota by anthropogenic activities, e.g. increased vessel movements, such as during construction phases for new infrastructure (bridges, cranes, port buildings etc.), increased personnel movements, increased tourism, increased vehicular movements on shore etc. disturbing bird roosting areas, seal haul out areas etc.	None proposed	X	Suggest this pressure should be moved to the pressure theme 'Other physical pressures'
Hydrological changes (inshore/local)	Emergence regime changes - local, including tidal level change considerations	Changes in water levels reducing the intertidal zone (and the associated/dependant habitats). The pressure relates to changes in both the spatial area and duration that intertidal species are immersed and exposed during tidal cycles (the percentage of	Intertidal species (and habitats not uniquely defined by intertidal zone): A 1 hour change in the time covered or not covered by	X	X

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		immersion is dependant on the position or height on the shore relative to the tide). The spatial and temporal extent of the pressure will be dependant on the causal activities but can be delineated. This relates to anthropogenic causes that may directly influence the temporal and spatial extent of tidal immersion, e.g. upstream and downstream of a tidal barrage the emergence would be respectively reduced and increased, beach re-profiling could change gradients and therefore exposure times, capital dredging may change the natural tidal range, managed realignment, saltmarsh creation. Such alteration may be of importance in estuaries because of their influence on tidal flushing and potential wave propagation. Changes in tidal flushing can change the sediment dynamics and may lead to changing patterns of deposition and erosion. Changes in tidal levels will only affect the emergence regime in areas that are inundated for only part of the time. The effects that tidal level changes may have on sediment transport are not restricted to these areas, so a very large construction could significantly affect the tidal level at a deep site without changing the emergence regime. Such a change could still have a serious impact. This excludes pressure from sea level rise which is considered under the climate change pressures.	the sea for a period of 1 year. Habitats and landscapes defined by intertidal zone: An increase in relative sea level or decrease in high water level of 1mm for one year over a shoreline length >1km		
Hydrological changes (inshore/local)	Salinity changes - local	Events or activities increasing or decreasing local salinity. This relates to anthropogenic sources/causes that have the potential to be controlled, e.g. freshwater discharges from pipelines that reduce salinity, or brine discharges from salt caverns washings that may increase salinity. This could also include hydromorphological modification, e.g. capital navigation dredging if this alters the halocline, or erection of barrages or weirs that alter freshwater/seawater flow/exchange rates. The	Increase from 35 to 38 units for one year. Decrease in Salinity by 4-10 units a year	Significant changes in salinity regime (e.g. by constructions impeding water movements, water abstraction)	X

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		pressure may be temporally and spatially delineated derived from the causal event/activity and local environment.			
Hydrological changes (inshore/local)	Temperature changes - local	Events or activities increasing or decreasing local water temperature. This is most likely from thermal discharges, e.g. the release of cooling waters from power stations. This could also relate to temperature changes in the vicinity of operational sub sea power cables. This pressure only applies within the thermal plume generated by the pressure source. It excludes temperature changes from global warming which will be at a regional scale (and as such are addressed under the climate change pressures).	A 5°C change in temp for one month period, or 2°C for one year	Significant changes in thermal regime (e.g. by outfalls from power stations)	X
Hydrological changes (inshore/local)	Water flow (tidal current) changes - local, including sediment transport considerations	Changes in water movement associated with tidal streams (the rise and fall of the tide, riverine flows), prevailing winds and ocean currents. The pressure is therefore associated with activities that have the potential to modify hydrological energy flows, e.g. Tidal energy generation devices remove (convert) energy and such pressures could be manifested leeward of the device, capital dredging may deepen and widen a channel and therefore decrease the water flow, canalisation &/or structures may alter flow speed and direction; managed realignment (e.g. Wallasea, England). The pressure will be spatially delineated. The pressure extremes are a shift from a high to a low energy environment (or vice versa). The biota associated with these extremes will be markedly different as will the substrate, sediment supply/transport and associated seabed elevation changes. The potential exists for profound changes (e.g. coastal erosion/deposition) to occur at long distances from the construction itself if an important sediment transport pathway was disrupted. As such these pressures could have multiple and complex impacts associated with them.	A change in peak mean spring bed flow velocity of between 0.1m/s to 0.2m/s for more than 1 year. (Note that MNCR categories for tides are: v strong: >3m/sec; strong: 1.5-3m/sec; Mod strong: 0.5-1.5m/sec; weak: <0.5m/sec; v weak - negligible).	X	Benchmark changed from: A change in peak mean spring tide flow speed of between 0.1m/s to 0.2m/s over an areas > 1km2 or 50% if width of water body for more than 1 year. Extra text has been added from FEAST

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Hydrological changes (inshore/local)	Wave exposure changes - local	Local changes in wave length, height and frequency. Exposure on an open shore is dependant upon the distance of open seawater over which wind may blow to generate waves (the fetch) and the strength and incidence of winds. Anthropogenic sources of this pressure include artificial reefs, breakwaters, barrages, wrecks that can directly influence wave action or activities that may locally affect the incidence of winds, e.g. a dense network of wind turbines may have the potential to influence wave exposure, depending upon their location relative to the coastline.	A change in nearshore significant wave height >3% but <5% (Note that sig wave ht =the average height of the highest one third of waves. This considers wind fetch, wind strength, duration of wind, and topography; generally sig wave ht is <1.2m but can be up to 3m around UK coast)	X	MBA to suggest an alternative benchmark Extra text has been added from FEAST
Other physical pressures	Barrier to species movement	The physical obstruction of species movements and including local movements (within & between roosting, breeding, feeding areas) and regional/global migrations (e.g. birds, eels, salmon, whales). Both include up river movements (where tidal barrages & devices or dams could obstruct movements) or movements across open waters (offshore wind farm, wave or tidal device arrays, mariculture infrastructure or fixed fishing gears). Species affected are mostly birds, fish, mammals.	10% change in tidal excursion, or temporary barrier to species movement over ≥50% of water body width	X	Clarification needed as to what constitutes a 'tidal excursion'
Other physical pressures	Death or injury by collision	Injury or mortality from collisions of biota with both static &/or moving structures. Examples include: Collision with rigs (e.g. birds) or screens in intake pipes (e.g. fish at power stations) (static) or collisions with wind turbine blades, fish & mammal collisions with tidal devices and shipping (moving). Activities increasing number of vessels transiting areas, e.g. new port development or construction works will influence the scale and intensity of this pressure.	0.1% of tidal volume on average tide, passing through artificial structure	X	X
Other physical pressures	Electromagnetic changes	Localized electric and magnetic fields associated with operational power cables and telecommunication cables (if equipped with power relays). Such cables may generate electric and magnetic fields that could alter behaviour and migration patterns of sensitive species (e.g. sharks and rays).	Local electric field of 1V m-1. Local magnetic field of 10µT	X	X

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Other physical pressures	Introduction of light	Direct inputs of light from anthropogenic activities, i.e. lighting on structures during construction or operation to allow 24 hour working; new tourist facilities, e.g. promenade or pier lighting, lighting on oil & gas facilities etc. Ecological effects may be the diversion of bird species from migration routes if they are disorientated by or attracted to the lights. It is also possible that continuous lighting may lead to increased algal growth.	None proposed	X	X
Other physical pressures	Litter	Marine litter is any manufactured or processed solid material from anthropogenic activities discarded, disposed or abandoned (excluding legitimate disposal) once it enters the marine and coastal environment including: plastics, metals, timber, rope, fishing gear etc and their degraded components, e.g. microplastic particles. Ecological effects can be physical (smothering), biological (ingestion, including uptake of microplastics; entangling; physical damage; accumulation of chemicals) and/or chemical (leaching, contamination).	None proposed	Marine Litter	X
Other physical pressures	Underwater noise changes	Increases over and above background noise levels (consisting of environmental noise (ambient) and incidental man-made/anthropogenic noise (apparent)) at a particular location. Species known to be affected are marine mammals and fish. The theoretical zones of noise influence (Richardson et al 1995) are temporary or permanent hearing loss, discomfort & injury; response; masking and detection. In extreme cases noise pressures may lead to death. The physical or behavioural effects are dependant on a number of variables, including the sound pressure, loudness, sound exposure level and frequency. High amplitude low and mid-frequency impulsive sounds and low frequency continuous sound are of greatest concern for effects on marine mammals and fish. Some species may be responsive to the associated particle motion rather than the	MSFD indicator levels (SEL or peak SPL) exceeded for 20% of days in calendar year	Underwater noise (e.g. from shipping, underwater acoustic equipment)	X

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		usual concept of noise. Noise propagation can be over large distances (tens of kilometres) but transmission losses can be attributable to factors such as water depth and sea bed topography. Noise levels associated with construction activities, such as pile-driving, are typically significantly greater than operational phases (i.e. shipping, operation of a wind farm).			
Physical damage (Reversible Change)	Changes in suspended solids (water clarity)	Changes in water clarity from sediment & organic particulate matter concentrations. It is related to activities disturbing sediment and/or organic particulate matter and mobilising it into the water column. Could be 'natural' land run-off and riverine discharges or from anthropogenic activities such as all forms of dredging, disposal at sea, cable and pipeline burial, secondary effects of construction works, e.g. breakwaters. Particle size, hydrological energy (current speed & direction) and tidal excursion are all influencing factors on the spatial extent and temporal duration. This pressure also relates to changes in turbidity from suspended solids of organic origin (as such it excludes sediments - see the "changes in suspended sediment" pressure type). Salinity, turbulence, pH and temperature may result in flocculation of suspended organic matter. Anthropogenic sources mostly short lived and over relatively small spatial extents.	A change in one Water Framework Directive (WFD) ecological status class for one year	X	Benchmark changed from: A change in one rank on the WFD (Water Framework Directive) scale e.g. from clear to turbid for one year MarLIN to add a brief description of the different WFD water turbidity classifications.
Physical damage (Reversible Change)	Habitat structure changes - removal of substratum (extraction)	Unlike the "physical change" pressure type where there is a permanent change in sea bed type (e.g. sand to gravel, sediment to a hard artificial substrate) the "habitat structure change" pressure type relates to temporary and/or reversible change, e.g. from marine mineral extraction where a proportion of seabed sands or gravels are removed but a residual layer of seabed is similar to the pre-dredge structure and as such biological communities could re-colonize;	Extraction of substrate to 30cm	Selective extraction (e.g. by exploration and exploitation of living and non-living resources on seabed and subsoil)	Benchmrk changed from: Extraction of sediment to 30cm

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		navigation dredging to maintain channels where the silts or sands removed are replaced by non-anthropogenic mechanisms so the sediment typology is not changed.			
Physical damage (Reversible Change)	Abrasion/disturbance of the substrate on the surface of the seabed		Damage to seabed surface features		MarLIN to provide a pressure description
Physical damage (Reversible Change)	Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion	The disturbance of sediments where there is limited or no loss of substrate from the system. This pressure is associated with activities such as anchoring, taking of sediment/geological cores, cone penetration tests, cable burial (ploughing or jetting), propeller wash from vessels, certain fishing activities, e.g. scallop dredging, beam trawling. Agitation dredging, where sediments are deliberately disturbed by and by gravity & hydraulic dredging where sediments are deliberately disturbed and moved by currents could also be associated with this pressure type. Compression of sediments, e.g. from the legs of a jack-up barge could also fit into this pressure type. Abrasion relates to the damage of the sea bed surface layers (typically up to 50cm depth) Activities associated with abrasion can cover relatively large spatial areas and include: fishing with towed demersal trawls (fish & shellfish); bio-prospecting such as harvesting of biogenic features such as maerl beds where, after extraction, conditions for recolonisation remain suitable or relatively localized activities including: seaweed harvesting, recreation, potting, aquaculture. Change from gravel to silt substrate would adversely affect herring spawning grounds.	Damage to sub-surface seabed	Abrasion (e.g. impact on the seabed of commercial fishing, boating, anhoring)	MarLIN to review the pressure descriptor

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Physical damage (Reversible Change)	Siltation rate changes, including smothering (depth of vertical sediment overburden)	When the natural rates of siltation are altered (increased or decreased). Siltation (or sedimentation) is the settling out of silt/sediments suspended in the water column. Activities associated with this pressure type include mariculture, land claim, navigation dredging, disposal at sea, marine mineral extraction, cable and pipeline laying and various construction activities. It can result in short lived sediment concentration gradients and the accumulation of sediments on the sea floor. This accumulation of sediments is synonymous with "light" smothering, which relates to the depth of vertical overburden. “Light” smothering relates to the deposition of layers of sediment on the seabed. It is associated with activities such as sea disposal of dredged materials where sediments are deliberately deposited on the sea bed. For “light” smothering most benthic biota may be able to adapt, i.e. vertically migrate through the deposited sediment. “Heavy” smothering also relates to the deposition of layers of sediment on the seabed but is associated with activities such as sea disposal of dredged materials where sediments are deliberately deposited on the sea bed. This accumulation of sediments relates to the depth of vertical overburden where the sediment type of the existing and deposited sediment has similar physical characteristics because, although most species of marine biota are unable to adapt, e.g. sessile organisms unable to make their way to the surface, a similar biota could, with time, re-establish. If the sediments were physically different this would fall under L2. Eleftheriou and McIntyre, 2005 describe that the majority of animals will inhabit the top 5-10 cm in open waters and the top 15 cm in intertidal areas.	up to 30cm of fine material added to the seabed in a single event OR 5cm of fine material added to the seabed in a single event	Changes in siltation (e.g. by outfalls, increased run-off, dredging/disposal or dredge spoil)	Split this pressure into 2 categories - 'Light siltation rate changes' and 'Heavy siltation rate changes'. MarLIN to investigate how a temporal element of a benchmark can be incorporated i.e. a single event - can this be a single event which lasts several weeks/months/years - how can this be assessed?

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		The depth of sediment overburden that benthic biota can tolerate is both trophic group and particle size/sediment type dependant (Bolam, 2010). Recovery from burial can occur from: - planktonic recruitment of larvae - lateral migration of juveniles/adults - vertical migration (see Chandrasekara and Frid, 1998; Bolam et al, 2003, Bolam & Whomersley, 2005). Spatial scale, timing, rate and depth of placement all contribute the relative importance of these three recovery mechanisms (Bolam et al, 2006). As such the terms "light" and "heavy" smothering are relative and therefore difficult to define in general terms. Bolam, 2010 cites various examples: - H. ulvae maximum overburden 5 cm (Chandrasekara & Frid, 1998) - H. ulvae maximum overburden 20 cm mud or 9 cm sand (Bijerk, 1988) - S. shrubsolii maximum overburden 6 cm (Saila et al, 1972, cited by Hall 1994) - N. succinea maximum overburden 90 cm (Maurer et al 1982) - gastropod molluscs maximum overburden 15 cm (Roberts et al, 1998). Bolam, 2010 also reported when organic content was low: - H. ulvae maximum overburden 16 cm - T, benedii maximum overburden 6 cm - S. shrubsolii maximum overburden <6 cm - Tharyx sp.A. maximum overburden <6 cm			

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Physical loss (Permanent Change)	Physical change (to another seabed type)	The permanent change of one marine habitat type to another marine habitat type, through the change in substatum, including to artificial (e.g. concrete). This therefore involves the permanent loss of one marine habitat type but has an equal creation of a different marine habitat type. Associated activities include the installation of infrastructure (e.g. surface of platforms or wind farm foundations, marinas, coastal defences, pipelines and cables), the placement of scour protection where soft sediment habitats are replaced by hard/coarse substrate habitats, removal of coarse substrate (marine mineral extraction) in those instances where surficial finer sediments are lost, capital dredging where the residual sedimentary habitat differs structurally from the pre-dredge state, creation of artificial reefs, mariculture i.e. mussel beds. Protection of pipes and cables using rock dumping and mattressing techniques. Placement of cuttings piles from oil & gas activities could fit this pressure type, however, there may be an additional pressures, e.g. "pollution and other chemical changes" theme. This pressure excludes navigation dredging where the depth of sediment is changes locally but the sediment typology is not changed.	Change in 1 folk class for 2 years	Smothering (e.g. by man made structures, disposal of dredge spoil)	MarLIN to review. Do we need to make this into 2 pressures - one pressure looking at a change in sediment and another looking at a change from sediment to rock/artificial surfaces?
Physical loss (Permanent Change)	Physical loss (to land or freshwater habitat)	The permanent loss of marine habitats. Associated activities are land claim, new coastal defences that encroach on and move the Mean High Water Springs mark seawards, the footprint of a wind turbine on the seabed, dredging if it alters the position of the halocline. This excludes changes from one marine habitat type to another marine habitat type.	Permanent loss of existing saline habitat	Sealing (e.g. by permanent constructions)	X

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Pollution and other chemical changes	De-oxygenation	Any deoxygenation that is not directly associated with nutrient or organic enrichment. The lowering, temporarily or more permanently, of oxygen levels in the water or substrate due to anthropogenic causes (some areas may naturally be deoxygenated due to stagnation of water masses, e.g. inner basins of fjords).. This is typically associated with nutrient and organic enrichment, but it can also derive from the release of ballast water or other stagnant waters (where organic or nutrient enrichment may be absent). Ballast waters may be deliberately deoxygenated via treatment with inert gases to kill non-indigenous species.	Compliance with WFD criteria for good status Within estuaries, the WFD standard for good status is 5-(0.028xsalinity) compared to a suggested level of 6-(0.028xsalinity) in WQTAG088e. The latter standard is more precautionary as it also seeks to protect migratory fish, which are likely to be the most sensitive element.	X	MarLIN to review all Pollution benchmarks. The benchmarks need to look at the ecological effects not compliance with the legislation. Possible suggeston is to set the benchmark to "Non complaince" Extra text has been added from FEAST
Pollution and other chemical changes	Hydrocarbon & PAH contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC.	Increases in the levels of these compounds compared with background concentrations. Naturally occurring compounds, complex mixtures of two basic molecular structures: - straight chained aliphatic hydrocarbons (relatively low toxicity and susceptible to degradation) - multiple ringed aromatic hydrocarbons (higher toxicity and more resistant to degradation) These fall into three categories based on source (includes both aliphatics and polyaromatic hydrocarbons): - petroleum hydrocarbons (from natural seeps, oil spills and surface water run-off) - pyrogenic hydrocarbons (from combustion of coal, woods and petroleum) - biogenic hydrocarbons (from plants & animals) Ecological consequences include tainting, some are acutely toxic, carcinomas, growth defects.	Compliance with all AA EQS, conformance with PELs, EACs/ER-Ls	Introduction of non-synthetic substances and compounds (e.g. heavy metals, hydro-carbons, resulting, for example, from pollution by ships and oil, gas and mineral exploration, atmospheric deposition, riverine inputs)	MarLIN to review all Pollution benchmarks. The benchmarks need to look at the ecological effects not compliance with the legislation. Possible suggeston is to set the benchmark to "Non complaince"
Pollution and other chemical changes	Introduction of other substances (solid, liquid or gas)	The 'systematic or intentional release of liquids, gases …' (from MSFD Annex III Table 2) is being considered e.g. in relation to produced water from the oil industry. It should therefore be considered in parallel with P1, P2 and P3.	None proposed	Introduction of other substances, whether solid, liquid or gas, in marine waters resulting from their systematic and/or international release into	MarLIN to review all Pollution benchmarks. The benchmarks need to look at the ecological effects not compliance with the legislation. Possible

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				the marine environment, as permitted in accordance with other Community legislation and/or international conventions	suggeston is to set the benchmark to "Non complaince"
Pollution and other chemical changes	Nutrient enrichment	Increased levels of the elements nitrogen, phosphorus, silicon (and iron) in the marine environment compared to background concentrations. Nutrients can enter marine waters by natural processes (e.g. decomposition of detritus, riverine, direct and atmospheric inputs) or anthropogenic sources (e.g. waste water runoff, terrestrial/agricultural runoff, sewage discharges, aquaculture, atmospheric deposition). Nutrients can also enter marine regions from 'upstream' locations, e.g. via tidal currents to induce enrichment in the receiving area. Nutrient enrichment may lead to eutrophication (see also organic enrichment). Adverse environmental effects include deoxygenation, algal blooms, changes in community structure of benthos and macrophytes.	Compliance with WFD criteria for good status	Inputs of fertilisers and other nitrogen - and phosphorous-rich substances (e.g. from point and diffuse sources, including agriculture, aquaculture, atmospheric deposition)	MarLIN to review all Pollution benchmarks. The benchmarks need to look at the ecological effects not compliance with the legislation. Possible suggeston is to set the benchmark to "Non complaince"
Pollution and other chemical changes	Organic enrichment	Resulting from the degraded remains of dead biota & microbiota (land & sea); faecal matter from marine animals; flocculated colloidal organic matter and the degraded remains of: sewage material, domestic wastes, industrial wastes etc. Organic matter can enter marine waters from sewage discharges, aquaculture or terrestrial/agricultural runoff. Black carbon comes from the products of incomplete combustion (PIC) of fossil fuels and vegetation. Organic enrichment may lead to eutrophication (see also nutrient enrichment). Adverse environmental effects include deoxygenation, algal blooms, changes in community structure of benthos and macrophytes.	A deposit of 100gC/m^2/yr	Inputs of organic matter (e.g. sewers, mariculture, riverine inputs)	MarLIN to review all Pollution benchmarks. The benchmarks need to look at the ecological effects not compliance with the legislation. Possible suggeston is to set the benchmark to "Non complaince"

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Pollution and other chemical changes	Radionuclide contamination	Introduction of radionuclide material, raising levels above background concentrations. Such materials can come from nuclear installation discharges, and from land or sea-based operations (e.g. oil platforms, medical sources). The disposal of radioactive material at sea is prohibited unless it fulfils exemption criteria developed by the International Atomic Energy Agency (IAEA), namely that both the following radiological criteria are satisfied: (i) the effective dose expected to be incurred by any member of the public or ships crew is 10 µSv or less in a year; (ii) the collective effective dose to the public or ships crew is not more than 1 man Sv per annum, then the material is deemed to contain de minimis levels of radioactivity and may be disposed at sea pursuant to it fulfilling all the other provisions under the Convention. The individual dose criteria are placed in perspective (i.e. very low), given that the average background dose to the UK population is ~2700 µSv/a. Ports and coastal sediments can be affected by the authorised discharge of both current and historical low-level radioactive wastes from coastal nuclear establishments.	An increase in 10µGy/h above background levels	Introduction of radio-nuclides	MarLIN to review all Pollution benchmarks. The benchmarks need to look at the ecological effects not compliance with the legislation. Possible suggeston is to set the benchmark to "Non complaince"
Pollution and other chemical changes	Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals). Includes those priority substances listed in Annex II of Directive 2008/105/EC.	Increases in the levels of these compounds compared with background concentrations. Synthesised from a variety of industrial processes and commercial applications. Chlorinated compounds include polychlorinated biphenols (PCBs), dichlor-diphenyl-trichloroethane (DDT) & 2,3,7,8-tetrachlorodibenzo(p)dioxin (2,3,7,8-TCDD) are persistent and often very toxic. Pesticides vary greatly in structure, composition, environmental persistence and toxicity to non-target organisms. Includes: insecticides, herbicides, rodenticides & fungicides. Pharmaceuticals and Personal Care Products originate from veterinary and human applications compiling a variety of products	Compliance with all AA EQS, conformance with PELs, EACs, ER-Ls	Introduction of synthetic compounds (e.g. priority substances under Directive 2000/60/EC which are relevant to the marine environment such as pesticides, anti-foulants, pharmaceuticals, resulting, for example, from losses from diffuse sources, pollution by ships, atmospheric deposition and biologically active substances)	MarLIN to review all Pollution benchmarks. The benchmarks need to look at the ecological effects not compliance with the legislation. Possible suggeston is to set the benchmark to "Non complaince"

Pressure theme	ICG-C Pressure	ICG-C description	MB102 benchmark	MSFD Annex III Table 2	SNCB Changes made
		including, Over the counter medications, fungicides, chemotherapy drugs and animal therapeutics, such as growth hormones. Due to their biologically active nature, high levels of consumption, known combined effects, and their detection in most aquatic environments they have become an emerging concern. Ecological consequences include physiological changes (e.g. growth defects, carcinomas).			
Pollution and other chemical changes	Transition elements & organo-metal (e.g. TBT) contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC.	The increase in transition elements levels compared with background concentrations, due to their input from land/riverine sources, by air or directly at sea. For marine sediments the main elements of concern are Arsenic, Cadmium, Chromium, Copper, Mercury, Nickel, Lead and Zinc Organo-metallic compounds such as the butyl tins (Tri butyl tin and its derivatives) can be highly persistent and chronic exposure to low levels has adverse biological effects, e.g. Imposex in molluscs.		Introduction of non-synthetic substances and compounds (e.g. heavy metals, hydro-carbons, resulting, for example, from pollution by ships and oil, gas and mineral exploration, atmospheric deposition, riverine inputs)	MarLIN to review all Pollution benchmarks. The benchmarks need to look at the ecological effects not compliance with the legislation. Possible suggeston is to set the benchmark to "Non complaince"