WORKSHOP TO EVALUATE AND TEST OPERATIONAL ASSESSMENT OF HUMAN ACTIVITIES CAUSING PHYSICAL DISTURBANCE AND LOSS TO SEABED HABITATS (MSFD D6 C1, C2 AND C4) (WKBEDPRES2)

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i Executive summary

ICES was requested to investigate the main physical disturbance pressure(s) causing benthic impact on habitats per EU ecoregion. The three workshops in this process - WKBEDPRES1, WKBEDLOSS and WKBEDPRES2 – form part of a stepwise process that will deliver advice on seafloor integrity for the Marine Strategy Framework Directive (MSFD). In collaboration with its strategic partners, the high level objectives undertaken by ICES within the advice request process were: 1) to identify benthic physical disturbance pressure layers available within ICES and the European and wider marine community across the four EU (MSFD) regions – including the mapping of pertinent data flows and the establishment of criteria needed to ensure the practical use of the data in assessing benthic impact in the workshop WKBEDPRES1 (ICES HQ 24–26 October 2018); 2) to identify physical pressure layers causing loss of benthic habitats across the four EU regions, including mapping of data flow and establish guidance to ensure the practical use of the data in assessing benthic impact in the workshop WKBEDLOSS (ICES HQ 11–13 March 2019); 3) to collate physical pressure layer data causing loss or disturbance (October 2018–Aug 2019), using identified sources and targeted data calls; and 4) to evaluate and operationally test the application of compiled physical pressure layer data causing loss or disturbance (WKBEDPRES2, 30 September–2 October 2019). WKBEDPRES 2 represents the end of this process prior to submission to an ICES coordinated scientific peer-review. During this ICES review phase the EU's TG SeaBed group will also be given the opportunity to highlight any issues requiring further clarification, and input on the operational implementation of the suggested approaches. An ICES Advice Drafting Group (ADGD6PRES) will be convened to draft advice in response to the original advice request based on the workshop reports and their review (including TG SeaBed input) to then be approved by the ICES Advisory Committee. The expected release of the ICES advice is 5 December 2019.

WKBEDPRES2 focused on objectives 3 and 4 above, developing EU-wide guidance on how to assess and report human activities that cause physical disturbance to the seafloor and loss of benthic habitats and to present relevant methodological flows and demonstration products. Within WKBEDPRES2 suitable data streams relating to activities thought to be the main causes of physical disturbance were identified, as were the links from activity to pressure and then through to impact. To produce an assessment process that allowed an accurate assessment of pressures, whilst at the same time being tractable operationally, key pressures drivers and activities were identified and have been reported herein. Definitions of what constitutes physical disturbance and loss, including further definitions required in their assessment, were also set out. The methodology laid out in WKBEDPRES2 was found to be generally applicable to each ecoregion and pressure type thought to have a main impact upon seabed integrity. The resultant demonstration product confirms the current availability of reliable methods that can implement such an assessment and the data requirements needed to serve such methods. Limitations to this assessment process, in terms of supporting models and data gaps were also identified. The implementation of such methods provides a framework that is able to assess multiple pressures arising from multiple activities and presents the possibility of further activities being included into the assessment framework in a cumulative and biologically relevant manner: appropriate to assessment of adverse effects under D6C3 and D6C5, both for the single pressure and the cumulative of all pressures.

ii Expert group information

Expert group name	Workshop to evaluate and test operational assessment of human activities causing physical disturbance and loss to seabed habitats (MSFD D6 C1, C2 And C4 (WKBED-PRES2))
Expert group cycle	Annual
Year cycle started	2019
Reporting year in cycle	1/1
Chair(s)	Philip Boulcott, Scotland
Meeting venue(s) and dates	30 September– 2 October 2019, Copenhagen, Denmark (26 Participants)

1 Introduction

Background and context

The Marine Strategy Framework Directive (MSFD) sets the broad requirement under Descriptor 6 that sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected (Directive 2008/56/EU). Under the D6 criteria of Commission Decision (EU) 2017/848, the spatial extent and distribution of physical loss (D6C1) and disturbance (D6C2) pressures must be assessed in order to assess the status of each MSFD broad habitat type, within each marine region and subdivision. To meet this requirement, EU funded projects have made advances in the cataloguing of human activities and their associated pressures on the benthic environment.

Considering this, the EU (DG ENV) has requested guidance from ICES to identify which human activities are responsible for the physical disturbance and loss of the seabed within MSFD marine waters, to propose suitable methods for assessment of these physical pressures and, to collate pressure data layers to demonstrate the application of the methods in each marine region. The data collected are required to be appropriate to the assessment of benthic habitats (D1) and sea-floor integrity (D6C3-C5) as set out in the Commission Decision 2017/848/EU.

The workshop WKBEDPRES2 brought together work over the past year on physical disturbance pressure layers (initiated in WKBEDPRES1, ICES 2018) and human activities causing the loss of benthic habitats (WKBEDLOSS, ICES 2019). As such WKBEDPRES2 is the final workshop in this series with a focus on MSFD Descriptor 6 Seafloor integrity: C1, C2 and C4. The workshops are part of the formal ICES advisory process in response to a request from the EU. As such the workshop reports will be peer-reviewed, after which an advice drafting group will be convened to drafted advice for approval by ICES Advisory Committee (ACOM).

Workshop to combine physical loss and physical disturbance

The WKBEDPRES2 workshop was tasked to develop EU-wide guidance on how to assess and report human activities that cause physical disturbance to the seafloor and loss of benthic habitats. WKBEDPRES2 evaluated the operational use of data products to describe the spatial extent and distribution of human activities affecting seabed habitats.

The evaluation of data products included, as a demonstration, an assessment of the spatial extent and distribution of different human activities that cause physical disturbance or loss by broad benthic habitat types (assessment of MSFD D6 C1, C2 and C4). The workshop prepared technical guidance on how to assess and report on both disturbance (based on WKBEDPRES1, ICES 2018) and loss (based on WKBEDLOSS, ICES 2019). This also included a review of the applicability of combining AIS (automatic identification system) and VMS (vessel monitoring by satellite) data in derived benthic pressure products. Suggestions for necessary improvements to the proposed methods and/or associated data were provided to ensure the harmonisation and operational use of data products across European Seas for MSFD purposes.

Approach to address the workshop TORs

Having insight as to what activities contribute to each pressure type, and how this equates to impact on seafloor habitats (the "impact chain"), was a required step of WKBEDPRES2 (see Annex 2 for a list of ToRs). Knowledge of the impact chain allows us to prioritise data flows in the regional assessment and to determine the most appropriate spatial resolution for each pressure type during the assessment of impact (given e.g. spatial variation in broad habitat types). A clear analysis of these links also facilitates the assessment of variation in trends in data during a 6-year cycle and their potential effect on: 1) the final assessment of environmental status, and 2) the management decision making process.

By providing guidance on the benefits of knowing the variation spatial and temporal trends in data, TOR A ensured that the usability of data products describing physical disturbance and pressure layers causing habitat loss, and their operationalisation, is at heart of the aims of WKBEDPRES2. TOR A also lent insight to the characterisation of pressures, in relation to D6C3 and D6C5, in that it allows the assessment of adverse effects for single and cumulative pressures. As such, characterisation should be cognisant of the operational requirements of impact indicators that are presently in development (ICES advice 2017) and for which a technical guideline document has been produced by WGFBIT in their 2019 report (Annex 4, page 47, ICES 2019b).

An operational product (for demonstration purposes) of how to include some of the main pressure types in an assessment per habitat type for an ecoregion (and per EEZ and subregion) has also been produced under WKBEDPRES2 (TOR C). This worked example was used within the workshop to draft generic technical guidance on how to report on loss and disturbance. The workshop also identified some of the main stumbling blocks, suggesting alternative solutions for estimating main pressure types in a consistent way across EU ecoregions and their respective impact on MSFD broad habitat types.

AIS data (Automatic Identification System) on fishing vessels has been suggested as another means by which to derive a picture of spatial and temporal coverage of fishing pressure layers. Building on from their previous work, the ICES working group on spatial fisheries data (WGSFD) have been tasked in the context of this advice process to assess the applicability of AIS and VMS data derived products and to determine if their use increases spatial and temporal resolution or coverage. WGSFD has produced a set of recommendations of when AIS might be used, as well as some further technical guidance as to how AIS and VMS data derived products might be used (together) in the assessment of physical disturbance from different fishing activities. The purpose of TOR D was to distil, in the context of WKBEDPRES2, the information produced by WGSFD into some concrete proposals on how and when to make use of these data.

Given the overall findings resulting from the analysis of both physical disturbance pressure layers and pressure layers causing loss of benthic habitats, the workshop provided general recommendations and technical guidance that explain how to prioritise data flows of different human activities in relation to an overall assessment, including the advice concerning the combing of main pressure types.

WKBEDPRES2 was able to draw from the wide range of expertise represented by 25 attendees from across 10 countries, including DG ENV, RSCs, various EU-funded projects, and ICES working groups e.g. WGFBIT, WGEXT, WGSFD (Figure 1). The workshop was able to make use of worked examples from countries representing the Black Sea, Mediterranean Sea, Bay of Biscay, Celtic Sea, North Sea and Baltic

Figure 1. Group picture of the experts at the workshop WKBEDPRES2 whom evaluated and tested operational application of human activities causing physical disturbance and loss to seabed habitats (assessment of MSFD D6 C1, C2 and C4).

References:

ICES 2016. EU request for guidance on how pressure maps of fishing intensity contribute to an assessment of the state of seabed habitats. In Report of the ICES Advisory Committee, 2016. ICES Advice 2016, 1.6.2.4. 5pp

ICES. 2017. EU request on indicators of the pressure and impact of bottom-contacting fishing gear on the seabed, and of trade-offs in the catch and the value of landings. In Report of the ICES Advisory Committee, 2017. ICES Advice 2017, sr.2017.13. 29pp

ICES. 2018. Workshop on scoping for benthic pressure layers D6C2 -from methods to operational data product (WKBEDPRES1), 24–26 October 2018, ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:59. 62pp.

ICES. 2019a. Workshop on scoping of physical pressure layers causing loss of benthic habitats D6C1–methods to operational data products (WKBEDLOSS). ICES Scientific Reports. 1:15. 37 pp.

ICES. 2019b. Interim Report of the Working Group on Fisheries Benthic Impact and Trade-offs (WGFBIT), 12–16 November 2018, ICES Headquarters, Copenhagen, Denmark. ICES CM 2018/HAPISG:21. 74 pp.

2 Activities & pressures

Under the D6 criteria of Commission Decision (EU) 2017/848, the spatial extent and distribution of physical loss (D6C1 and C4) and disturbance (D6C2) pressures must be assessed in order to assess the status of each MSFD broad habitat type, within each marine region and subdivision. Within WKBEDPRES2, and in continuation from WKBEDPRES1 (ICES 2018) and WKBEDLOSS (ICES 2019a), terminology that is required by this assessment process was defined in the following chapter. In order to make regional benthic assessments tractable, Chapter 2 also identifies the main pressures relevant to this type of assessment. This prioritisation exercise follows on from earlier analysis in WKBEDPRES1 by examining linkages from activities to specific pressures that cause physical damage and loss in the regional seas.

2.1 Definitions

Activity: basic human activities to satisfy the needs of societal drivers; e.g. aquaculture or tourism (Scharin *et al*., 2016). One activity may cause many different pressures with different scales of impacts (as defined below).

Pressure: is considered as the mechanism through which an activity has an actual or potential effect on any part of the ecosystem, e.g. for demersal trawling activity, one pressure would be abrasion of the seabed (Robinson *et al*., 2008). It should be noted that one pressure may be caused by many different activities (e.g. abrasion from fishing, aggregate extraction, dredging) with different extents, frequencies and impacts, and that one activity may be responsible for multiple pressures (e.g. other non-physical pressures by fishing: spread of non-indigenous species, mortality/injury to wild species and inputs of litter). Pressures can cause multiple and progressive biological (e.g. lethal and various sub-lethal changes through damage and stress) and physico-chemical state changes (e.g. sediment homogenisation, changes in sediment topography and compaction) at any level (e.g. communities and habitats) (Smith *et al*. 2016).

Impact/ adverse effect: For the purposes of the WKBEDPRES/ WKBEDLOSS process, impact is defined as: a possible adverse change, influencing or affecting an environmental component, caused by a pressure related to one or more anthropogenic activities.

The is no MSFD definition for impact, although impacts are mentioned in MSFD Annex III in relation to 'environmental impacts of the pressure' and the alternative term 'adverse effects' is used throughout Commission Decision (EU) 2017/848. The revised Commission Decision specifies that Criteria D6C1, D6C2 and D6C3 relate only to the pressures 'physical loss' and 'physical disturbance' and their impacts. Impact is shown to be associated with criterion 'D6C3 Spatial extent of adverse effects from physical disturbance on benthic broad habitats'. Additionally, Annex III mentions (Commission Directive (EU) 2017/845), for the assessment of environmental impacts relating to a pressure, the need to select the relevant ecosystem elements (species, habitats, ecosystems) and parameters from 'Table 1: Structure, functions and processes of marine ecosystems'. Pressure assessments studies mention impact chains linking activities to pressures and then to impacts via the exposure and sensitivity of ecological components to those activities/pressures (Knights *et al*. 2015, Kenny *et al*. 2017, Pedreschi *et al*. 2019).

Physical disturbance: activities that disturb benthic biota, but do not change the benthic substrate type permanently, even when full recovery would take longer than 12 years, as long as recovery to the original state can be expected given enough time.

Physical loss: any human-induced permanent alteration of the physical habitat from which recovery is impossible without further intervention.

Physical loss typology – three types of loss are defined that have implications for specific data flows and how they are used within the assessment protocol.

1. **Sealed physical loss**: distribution of structures placed in the marine environment (e.g. wind turbines, port infrastructure) and introduced substrates that seal off the seabed
2. **Unsealed physical loss**: distribution of permanent seabed habitat change in terms of EUNIS 2 level-habitat type (e.g. during dredge disposal or aggregate extraction).
3. **Loss of biogenic* habitat**: historical loss of a biogenic habitat

***where animals or, more rarely plants, form a hard substrate for other organisms to attach to**.

Regarding disturbance and loss as a continuum: Disturbance can lead to loss in certain circumstances, where extent, frequency, intensity or severity of a pressure leads to a permanent change in habitat, particularly when the habitat has a high degree of sensitivity (low resistance and resilience/recovery). An example of this is aggregate extraction, where, if severe enough or of sufficient duration, its continuance may remove a surface sediment type exposing a different subsurface sediment type.

2.2 Pressure Types Considered

Pressure types examined within the assessment were physical disturbance and loss to the seabed. The relevant pressure types were selected according to 4 hierarchical criteria that required the selected pressure types to be:

- directly related to assessment of MSFD D6 C1, C2 and C4
- the main pathways of change (identified in WKBEDPRES1)
- related to impact in a biologically meaningful way
- easily communicated and understood by broad suite of managers and stakeholders

Four subtypes of loss/physical disturbance were identified from this selection process:

1. **Abrasion** – the process of scraping of the substrate (e.g. by a trawl door or an anchor). Whilst abrasion could result in the mixing of sedimentary substrates, any sediment removal is considered under removal. [*Resulting in physical disturbance/loss*].
2. **Removal** – the net transference of substrate away from the seabed resulting from human activities (e.g. either directly by human activities or indirectly through the modification of hydrodynamics). [*Resulting in physical disturbance/loss*].
3. **Deposition** – the movement of sediment and/or particulates to a new position on top of or in existing substrates (e.g. directly by human activities such as dredge disposal or indirectly through the modification of hydrodynamics). [*Resulting in physical disturbance/loss*].
4. **Sealing** – the capping of the original substrate with structures (e.g. metal pilings, concrete footings or blankets) or substrates (e.g. rock or stone fills) which in and of themselves change the physical habitat. [*Resulting in loss*].

For categories 1- 3, the subtypes can result in either disturbance or loss depending on the extent and severity, with disturbance leading to loss at extremes, e.g. dredging extensive or deep enough to change the broad scale habitat substrate (removal of one substrate, uncovering another substrate). Assessment of loss can be done at EUNIS level 2 for marine habitats (based on WKBEDLOSS, that constrained the definition of loss to EUNIS level 2 habitat change). The definition of agreed within WKBEDLOSS to facilitate a European sea-wide assessment that is comparable across Member States. Nevertheless, Member States may opt to assess at the lower MSFD

Broad Habitat Type level (BHT) and/or finer EUNIS levels (e.g. level 5) to meet their own reporting requirements. Similarly, assessment of disturbance by Member States can be done at broad habitat level and/or higher EUNIS levels (when for example using Habitats Directives assessments for particular habitats.) For the purposes of regional benthic assessment, in those instances where Member states do collect data at a finer spatial reposition, final reporting for both disturbance and loss should be by MSFD broad scale habitat type with appropriate aggregation of information as needed (for example aggregating loss from lower bathyal coarse, mixed, sand and mud EUNIS level 2 habitats to BHT lower bathyal soft habitat type).

Omissions from the regional assessments: The assessment of impact also relates to scale. The Commission Decision (EU) 2017/848 requires assessments of MSFD habitats to be at bio-geographically-relevant scales (subdivisions of a region or subregion). For the Greater North Sea subregion OSPAR in 2017 provided three separate assessments (Northern North Sea, Southern North Sea and English Channel) to reflect this requirement. There may be other pressure-activity combinations assessed nationally that lie beyond regional assessment, but are regarded as important when viewed at the smaller national (e.g. boating anchoring abrasion) or local scale; e.g. munition on-site demolition, firing ranges and pressures related to explosions (dumping grounds or military activities), or pressures related to research activities (abrasion and loss due to ballast weights, sampling, etc.). Whilst local scale means that their omission from regional assessment is unlikely to affect outputs, Member States have the option to record such disturbance or loss, if data are available.

2.3 Regional Activities

Taking each of the 4 major pressures listed in 2.2, the key activities identified in WKBEDPRES1 were assessed at a regional scale with respect to the availability of relevant occurrence/position data and operational metrics (if available: see sections 5.3.1 to 5.3.4), and with consideration as to whether a specific pressure for that activity was significant at the regional scale. This process permitted the identification of activity data streams necessary for the purposes of assessment and to allow the documentation of omissions in potential assessment models. For each pressure, key activities (green highlight) in the assessment process were identified along with lesser activities still thought to be important (yellow highlight), either due to their severity or areal extent (Tables 2.1 to 2.4). During this process small footprint activities were regarded as having little significance within the regional assessment unless they were constrained to a specific and limited habitat area (which is potentially more likely in the coastal zone because of higher habitat heterogeneity).

Abrasion

The dominant activity across all regions (Table 2.1) is fishing with mobile bottom contacting gears, with generally good data availability for vessels over 12 m (VMS and logbook) within the Member States or relevant institutions. Nevertheless, there is a data gap for vessels using mobile gears that are smaller than 12 m. Swept area ratio (SAR) analysis used to quantify pressure from VMS data is well developed and is routinely used nationally and by ICES. WKBEDPRES2 also considered abrasion in shallow and coastal waters arising from the passage and propeller turbulence from ships to be of importance, particularly in the Baltic, as well as coastal recreational anchoring in the Mediterranean Seas. However, there is presently little knowledge on parameterising/modelling abrasion from turbulence or anchoring. Similarly, there is no methodology available to assess the extent of abrasion due to static gears, which may be important in countries with large, Small Scale Fisheries. This also applies to aggregate extraction, the construction phase of structures, and dredging, all of which have relatively small footprints when assessed at the (sub) regional scale.

Table 2.1: ABRASION activity-regional sea interactions with data type, footprint, metric. Based on MSFD list and WKBED-PRES1 Priority Activities. Green highlights are key activities causing the pressure. Yellow highlight, denote important but not key activity. EMS = Electronic Monitoring System

ABRASION	Baltic Sea	North Sea	Celtic Sea	Mediterranean Sea	Black Sea	Notes
Extraction - Living (Fishing)	VMS + Log - SAR	VMS + Log - SAR	VMS + Log - SAR	VMS + Log - SAR	VMS + Log - SAR	Applies to mobile bottom contact gears, and VMS only vessels. Logbooks not available for all fishing in all regions
Aggregates Extraction	License (metric = surface area and/or volume) + AIS - Small footprint. No metric	License (metric = surface area and/or volume) + EMS/AIS - Small footprint. No metric	License (metric = surface area and/or volume) + EMS/AIS - Small footprint. No metric	License (metric = surface area and/or volume) + AIS - Small footprint. No metric	License (metric = surface area and/or volume) + AIS - Small footprint. No metric	Small footprint, no data on impact, No AIS available for all countries/regions
Structures (Tourism, O&G, Transport) - Construction	Plan/License - No metric	Plan/License - No metric	Plan/License - No metric	Plan/License - No metric	Plan/License - No metric	
Structures - Operation	NA	NA	NA	NA	NA	
Dredge (all) - dredging	License, Small footprint, no metric	License, Small footprint, no metric	License, Small footprint, no metric	License, Small footprint, no metric	License, Small footprint, no metric	
Dredging Disposal	NA	NA	NA	NA	NA	
Transport - Shallow routes, Anchoring & Recreational	Permitted Area, Shallow routes, AIS, no metric	Permitted Area, Shallow routes, AIS, no metric	Permitted Area, Shallow routes, AIS, no metric	Permitted Area, Shallow routes, AIS, no metric	Permitted Area, Shallow routes, AIS, no metric	Abrasion from propeller turbulence in shallow waters and anchoring
Cultivation (Aquaculture)	NA	NA	NA	NA	NA	Only anchor chain, small, no metric

Removal

The dominant activity causing removal (Table 2.2) in most of the regions (Baltic, North, and Celtic Seas) assessed in WKBEDPRES2 is aggregate extraction (removal of sediment for use elsewhere). Aggregate extraction was much less extensive in the Mediterranean and Black Seas than in the other areas examined. The second most important activity causing removal is dredging (removal of sediment to clear/maintain an area). This was equally important in all the regions. Aggregate-relevant metrics are available in most northern regions, but not the Mediterranean and Black Seas. No metrics are, as yet, available for dredging.

Scouring can be argued as either abrasion, or sediment removal arising from hydrological processes around new seabed structures, but is not considered here.

Table 2.2: REMOVAL activity-regional sea interactions with data type, footprint, metric. Based on MSFD list and WKBED-PRES1 Priority Activities. Green highlights are key activities causing the pressure. Yellow highlight, denote important but not key activity.

REMOVAL	Baltic Sea	North Sea	Celtic Sea	Mediterranean Sea	Black Sea	Notes
Extraction - Living (Fishing)	Gear & Métier specific, VMS + Log - SAR (small/part)	Gear & Métier specific, VMS + Log - SAR (small/part)	Gear & Métier specific, VMS + Log - SAR (small/part)	Gear & Métier specific, VMS + Log - SAR (small/part)	Gear & Métier specific, VMS + Log - SAR (small/part)	Taking out fine sediment. Not quantified. Could be modelled. Major disturbance covered elsewhere
Aggregates Extraction	License, AIS, Metric: minutes in grid. Some countries	License EMS/AIS. Metric: minutes in grid	License, AIS, Metric: minutes in grid. Some countries	License, no metric	License, no metric	AIS not available for all countries/regions. Aggregate extraction is removal of material for e.g. industrial or beach nourishment purposes.
Structures (Tourism, O&G, Transport) - Construction	Plan/License - Very Small, No metric	Plan/License - Very Small, No metric	Plan/License - Very Small, No metric	Plan/License - Very Small, No metric	Plan/License - Very Small, No metric	
Structures - Operation	NA	NA	NA	NA	NA	Structures may cause scouring - but not parameterised
Dredge - dredging	Plan/License - No metric	Plan/License - No metric	Plan/License - No metric	Plan/License - No metric	Plan/License - No metric	Dredging defined as sediment removal to clear an area.
Dredging Disposal	NA	NA	NA	NA	NA	Dumping of dredged material
Transport - Shallow routes, Anchoring & Recreational	Permitted Area, Tiny footprint, Shallow routes, AIS, no metric	Permitted Area, Tiny footprint, Shallow routes, AIS, no metric	Permitted Area, Tiny footprint, Shallow routes, AIS, no metric	Permitted Area, Tiny footprint, Shallow routes, AIS, no metric	Permitted Area, Tiny footprint, Shallow routes, AIS, no metric	Insignificant
Cultivation (Aquaculture)	NA	NA	NA	NA	NA	

Deposition

The activity exerting the highest levels of deposition per unit area (Table 2.3) was considered to be dredge disposal in all regions (although deposition from fishing was more widespread across these regions). Pressure data that were able to depict positioning/extent beyond the position of the vessel were available from only a few Member States. Mobile, bottom-contacting fisheries were considered the second most important activity causing deposition, based on its large spatial extent. However, the deposition of sediments after resuspension has not, as yet, been modelled as there is no agreed method, and its incorporation into regional assessments is unlikely despite it extending beyond the activity footprint.

Table 2.3: DEPOSITION activity-regional sea interactions with data type, footprint, metric. Based on MSFD list and WKBEDPRES1 Priority Activities. Green highlights are key activities causing the pressure. Yellow highlight, denote important but not key activity.

DEPOSITION	Baltic Sea	North Sea	Celtic Sea	Mediterranean Sea	Black Sea	Notes
Extraction - Living (Fishing)	Gear & Métier specific, VMS + Log, No metric.	Gear & Métier specific, VMS + Log, No metric.	Gear & Métier specific, VMS + Log, No metric.	Gear & Métier specific, VMS + Log, No metric.	Gear & Métier specific, VMS + Log, No metric.	Not modelled, Can extend beyond trawling footprint. Important as the extent of trawling is very large. Sediment- and current-specific
Aggregates Extraction	License, AIS - No metric	License EMS/AIS - No metric	License, AIS - No metric	License, AIS - No metric	License, AIS - No metric	AIS no available in all countries and regions. Not modelled, Can extend beyond extraction footprint. Sediment- and current-specific
Structures (Tourism, O&G, Transport) - Construction	Plan/License - Very Small, No metric	Plan/License - Very Small, No metric	Plan/License - Very Small, No metric	Plan/License - Very Small, No metric	Plan/License - Very Small, No metric	
Structures - Operation	Plan/License - Tiny, No metric	Plan/License - Tiny, No metric	Plan/License - Tiny, No metric	Plan/License - Tiny, No metric	Plan/License - Tiny, No metric	Potential deposition of scoured material
Dredge - dredging	Plan/License - No metric	Plan/License - No metric	Plan/License - No metric	Plan/License - No metric	Plan/License - No metric	Sometimes amount and area is specified within License area. Pressure is beyond the activity footprint
Dredge Disposal	Plan/License - No metric	Plan/License - No metric	Plan/License - No metric	Plan/License - No metric	Plan/License - No metric	Sometimes amount and area is specified. Some modelling. Pressure is beyond the activity footprint
Transport - Shallow routes, Anchoring & Recreational	Permitted Area, Very small, Shallow routes,	Permitted Area, Very small, Shallow routes, AIS, no metric	Permitted Area, Very small, Shallow routes,	Permitted Area, Very small, Shallow routes,	Permitted Area, Very small, Shallow routes,	Insignificant

DEPOSITION	Baltic Sea	North Sea	Celtic Sea	Mediterranean Sea	Black Sea	Notes
	AIS, no metric		AIS, no metric	AIS, no metric	AIS, no metric	
Cultivation (Aquaculture)	Plan/License - No metric	Plan/License - No metric	Plan/License - No metric	Plan/License - No metric	Plan/License - No metric	Some modelling. Very small areas

Sealing

The dominant pathway causing sealing (Table 2.4) arose from the placement of permanent structures during a variety of activities (oil and gas extraction, renewable energy, harbours and coastal defence, tourism/recreation, road and rail transportation, pipelines and cables, wrecks, artificial reefs, etc.). The extent of sealing may not be similar between areas and regions, but the methodological approach to data collection and its assessment is similar. All Member States have their own records, although not necessarily up to latest date or centrally collated (e.g. locally recorded coastal defence works are known to be in existence). However, it is likely that development records from more recent sectors (e.g. renewable energy) will be more detailed, accurate and in electronic (e.g. GIS) format. Taken as a whole, the precision of data may be variable; with data variously being stored as cartographic points, lines, polylines and polygons. There are fixed anchoring points/blocks in coastal waters that also cause sealing in all the regional seas. These are widespread but are insignificant in size when assessed at a regional scale.

A point relevant to all the pressures noted above is the need for even better mapping products that better relate to pressure layers. EMODNet maps with MSFD Benthic Broad Habitat Types, with respect to accuracy and resolution, particularly from areas that have been widely modelled rather than sampled, should not just be seen as a finished product with future efforts needed to improve accuracy, particularly through ground-truthing.

Table 2.4: SEALING-activity-regional sea interactions with data type, footprint, metric. Based on MSFD list and WKBEDPRES1 Priority Activities. Green highlights are key activities causing the pressure. Yellow highlight, denote important but not key activity.

SEALING	Baltic Sea	North Sea	Celtic Sea	Mediterranean Sea	Black Sea	Notes
Extraction - Living (Fishing)	NA	NA	NA	NA	NA	
Aggregates Extraction	NA	NA	NA	NA	NA	
Structures (Tourism, O&G, Transport) - Construction	NA	NA	NA	NA	NA	
Structures - Operation	Permit/License/Geolocation/Map/Different databases, Metric	Permit/License/Geolocation/Map/Different databases, Metric	Permit/License/Geolocation/Map/Different databases, Metric	Permit/License/Geolocation/Map/Different databases, Metric	Permit/License/Geolocation/Map/Different databases, Metric	Different structures, different data formats: points, polygons, lines, polylines

SEALING	Baltic Sea	North Sea	Celtic Sea	Mediterranean Sea	Black Sea	Notes
	Polygon/Polyline/Line	Polygon/Polyline/Line	Polygon/Polyline/Line	Polygon/Polyline/Line	Polygon/Polyline/Line	
Dredge - dredging	NA	NA	NA	NA	NA	
Dredging Disposal	NA	NA	NA	NA	NA	
Transport - Shallow routes, Anchoring & Recreational	Permit area. Fixed anchors. No metric	Permit area. Fixed anchors. No metric	Permit area. Fixed anchors. No metric	Permit area. Fixed anchors. No metric	Permit area. Fixed anchors. No metric	Insignificant footprint from concrete block anchors
Cultivation (Aquaculture)	Plan/License - No metric. Very small area.	Plan/License - No metric. Very small area.	Plan/License - No metric. Very small area.	Plan/License - No metric. Very small area.	Plan/License - No metric. Very small area.	Insignificant footprint from concrete block, mooring foundations, anchors

2.4 Parameterising Regional Activity/Pressure Interactions

The most significant interactions (green highlights in the overall tables) were further considered in a more detailed regional analysis that looked at the availability of data, relevant metrics, methods to assess the pressure, and data flows, as well as the identification of gaps and potential limitations.

Abrasion

For abrasion, the most significant activity is fishing with mobile, bottom-contacting gears (Table 2.5). For the Baltic Sea, North Sea, Bay of Biscay, Iberian Coast and Celtic Sea, data are collected from VMS and logbooks. There is also an established and published methodology to produce the pressure layer using swept area ratio per year on C-square as a metric (Chapter 3). For the Mediterranean and Black Sea, data are more spatially fragmented and are not compiled in a standard format as they derive from differing methodologies. For example, while the swept area ratio is calculated in parts of the Mediterranean, the presence of fishing vessels is applied as a metric in the Black Sea. Moreover, since tracking the small fishing boats is challenging (boats less than 12 meters in size are not obligated to have VMS in any of the regions and, in some cases, a deregulation for VMS exemption exists for fishing vessels up to 15 m) the replication of current VMS protocols within the Black Sea and Mediterranean Sea, both of which have large fleets of small vessels, proportionally, is unlikely to meet data requirement in these waters. Access and use of logbook data (where it exists) in the Mediterranean and Black Sea is limited, and will also serve to restrict assessment efforts.

Table 2.5 Regional/sub-regional assessment of data type, metric, data flow, method and gaps/ impediments to operation for key pressures: ABRASION caused by mobile bottom contacting fishing gears

	Baltic Sea	North Sea	Celtic Sea	Mediterranean Sea	Black Sea
Data	VMS + Logbook data	VMS + Logbook data	VMS + Logbook data	VMS + Logbook data (for large trawlers, and for some areas), Non-EU and smaller vessels maybe possible from AIS data	VMS + some logbook data / or AIS data
Metrics	Swept area ratio (km2) per year on C-square grid (0.05° x 0.05°)	Swept area ratio (km2) per year on C-square grid (0.05° x 0.05°)	Swept area ratio (km2) per year on C-square grid (0.05° x 0.05°)	Swept area ratio (km2)	Presence of fishing vessels
Data flow	ICES data call	ICES data call	ICES data call		National agency of fisheries and aquaculture
Method	Methods to calculate the pressure regionally are coherent, established and published. Vessel speeds representing fishing activity are assigned to a 0.05° × 0.05° grid (the c-square approach), each covering about 15 km² at 61°N latitude, which is the spatial resolution adopted by ICES. Estimates on total SAR within each grid cell are calculated by métier and habitat.		No common regional method developed to use VMS/AIS (except Italy and Greece have a common method to calculate the SAR)		Common method to calculate the presence of fishing vessels

	Baltic Sea	North Sea	Celtic Sea	Mediterranean Sea	Black Sea
Gaps or impediments to operation	Vessels < 12 m length don't have VMS (Vessel Monitoring data by Satellite). AIS (Automatic Identification System) from some vessels is available but is not used at present. Benthic impact assessment methodologies are well established, but the interaction with oxygen depletion has to be considered. Russia does not supply VMS but might be derived from AIS.	Vessels < 12 m length do not have VMS. Benthic impact assessment methodologies are well established.	Vessels < 12 m length don't have VMS. AIS from some vessels is available but is not used at present. Benthic impact assessment methodologies are well established.	The majority of coastal fishing vessels are not equipped with VMS, vessels < 12m and in some cases < 15m. Could use AIS (the ping frequency is acceptable but it does not cover a large number of vessels). Benthic impact assessment methodologies very well established, however, lack of benthic community maps (and in general spatially-explicit data). Regular monitoring conducted by many EU countries but data (including VMS) is not open access. Lack of applicability of SAR to static gears where the disturbance levels are unknown (but potential to do this: several project proposals).	Black Sea EU MS (Bulgaria & Romania) are submitting some aggregated effort data to JRC. Logbook data exists only partly. There were no Black Sea partners involved with VMS work under the BENTHIS project. Existence/availability of log book data unknown by group.

Removal

For removal, the most significant activity is aggregate extraction (Table 2.6). While licensed areas of the extraction sites are available for all of the regions, more detailed data on the location of extraction (within a site) is available from Electronic Monitoring System (EMS) on board or AIS for the Baltic Sea, North Sea and Celtic Sea. The common metric used within these regions is area (km^2), but additional metrics on duration (minutes extracted) or volume (e.g. in m^3) is used in some areas. Aggregate extraction is limited both in the Mediterranean and Black Sea where there are no commonly agreed reporting methods.

Table 2.6 Regional/sub-regional assessment of data type, metric, data flow, method and gaps/ impediments to operation for key pressures: REMOVAL caused by aggregate extraction

	Baltic Sea	North Sea	Celtic Sea	Mediterranean Sea	Black Sea
Data	License areas, AIS from some countries	License areas, EMS/AIS	License areas, EMS/AIS	License areas	License areas (points of the polygon corners)
Data flow	ICES WGEXT Data call, HELCOM regional data	ICES WGEXT Data call	ICES WGEXT Data call	National fragmented databases	In reports
Metrics	Area in km2, minutes extracted in 50 m grid in DK	Area in km2, minutes extracted in 50 m grid for some countries	Area in km2, minutes extracted in 50 m grid for some countries	Area in km2	Area km2, volume m3 / license
Method	Method to produce minutes extracted in 50m grid only for DK	Method to produce minutes extracted in 50m grid		No common method	No method
Gaps or impediments to operation	AIS not available for all countries/regions. Minutes extracted in 50m grid only for the one year the exercise was done. Volume reported not per site but total for the country. If volume would be included in the pressure, the information is confidential. A synthesis of rates of depth and recovery rate of fauna for aggregate extraction activities has not been carried out, although lots of individual studies exist and are often available (some may be company owned).			Data is diverse through the region if available, limited regional coordination, no common method, very small scale activity	Very small scale activity

Deposition

For deposition, the most significant activity is the disposal of material (Table2.7). While licensed areas of the disposal sites are available for all of the regions, more detailed data on the exact location of the disposal (within a licensed area) should be available through HELCOM and OSPAR through the regional data reporting cycle. Area of the disposal site (km^2) is common metric to all the regions; however the amount (in volume, tonnes dry weight) of deposited material should also be available through HELCOM and OSPAR for some countries. Disposal of material is limited both in the Mediterranean and Black Sea (but see EMODNET and IDEM (www.msfd-idem.eu) geospatial portals) where there are currently no commonly agreed reporting methods).

Table 2.7 Regional/sub-regional assessment of data type, metric, data flow, method and gaps/ impediments to operation for key pressures: DEPOSITION caused by disposal of (dredged) material

	Baltic Sea	North Sea	Celtic Sea	Mediterranean Sea	Black Sea
Data	Licensed areas, deposition areas or points	Licensed areas	Licensed areas	License areas	Licensed areas
Data flow	HELCOM Annual data call, national databases	OSPAR Annual data call, National plans	OSPAR Annual data call, National plans	National fragmented databases	In reports
Metrics	Area in km2, amount of deposited material	Area in km2, amount of deposited material (for some countries)	Area in km2, amount of deposited material (for some countries)		
Method	Regional level perspectives may be possible.			No common method	No method
Gaps or impediments to operation	Data is reported as points or polygons, amount and the material of the deposit reported for some sites. Scale of reported activities differs between the different coastal states. Sometimes amount and area is specified. Some modelling of the foot print e.g. in Danish waters. Pressure is beyond the activity footprint. We do not have a corresponding impact analysis so we don't have it.	At the moment no model or parameter estimates are available to convert deposition into an estimate of the state of the seabed.	At the moment no model or parameter estimates are available to convert deposition into an estimate of the state of the seabed.	Data is diverse through the region if available, limited regional coordination, no common method, very small scale activity	Very small scale activity

Sealing

For sealing, the most significant activity is the placement of physical structures (Table 2.8). For all the regions, the data is consistent from permits and licenses. Diverse data sets are available in national databases or from regional databases, if existing. A common metric - the area sealed in km^2- exists for this pressure. To assess the footprint (in km^2) of the structure, either polygon data can be used directly, or in the case where the original data is provided as points or lines, a footprint can be estimated by applying a buffer.

Table 2.8 Regional/sub-regional assessment of data type, metric, data flow, method and gaps/stumbling blocks for key pressures: SEALING caused by physical structures

	Baltic Sea	North Sea	Celtic Sea	Mediterranean Sea	Black Sea
Data	Permit/License/Geolocation/Map	Permit/License/Geolocation/Map	Permit/License/Geolocation/Map	Permit/License/Geolocation/Map	Permit/License/Geolocation/Map
Data flow	National databases, existing regional databases	National databases, existing regional databases	National databases, existing regional databases	National databases, existing regional databases	National databases, existing regional databases
Metrics	Area in km2	Area in km2	Area in km2	Area in km2	Area in km2
Method	Assess footprint of the structure either directly from the polygon data at hand or, if original data is points or lines, a footprint should be estimated.				
Gaps or impediments to operation	A lot of different structures, different data formats for structures: points, polygons, lines, polylines. Fragmented datasets, but improved with new sectors (e.g. renewables, oil & gas)				

2.5 The Reversal of Loss

There is no formal way of accounting for loss reversal within the MSFD. However, taking account of the restoration of benthic habitats in their national assessments for D6 is an issue raised by Member States as actions taken at the national level that aim to restore habitats to their original state will cause a reversal in loss (albeit at a localised scale). Two examples:

Licencing requirements

New developments often have legal obligations for removal of structures and related protection (footings or anti-abrasion covers) as well as restoration to pre-installation habitat. These obligations may begin in the near future, first, with the removal of oil and gas installations and, secondly, after another 20+ years, with the removal of wind farm installations.

Restoration of degraded habitats

Policy requirements (EU Biodiversity Strategy, etc.) require the restoration of degraded habitats without specifying details (habitats, priorities). The primary mechanism by which restoration may be realised is through the cessation of activities causing the pressure (e.g. physical disturbance), and allowing passive recovery of the seabed. Management allow such recovery may be spatial, through the designation of MPAs, cessation of permit licences and spatial management of fisheries. However, there are, for example, a number of active restoration actions now being taken to address historic loss, including the re-seeding of oyster reefs (Wadden Sea and other European seas, noraeurope.eu), seagrass meadows (North, Baltic and Mediterranean Seas, merces.eu) and coralligenous habitats (sponges and gorgonians) in the Mediterranean. All of these targeted areas represent historical, biogenic loss, but exhibit different degrees of loss. The restoration of stone reefs in Denmark is a non-biogenic example of this initiative.

2.6 Importance of Scale in Habitat Loss and Disturbance

At small scales, disturbance can lead to habitat degradation or loss, but may not be reported or assessed (e.g. small scale (< 500 m^3) individual private dredging allowed with reporting but without obligatory impact assessment in Finland). However, this may be important when the national/regional extent of the affected habitat is small and the pressure footprint proportionally large: for example, in the Danish Baltic region 50 km^2 of the broad habitat type infralittoral coarse sediment has been lost from aggregate extraction. This loss corresponds to 52 % of a rare habitat type in the region.

2.7 Summary

Definitions were refined and agreed for physical disturbance D6 C2 and loss and D6 C1/C4. The scoping process carried out in Chapter 2, was completed across major regional seas and selected sub-regional marine areas for which expertise was available (based on BEDPRES1), and is relevant to other sub/regional sea areas. For each physical pressure related to physical disturbance and loss (abrasion, removal, deposition and sealing), the same activities across the regional areas were judged to cause the most widespread/significant effect, although their magnitude is likely to be variable between the regional areas. However, the requirement to assess regionally at broad habitat scale (based on EUNIS level 2), although finer scales may be examined at Member State level, may overlook activities/pressures that have a disproportionate effect on specific biological habitats (EUNIS higher level 4+).

Managing disturbance and loss at EUNIS Level 4+ habitat types might be carried out by Member States with specific spatial measures and in alignment with other EU policies. In addition, there may be other pressure-activity combinations beyond those assessed here, as part of the regional assessments, which may be more important at a national or local scale. National assessments might also highlight areas of concern to prioritise action following a similar risk assessment/scoping exercise.

2.8 References

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3 Fishing activity (VMS vs AIS)

Fishing was identified as a major cause of physical disturbance (via abrasion) on the sea floor in EU waters during the regional scoping presented in chapter 2 and in WKBEDPRES1 and WKBEDLOSS. The following chapter gives more detail on the availability of data relating to fishing activity at a regional scale.

3.1 VMS data on a regional scale

ICES issues an annual data call for VMS/Logbook data- for the ICES area covering the North East Atlantic and Baltic to all ICES/EU countries. This call has been running for several years and currently contains data for the time period 2009-2018. While Member States at National scale have established practices and conventions for handling VMS and Logbook data, the ICES data call is extended to all ICES countries in order to standardize, harmonize and aggregate the different national datasets. The associated workflow is implemented within the R programming environment.

There is a well-established workflow for handling the VMS and logbook data at national level. This is a standardized workflow and R-script that processes the data, aggregating final outputs to the data call aggregation level. A subgroup of WGSFD runs a quality check of the submitted data. In cases where issues or anomalies in the data are found, the data submitter is contacted and asked for clarifications. The ICES datacentre has a workflow to calculate swept area ratios (SAR) based on hours fished, average fishing speed and gear width. The gear width is found from relationships between gear widths and average vessel length or engine power (kW), Eigaard *et al*. (2015). One data gap apparent in VMS data is that it is only mandatory for vessels larger than 12 m (overall length) (since 2012) and the interval between the positions is recorded at a maximum of 2 hours (varying between 15 minutes and 2 hours on EU level). The VMS/Logbook data call requests that data are aggregated on the 0.05 degrees c-squares level; this resolution was chosen to reflect the ping rate and the normal speed of a vessel during fishing activities, and minimising the possibility that a vessel can traverse grid cells without being recorded.

The spatial resolution of aggregated VMS data

It is often highlighted that the 0.05 degrees resolution (corresponding to 15 km^2 at 61 °N) is not sufficient for the purpose of impact assessments that relate fishing pressure to habitat distribution and sensitivity, as there are often several habitats within a single 0.05 degrees c-square. Moreover, at the level of the 0.05 c-square, fishing activity is often overestimated, as only a part of the c-square might have a fishing pressure. For creating the fishing pressure layer on a higher spatial resolution - e.g. 0.01 degrees c-squares - either a higher resolution of positions (related to ping rate) or interpolation between VMS positions would be needed. Interpolation methods, which attempt to fill in position data between pings, have been developed for trawlers and beam trawlers but not for seiners and passive gears. If data should be aggregated on a 0.01 degrees resolution without using interpolation, the ping rate should increase accordingly with a five times higher frequency. The latter recourse not only allows data to be collected across the fleet but allows the activity to be assessed on true position data, thereby reducing uncertainty in when/where the vessel is fishing.

Data confidentiality and resolution

Increasing position resolution reduces the "smearing effect" of fine scale trawl tracks, which makes them appear to be present over larger areas than they actually affect. If finer scale fishing activity maps were made available, by for example adoption of smaller aggregated grids, it would most likely reduce the overall pressure footprints (see section 4.5, also Amoroso *et al*. 2018). However, whilst this may be desirable at an industry scale, data confidentiality can cause problems in the use of VMS data if individual vessels can be identified from the data or maps. This problem is exacerbated at the edge of fishing areas or where finer resolutions in aggregated data are required. WGSFD suggested that SAR is not considered sensitive information that can relate back to an individual vessel. However, if steps towards higher data resolutions are taken in the future, issues around data confidentiality should be considered.

In the proposal for amending the fisheries control regulation (COM/2018/368 final) it is stated that, "All vessels including those below 12 metres' length must have a tracking system", and that "The transmission of vessel position data and the polling shall either pass through a satellite connection, or may use a land-based mobile network when in reach of such network". If this proposal is approved, it would greatly improve our ability to document fishing pressure from the small-scale fisheries from vessels below 12 meters (overall length).

It should be noted that the ICES VMS/Logbook data call does not cover the Mediterranean and Black Sea regions. Additionally, in these regions, a large proportion of the fleet is below 12 meters, and does therefore not currently have VMS on-board.

3.2 AIS data on a regional scale

The ICES WGSFD 2019 meeting included a ToR to: analyse current Automatic Identification System (AIS) datasets available to the WG, assess their fitness for purpose in provision of advice, and investigate the possibility of the inclusion of AIS data in the annual request from ICES to its member countries to provide spatial fisheries effort data to the data centre ("the ICES VMS data call"). The working group deliverable is a section in the WG report to be forwarded to WKBEDPRES2 describing best practice, data gaps and approaches to data handling.

AIS is a position location system that gathers detailed vessel positioning data for the purpose of improving maritime safety. The signals can be picked up at base stations, at coastlines, or by satellites with AIS receivers. Since May 2014, AIS has been compulsory for all fishing vessels larger than 15 m overall length (class A); smaller vessels can have AIS class B installed voluntarily for maritime safety. AIS data are collected by national coast guards and other institutions and commercial vendors. Data sources for the AIS data are listed in the WGSFD 2019 report. Some of the contributors to the ICES VMS/Logbook data call have access to AIS data, but the majority do not have access to national AIS data. In lieu of national data, JRC has an AIS dataset covering all EU waters from October 2014 - September 2015, but it does not as yet cover other periods. Similarly, an AIS dataset is available from EMODNet (currently limited to 2017). AIS data can be bought from commercial providers over longer time periods, but their reporting coverage (network of operators) often does not match all vessels operating within a region.

Some of the data challenges when working with the AIS data are listed below:

- **Lack of gear information:** AIS has information on position, date/time, speed, heading, call sign, vessel type, MMSI etc., but no information on fishing gear. Information on the fishing gear used during a trip is required for assessment and can be found from fishing logbooks, which are available to data providers nationally and considered confidential data. When working with AIS data without access to logbook data, fleet registers are often used to assign fishing gear used by the vessel. This can lead to the misclassification of the gear - e.g. the EU fleet register has information on 3 main gears of a vessel, but not on a trip basis, so it is not known which gear was used on a specific trip.
- **Irregular coverage**: Due to its technical specifications, terrestrial AIS networks have a range of about 40 nautical miles, as most of the antennas used to pick AIS signal have

such range when no obstacle is in line of sight. If the vessel is far from reach of the terrestrial network the AIS message will be lost. Some providers offer datasets that integrate terrestrial and satellite AIS to provide a better coverage. Commercial AIS datasets coverage is affected by the network of providers and it changes considerably depending on the area of interest. Technical and logistical considerations aside, irregular coverage may also arise purely due to operator behaviour since it is possible for vessel operators to switch off AIS; for example, in an attempt to maintain the confidentiality of commercially important fishing locations. In the Mediterranean area, gaps in control enforcement allow VMS to be switched off as well.

- **Lack of unique vessel identifier for merging with logbook data**: in order to merge the AIS data to a fishing trip in the logbook, a vessel identifier is needed. The AIS data has an MMSI identifying the AIS device, but not necessarily the vessel. It also has a call sign that might also be present in fleet registers, and the vessel ID might be included in the vessel name, but not in a consistent way, so logbook data can be difficult to extract. The International Maritime Organization (IMO) number has been suggested as the best candidate for Unique Vessels Identifiers (UVI). In the absence global UVIs the coupling of Logbook and AIS data should be done at national/subnational level.
- **Time zone**: The timestamp column in AIS data is not linked to a specific time zone. It can therefore be challenging to link correctly with VMS and logbook data.

AIS could be used to supplement the VMS and logbook data, but it is not yet a standardised product in most ICES countries (Table 3.1).

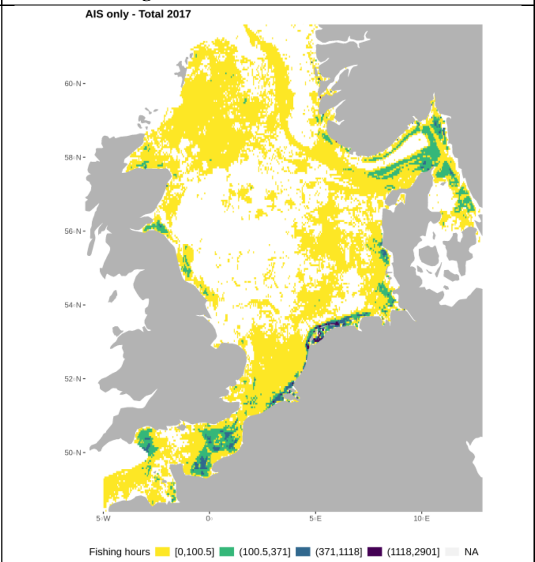
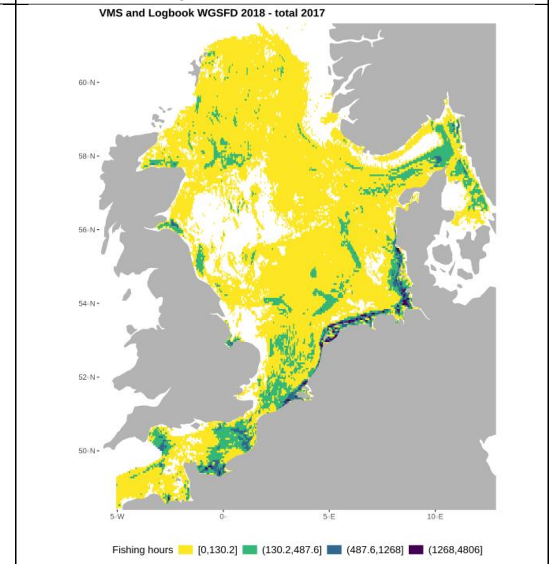
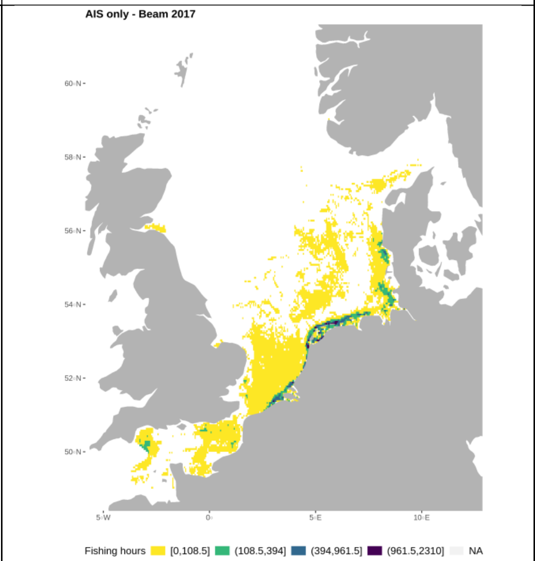
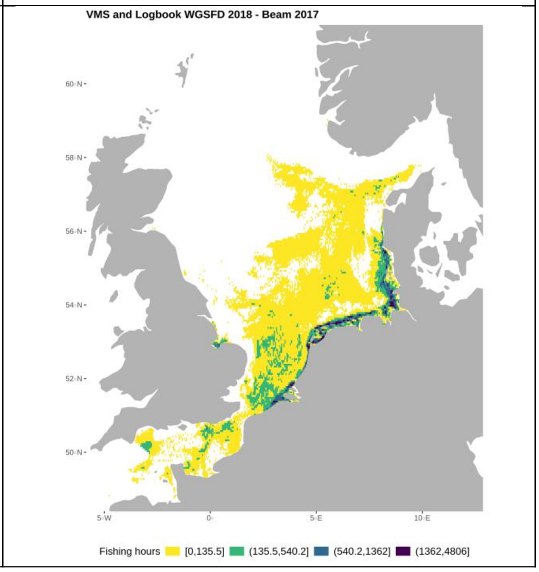
Table 3.1: Overview of some differences between VMS and AIS data

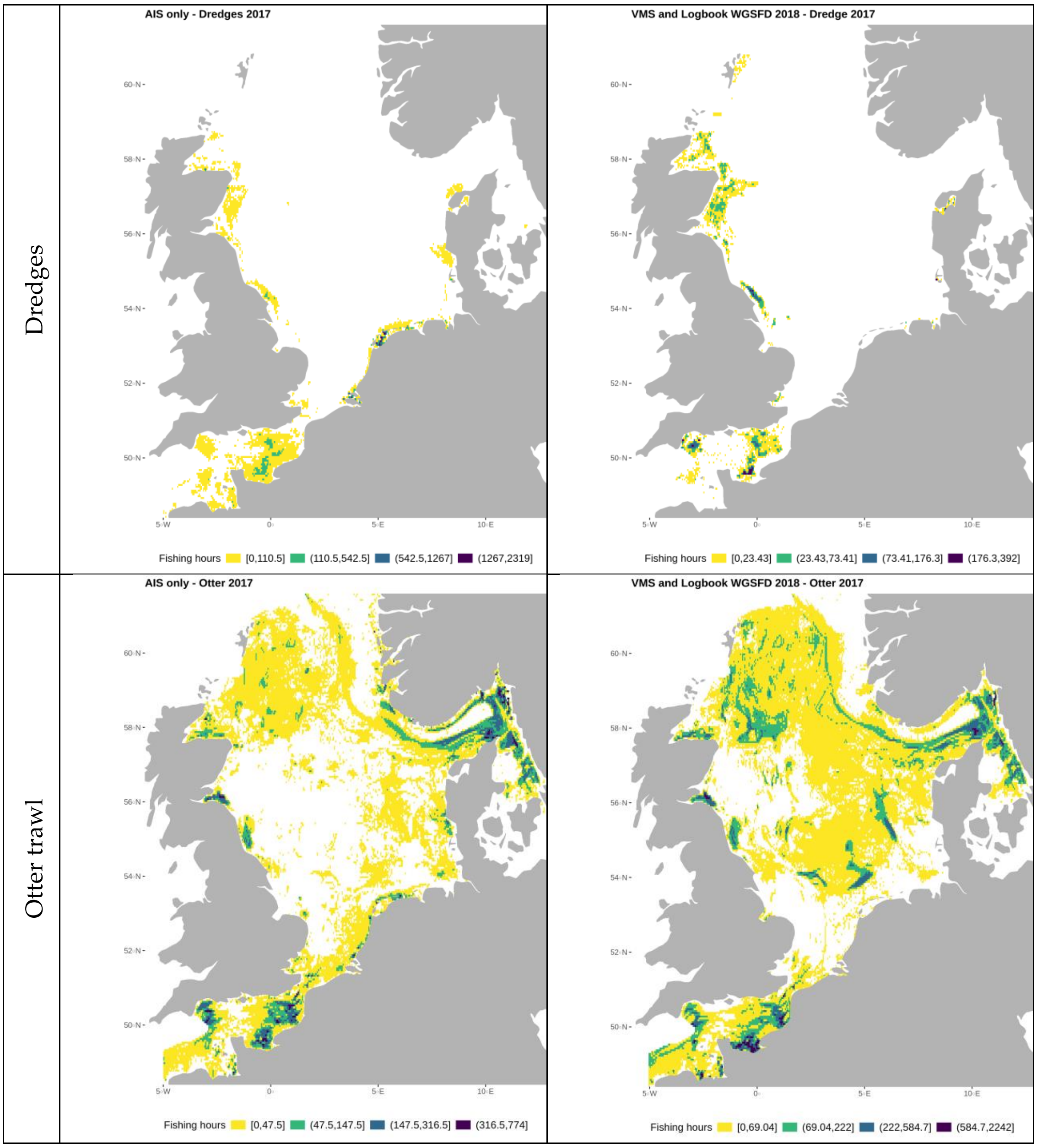
	VMS	AIS
Purpose	Fisheries control	Vessel security
Temporal resolution	Minimum 2 hours	Higher but variable (class A and B)
Possible to switch off?	No	Yes
Data transmission	Transmitted via satellites. Signals are picked up.	Signals picked up by coastal receivers or satellites. Some signals are not picked up
Vessel ID	Vessel ID to merge with logbooks	No vessel ID, but MMSI and radio call sign

3.3 AIS North Sea case study

An AIS dataset for 2017 from the commercial vendor CLS, acquired by EMODNet, was made available to JRC. The spatial extent is FAO areas 27 and 37. The AIS dataset has been merged with the EU fleet register and other RFMO registers (ICCAT, IOTC, IUU list, WCPFCRFV, NPFC, CLAV) for 52% of MMSIs and an additional 26% from the Global Fishing Watch fleet register.

The maps in figure 3.1 show differences when the AIS/Fleet register data are compared with ICES VMS/Logbook data. In general, AIS data underestimate fishing activity, showing lower maximum fishing hours. Moreover, in the central North Sea, away from the coastlines, some AIS data are missing. In some cases the maps show a misclassification of gears in the AIS/Fleet register data.

	AIS/Fleet register data 2017	ICES VMS/Logbook data 2017
All 4 gear classes		
Beam trawl		


Dredges
AIS only - Dredges 2017
Fishing hours [0,110.5] (110.5,542.5] (542.5,1267] (1267,2319]
VMS and Logbook WGSFD 2018 - Dredge 2017
Fishing hours [0,23.43] (23.43,73.41] (73.41,176.3] (176.3,392]
Otter trawl
AIS only - Otter 2017
Fishing hours [0,47.5] (47.5,147.5] (147.5,316.5] (316.5,774]
VMS and Logbook WGSFD 2018 - Otter 2017
Fishing hours [0,69.04] (69.04,222] (222,584.7] (584.7,2242]

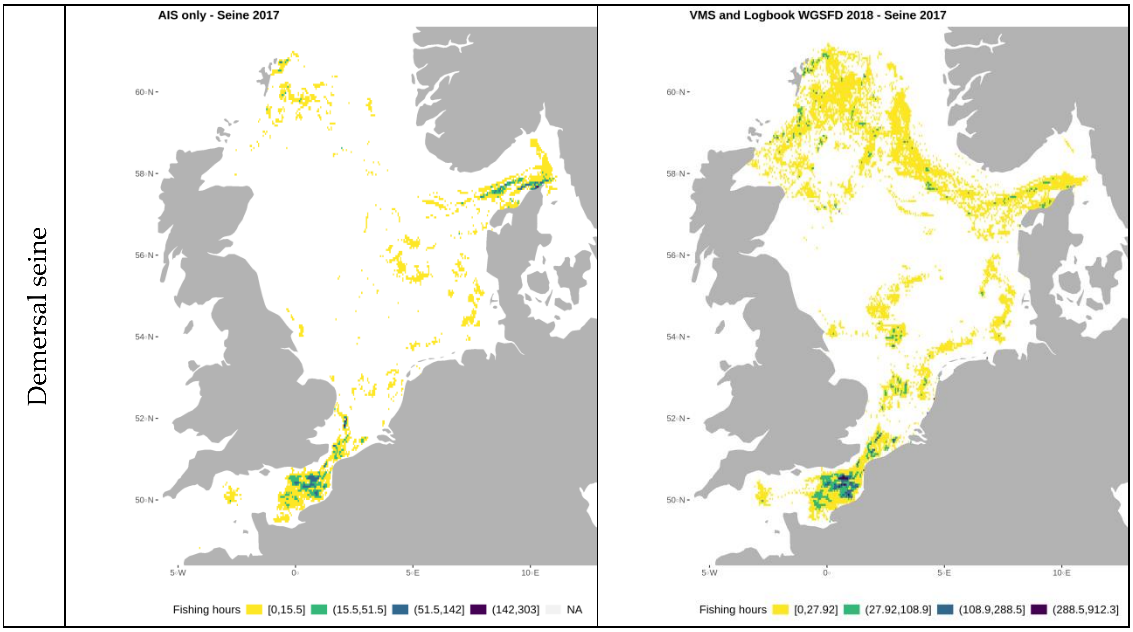


Figure 3.1: Maps comparing AIS/Fleet register data from 2017 (left) with the ICES VMS/Logbook data from 2017 (right) in the North Sea – for all 4 gear classes (beam trawl, dredges, otter trawl and demersal seine)l and by the gear type. Note the different colour scale for fishing hours between AIS and VMS maps.

The métiers used by the Benthis Project and WGSFD for the production of swept area ratio layers are based on the gear used in the trip as well as target species groups; for this logbook data are needed.

AIS within a regional assessment

The conclusion of the study of analysing AIS/Fleet register data for fisheries on a regional scale is that AIS data should be merged with logbook at a national level to minimise errors. However, issues relating to vessel ID to ensure correct coupling with logbooks remain a major restriction in their applicability. Examined overall against VMS data, AIS data coverage is uneven, and including AIS in fisheries data processing is still not a standardised operational task on national level. For this reason AIS datasets should always be presented with an assessment of its coverage. In regions where VMS/Logbook data are available, the VMS data gives a more reliable data product, but with lower frequency position data. If available, the AIS can be used at national level to supplement the VMS data, or in areas where VMS is not available.

3.4 AIS data at local scale

There are several examples of case-studies around Europe where AIS data have been used successfully at a local scale. Some countries are using logbooks merged with both AIS and VMS to give higher frequency data (e.g. Iceland). Denmark is working on a dataset with logbooks merged with VMS and then using a combination of AIS, Black Box (high frequency data of mussel dredgers) and interpolation methods to give a high-resolution grid (100 m). However, lifting these methods to a regional scale is still problematic.

An example of high-frequency position data (AIS system, 5 min resolution) is provided by a pilot study in the Northern Adriatic Sea, conducted by ISPRA (Italian National Institute for Environmental Protection and Research). Here, AIS data are confirmed by acoustic surveys and effectively analysed through experimental GIS tools. Preliminary results seem encouraging (Figs. 3.2 and 3.3), as they indicate an overlap of fishing activity (AIS data selected by speed) to type of gear as seen on the bottom, thus reducing the need for interpolation - hence reducing uncertainty

- and giving a sharper picture for random effort. This pilot study has yet to be replicated in the other Italian sub regions and on broader geographical scales.

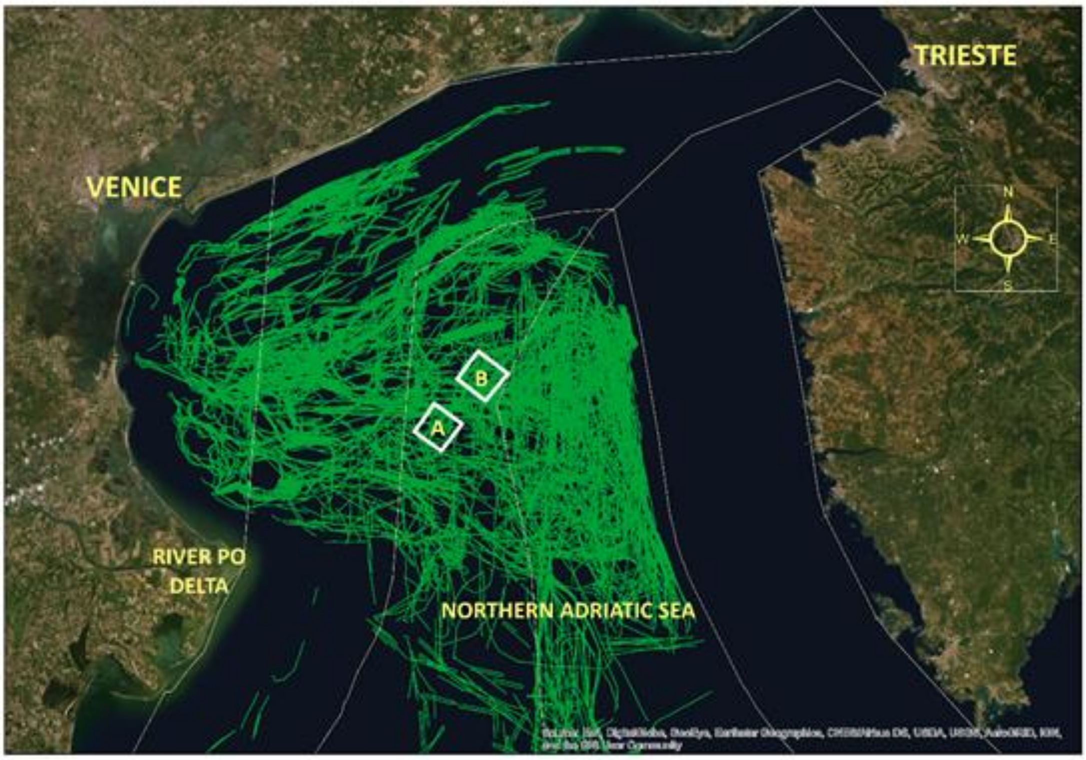


Figure 3.2: Example of fishing tracks from AIS data from the pilot study in the northern Adriatic Sea

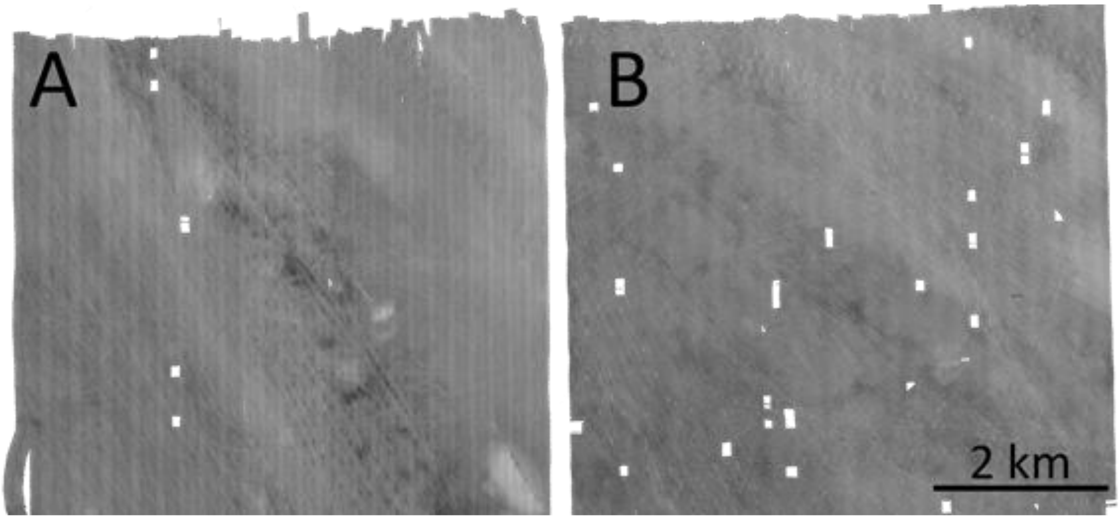


Figure 3.3: Result of multi-beam survey showing fishing tracks for validation of AIS data analysis from are A and B in Figure above.

Other alternatives to the current solution

WGSFD 2019 discussed alternatives to the current solution (the ICES VMS/Logbook data call at the 0.05 degree resolution) with benefits and costs. The options listed in Table 3.2 are relevant to WKBEDPRES2.

Table 3.2: cost benefit summary of methods used to assess the extent of fishing activities.

Approach	Benefits	Costs
Interpolate between points	Improve on knowledge of footprint with a certain degree of confidence. Valid for certain towed gear types.	Appropriateness of interpolation method needs to be investigated. Interpolation is not a valid approach for a number of gear types (e.g. static gears and seine nets).
Include habitat type in the data call and aggregate to habitat types within grid cells	Provides information on the distribution of fishing activity at a finer scale than currently. The fishing activities will be related to the habitat type at the stage where raw VMS pings are available. Could be tested/ available relatively soon.	Additional effort in data call stage required to assign point data to habitat layers. Approach is not flexible beyond the point where the data call is issued Need a habitat layer as input (e.g. WGFBIT uses source EMODNet).
Increase VMS ping rates	Existing system is reliable, produces true position data/ coverage, and has data management and quality assurance process in place. Official source of data with consequences if it is turned off.	Increased costs associated with data storage and potentially satellite transmission. Potential limitation in precision and data resolution which varies between service providers.
Move to alternative data sources (e.g. electronic logging systems)	Potential for very high frequency data recording. Might be a less costly option than increasing VMS ping frequency.	Installation of new equipment required, and associated costs. No time series. Requires voluntary acceptance by fishers or changes to regulatory frameworks.

3.5 Recommendations:

- All fishing vessels should have a vessel positioning system as proposed in the revision of the EU Fisheries Control Regulation (COM/2018/368 final).
- WKBEDPRES2 recommends that the minimum fishing vessel position frequency (VMS) should be increased in the EU Fisheries Control Regulation. Decreasing the interval between recordings of vessel position (from 2 hrs to 24 min) would mean that a vessel would not traverse a 0.01 degrees c-square cell without being recorded. We recommend that a ping frequency of 10 minutes is selected to significantly limit the current uncertainty as to which habitat type is being fished.
- For the purpose of assessing the fishing pressure and impact, real-time data (i.e. via satellite are not needed; higher frequency positions could be transmitted when the vessel is within a land-based mobile network.

4 From activities to impact

4.1 Making the jump from activity to pressure to impact – what are we aiming for?

Human activities, such as fishing and aggregate extraction, can result in disturbance of the seabed. The disturbance caused by different activities that result in impacts on the seabed acting through the same mechanisms, can be combined into a single pressure. For example, abrasion of the seabed by different types of mobile bottom fishing gears have similar impacts on the seabed, and are routinely combined into a single measure of pressure, the swept-area-ratio. Many different activities result in the deposition of sediments on the seabed, for example resuspension of sediment by mobile bottom gears, hydrodynamic scouring around structures and the disposal of dredged sediments all result in the covering of the seabed with sediment, resulting in an effect on the seabed which depends on the rate of sediment deposition and other parameters, and as such these activities all contribute to a single pressure ("deposition"). Similarly, a single activity can result in, and contribute to, many pressures. Mobile bottom fishing results in both abrasion of the seabed and deposition of sediments, while aggregate extraction results in both removal of sediments and the deposition of sediments. Key is to define and quantify pressures in a way that allows their use in the assessment of impacts on seabed integrity in a next step, which means that pressures need to be relatable to changes in biological processes, such as growth and mortality of populations of benthic invertebrates.

Quantification of pressures causing seabed disturbance for D6 therefore need to aim at the quantification of pressures that can be used for the assessment of the impacts of these pressures on seabed integrity. This means that pressures need to relate to the mechanisms through which activities will affect benthic ecosystems, and quantified in ways in which they can be used once the impact of the pressures is assessed. Assessment of impacts should capture the physical and ecological recovery after cessation of the pressure. It should be noted that ecological recovery of biota can occur without physical recovery of the geomorphology of the seabed.

Some of the existing, and most popular, approaches for combining multiple activities into a single measure of pressure in marine ecosystems were developed by Halpern *et al*. (2008). This approach simply adds up different activities, without considering what pressures these activities are causing or the biological mechanisms through which the activities may be affecting marine ecosystems. The result is a map of the number of activities (that are measured in different units), which is useful for some purposes, but not for the quantification of pressures and the assessment of impacts.

In summary, one activity can contribute to several pressures, and many activities can contribute to a single pressure. To be able to make the jump from activity to pressure to impact, different activities should be combined into a single pressure when they impact on the seabed ecosystem by affecting biological processes in the same way, and single activities can contribute to different pressures if they act on different biological processes.

4.2 Brief description of the four main pressure types, and how they relate to impact

The four pressure subtypes that can lead to physical disturbance and loss of seabed are 1) abrasion, 2) removal, 3) deposition, and 4) sealing. Definitions pertaining to these four pressures are given in chapter 2. In this section, the way in which activities contribute to each of these four pressures, how they, in turn result in physical disturbance and loss, and how this impacts on seabed ecosystems is summarised. This discussion builds on the WKBEDPRES1 and WKBEDLOSS reports.

Abrasion Abrasion of the seabed results primarily from mobile fishing gears, but other activities, such as aggregate extraction, can also result in abrasion. All activities that result in abrasion of the seabed can be combined as a single pressure through the mapping of the footprint of the activities on the seabed, and the intensity of the abrasion within this footprint can be quantified as the depletion of benthic fauna within this footprint (where depletion is defined as the fraction of benthic fauna killed or removed by a single pass within the footprint). Methods for converting pressure to benthic impacts for abrasion by mobile fishing gears are very well established and are based on a synthesis of all available evidence (Pitcher *et al.*, 2017; Sciberras *et al.*, 2018; Hiddink *et al.*, 2019), and these can be extended to abrasion by other activities where a footprint and depletion rate can be quantified. The quantitative method is based on a simple equation for relative benthic status (RBS), derived by solving the logistic population growth equation for the equilibrium state. Estimating RBS requires only maps of fishing intensity and habitat type – and parameters for impact and recovery rates, which may be taken from meta-analyses of multiple experimental studies of towed-gear impacts. The aggregate status of habitats in an assessed region is indicated by the distribution of RBS values for the region (Pitcher *et al.*, 2017).

Removal Removal of the seabed can result from aggregate extraction, dredging, scouring around structures, ship propellers and other activities. The impacts of removal on the seabed can be assessed using the same assessment framework as the impacts of abrasion for activities, provided that the footprint of substrate removal can be quantified and an estimate of the depletion of benthic biota within this footprint can be provided. This means that the population-dynamic model used to estimate trawling impact (Hiddink *et al.*, 2019) can be to assess the impact of removal. There are a large number of studies available that could be used in the estimation of the mortality parameter, but this analysis has not yet been carried out.

Deposition Sediment deposition or the deposition of particulates on the seabed can result when aggregate extraction, dredging of harbours and channels, scouring around structures, ship propellers, mobile bottom fisheries and other activities suspend sediments that settle out again. Dredge disposal will also result in the deposition of sediments, potentially in much larger quantities. Quantification of the spatial extent of pressure needs to use hydrodynamic modelling for each region (e.g. Lagrangian particle distribution) that can take account of the dynamism in the spatial distribution of the pressure. This approach is less arbitrary than adopting a 'buffer zone' approach, where the impact is assumed to occur in a fixed diameter buffer zone around the activity. However, parameterising such models is computationally more difficult and the approach is data hungry: relying on appropriate sediment data and hydrodynamic models. These pressure maps are not currently operational.

It is expected that the deposition of sediments originating from different activities will have comparable impacts on seabed ecosystems, but that the impact will scale with the rate of deposition, which is likely to be much higher for dredge disposal than for other activities. The severity of this pressure and the magnitude of its effect on benthic communities depend on the amount of sediment released, the grain size, and the hydrodynamics driving sedimentation. The unit of measure of the pressure could be cumulative sediment deposition rate x area x time (g m^{-2} day^{-2}). This unit of measure should be estimated by grain size, as fine sediments and gravel would have a different effect on the fauna (Cooper *et al.*, 2011). Available trawling assessment models (e.g. Hiddink *et al*., 2019) cannot be used in their current form because these approaches only capture the effects of additional mortality on the benthos, while for sediment deposition sub-lethal effects, for example on growth, are likely to be important, and not only mortality. Further development of these models to capture the effects of sediment deposition on r, the population growth rate, and depletion, the mortality caused by deposition, may be feasible in the future. A non-linear relationship between sediment deposition and the response is expected, with no response at low levels, which may be similar to background sedimentation rates, and 100% mortality at high sediment deposition levels (e.g. dredging disposal). In order to assess the impact level of sediment deposition, there is a need to estimate how it affects the growth and mortality of benthos. Such models currently do not exist. Because of the lack of pressure maps and models to translate pressure to impacts, assessment of the impact of sediment deposition on seabed ecosystems is not currently tractable, and both of these need development.

Sealing Sealing results from activities that introduce structures on the seabed. Seabed is considered lost when it is sealed, and the assessment of the impact of sealing (habitat loss) therefore simply requires the mapping of the presence of sealing structures.

4.3 Loss of seabed habitats resulting from abrasion, removal and deposition

Although this text discusses how to assess physical disturbance by the first three pressures, they can also result in unsealed loss. To distinguish unsealed physical loss from physical disturbance, unsealed loss requires further qualification (i.e. in situ observation of habitat change) following the compilation of activity/pressure data to ascertain if loss rather than disturbance has occurred. The overall assessment process considers all forms of loss directly arising from human activities and pressures, including both sealed loss (e.g. from constructions) and unsealed loss (e.g. through permanent change in type of sediment during aggregate extraction). Chapter 2 details all sealed loss forms identified and quantified across the regions. Unsealed loss could be incorporated in the overall assessments in a way similar to sealed loss, and all forms of loss could be grouped together. This layer can then be used to assess contemporary total loss under D6C1 and D6C4. The loss layer is also being used as a mask in the benthic physical disturbance model. In this instance, areas that are assigned to loss are not available to the model, allowing the model to refine its geographical extent of disturbance.

Biogenic loss

A distinct type of loss is seen in the historical loss of various biogenic reefs, due to both anthropogenic and other causes, as evidenced across Europe over time. It should be noted however, that for MSFD purposes, the assessment of biogenic habitat loss should be conducted at the regional sub-division level and that loss of biogenic habitat may currently represent only a very small proportion at the national/EEZ level. However, when reporting within individual EUNIS level 2 habitat types (e.g. infralittoral biogenic habitat MB2), bringing in all the relevant national data, the proportion of recorded loss in a subdivision (e.g. Southern North Sea level) could be much higher. Some information is available to help quantify biogenic loss as Member States do report on current state of specific types of their biogenic reefs (e.g. for Habitats Directive Code 1170 Reefs, from various EUNIS level 4 or 5 habitats) and habitat suitability models do exist for some regions/sub-regions. Thus, while the regional assessment methodology set out here is unlikely to adequately encapsulate biogenic loss at a regional scale, other approaches are available to inform on this.

Protection of biogenic habitat: Abrasion pressures that arise as a direct consequence of fishing activity present the single greatest threat to biogenic habitat. Activities operating on biogenic habitats are, or can be, spatially regulated through appropriate zoning and license procedures at Member State level (and by additional fisheries technical measures such as by-catch move-on rules in the North East Atlantic and the Mediterranean for some coral species). The data-policy based spatial and temporal restrictions that apply to fisheries VMS data represent the main obstacle for conducting pressure and impact assessments at fine scales (e.g. when assessing biogenic reefs and vulnerable marine ecosystems, VMEs). Moreover, not all vessels (< 12 m) that could present a potential impact to such habitats are monitored under the VMS scheme. Issues of assessment scale aside, the methods set out under this assessment cannot then be considered appropriate to the management of biogenic habitats. Recourse to spatial protection measures are available under MSFD, instituted at the member state level. The assessment of condition and protection of biogenic features should, therefore, be conducted within this process. Habitat suitability models (e.g. for Lophelia in the North East Atlantic) can also inform marine managers about new suitable habitat areas for the species and therefore help identify possible areas for restoration.

Historical loss of biogenic habitat: estimates of current biogenic habitat loss are likely to grossly underestimate actual loss as historical loss is likely to have been significant. The assessment of the natural spatial distribution and extent of the biogenic habitat lies outside the currently proposed assessment as it requires the setting of historic extent baselines and/or reference point/conditions. Estimating the loss will also rely on the availability of relevant historical records (including disentangling natural from anthropogenic causes) and the development of appropriate models of habitat suitability in order to estimate historic distribution and extent. Following the identification of such baselines, and corresponding loss estimates, biogenic loss can then be incorporated into the proposed assessment protocol, assigning such areas as unsealed loss.

In summary, approaches to translate activities to pressure to impact, relating to physical disturbance, exist for abrasion, and these methods could be applied to removal too. An approach for the quantification of the pressure and impact by sediment deposition does not exist and requires further development. Approaches for assessing loss caused by abrasion, removal and sediment deposition require further development. Approaches for assessing loss from sealing do exist.

4.4 What are the benefits of knowing (or distinguishing between) surface and subsurface abrasion?

The extent to which different activities penetrate the seabed substrate is different. For example, scallop dredges penetrate about 5.5 cm into the sediment but otter trawls only 2.4 cm, and the depletion caused by different gear types correlates to their penetration depth (Hiddink *et al.*, 2017). The seabed abrasion pressure and physical disturbance caused by mobile fishing gears therefore needs to take account of the penetration depth of the gears. For visualisation on maps, separating the abrasion into two classes (surface and subsurface) may be useful, but the assessment of the pressure will be more accurate if the actual penetration of each gear (or gear component) is used to quantify pressure, and when penetration depth dependent depletion is used in impact assessment (as in the PD assessment method). An alternative way of presenting abrasion pressure that takes account of both the footprint (SAR) of the fisheries using different gear types and the depletion (d) of the gear used, would be to sum the product of SAR and d for all different gear types used. This product would directly correlate with the abrasion pressure by mobile fishing.

Similarly, the extraction depth for aggregate extraction, where repeated extraction over the same area causes marked variation in this metric, is likely to determine impact on benthic fauna.

4.5 What is the most appropriate spatial resolution for each pressure type to assess impact?

To answer this question, general remarks must be taken into account:

- There is a limitation from the resolution of the available benthic data.
- The spatial resolution of the data of pressure type must be correlated to the scale of the activity. The smaller scale the activity contributing to the pressure, the higher resolution data needed to avoid overestimating the impact.
- Lack of knowledge of detailed spatial resolution of benthic habitats sensitivities is problematic for the assessment of the impact on the ecosystems.
- Depending on the needs: MFSD assessment can be done at large scale whereas for management of local MPA (Natura2000 area) information on pressures is needed at a smaller scale.

In the following, the appropriate spatial resolution for the four identified pressures types is discussed.

Abrasion

As noted in chapter 2, bottom fishing swept-area-ratio is reported by ICES per c-square (0.05° x 0.05°, ~15 km^2 at 61 °N). This choice of grid size is driven by the VMS ping rate (every 2 hours) and the desire to avoid fishing vessels crossing cells without pings being recorded. Therefore, reporting fishing effort in smaller cells would require a proportionally higher ping rate. For instance, a grid cell of 0.01° x 0.01° would require a 24 minutes ping interval to avoid fishing vessels crossing cells without their effort being recorded there. Further limitations on the reporting of fishing effort are caused by the legal obligation not to report effort for cells where fewer than 3 or 4 vessels per cell were recorded (3 in UK, 4 in France).

If the cell size used for gridding is large relative to the size of the fishing or aggregate extraction gear used, and if fishing is patchy, which it normally is, large parts of the cells are likely to remain unfished even when the mean SAR>1 yr^{-1}. Using the mean SAR for large cells is therefore likely to result in an overestimate of pressure and impact, even when assessed over longer time periods. Amoroso *et al.* (2018) illustrated this effect clearly in their analysis of global trawl effort patterns (Figure 4.1). However, because fishing activity will move around between years, when pressure and impact are assessed using means over longer time-scales, the distribution of fishing and dredging will become more homogeneous within grid cells and using larger grid cells causes a smaller overestimate of pressure and impact.

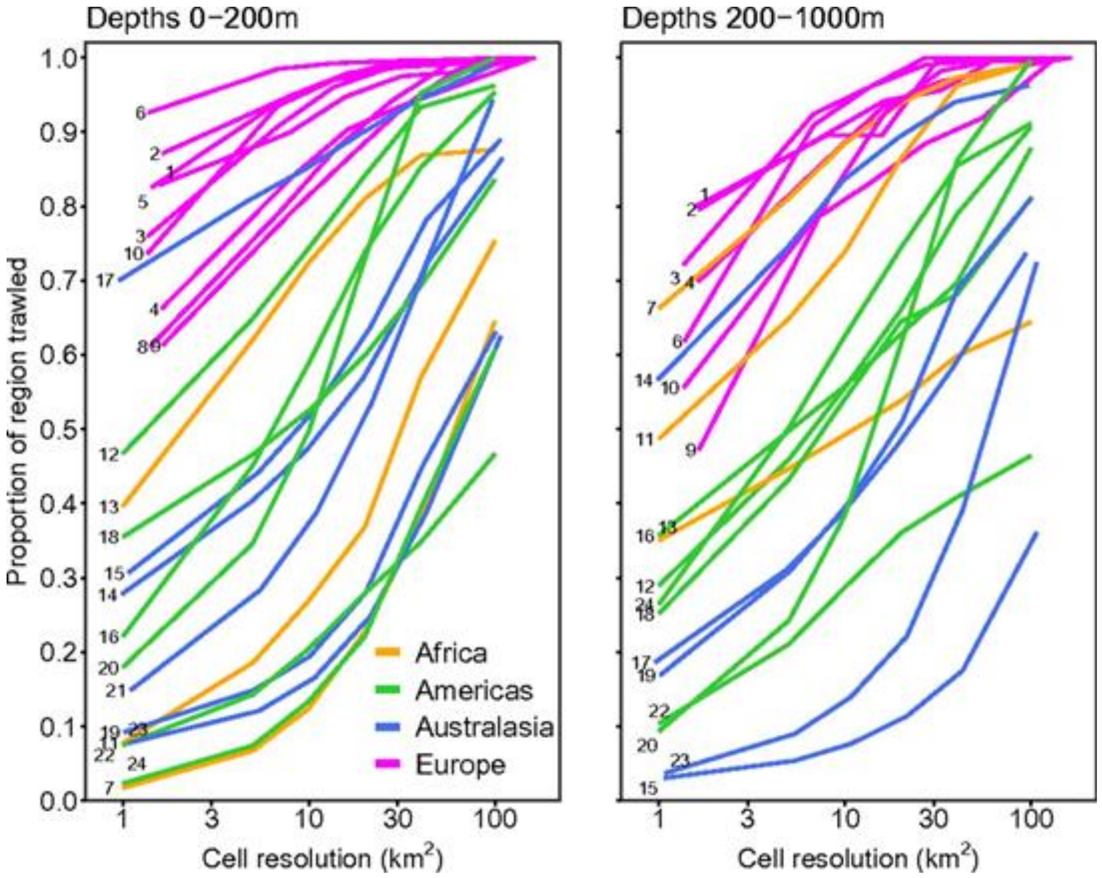


Figure 4.1: relationships between the spatial resolution of effort data and the trawling footprint (approach A, grid cell based; in the text) for depth ranges of 0-200 and >200-1,00m. Region codes are: 1. Adriatic Sea, 2. West of Iberia, 3. Skagerrak and Kattegat, 4.Tyrrhean Sea, 5. Irish Sea, 6.North Sea, 7. North Benguela Current, 8. Western Baltic Sea, 9.Aegean Sea, 10. West of Scotland, 11. South Benguela Current, 12. Argentina, 13. East Agulhas Current, 14. Southeast Australian Shelf, 15. Northeast Australian Shelf, 16. New Zealand, 17. East Bering Sea, 18. North California Current, 19. Southwest Australian Shelf, 20. Aleutian Islands, 21. North Australian Shelf, 22. Gulf of Alaska, 23. Northwest Australian Shelf, 24. South China . Three regions are not presented in the right panel as they are not of sufficient depth.

Abrasion due to other activities (e.g. anchoring and cable deployment) act at very local scales and as a result the assessment needs detailed spatial data, as polygons on meter scales, to avoid overestimating their pressure and impact.

Removal

Extraction activities need authorisations and therefore the spatial extent of the licensed areas is known. However, licensed areas for aggregate extraction can be much larger than actual footprint of the dredging activity, so the area of actual extraction is needed to have a good estimate of the pressure. Considering the whole licensed area under pressure overestimates impacts in the same way the footprint from fishing activities is overestimated when using large grid cells. The choice of grid size to calculate actual footprint should be (as for fishing) driven by the time interval between the registered signals. For EMS, this is 30 sec, so a grid size of 50 x 50 m is the best spatial resolution, for AIS this can be adjusted as favoured. For 5 min, time intervals, a 100 x 100 m resolution is suggested (Bokuniewicz & Jang 2018).

Scouring resulting from the placement of structures (e.g. coastal defence structures, wind turbines, offshore structure) act at very local scale (meters to 100s of meters) and as a result the assessment needs detailed spatial information to accurately quantify its extent.

Sediment deposition

Mapping of the sources of suspended sediment in the water column is not well developed, except for dredge disposal, and even where this is known, it is not always known where sediment deposition will occur, and for dredge disposal, to which extent sediments disperse during and after the disposal. Part of the sediment will settle and deposit on the seabed while finer particles can spread out much more, depending on grain size, hydrodynamic conditions and seabed morphology (Du Four and Van Lancker (2008), Virtasalo *et al*., 2018). The rate of deposition and the resulting thickness of the deposited layer are hard to estimate, but are likely to vary significantly over small spatial scales. It is therefore recommended that the spatial scale for mapping deposition should be grid cells of <1 km^2. The diameter of the area where deposition and erosion rates are modified by coastal structures (for instance groynes) is typically around 5 to 10 times the size of the structure, and the spatial scale at which sediment deposition is mapped should allow resolving these scales.

Sealing

Sealing occurs as a result of the installation of structures. The spatial extent of structures is generally known exactly, and needs to be known exactly to avoid biased estimates of loss.

In conclusion, the spatial patchiness of activities means that assessment of the pressure and impacts on smaller spatial scales will yield more accurate and lower estimates of pressure and impact.

4.6 What are the benefits of knowing variation in the level of human activities over the 6-year cycle?

Having trends during 6-year cycle allows assessment to:

- identify increases or decreases of the pressure
- identify the existence of episodic pressures
- evaluate the effectiveness of management measures

If there is potential for recovery and the pressure is variable in space and time, taking account of variations in pressure between years will help to get to most accurate estimate of impact. If no recovery occurs, or the pressure is constant in space and time, taking account of temporal variation in pressure over time will not make a difference in assessing the impact. Therefore, impact assessments for all pressures, except sealing resulting in loss, would benefit from taking account of variations in the pressure.

The distribution of fishing and aggregate extraction effort becomes less patchy and more homogeneous over longer time scales, within cells and between cells. Evaluating pressures over longer time-scales will therefore result in a higher, and probably more realistic, estimate of the impact of these activities.

4.7 The setting of thresholds

MSFD requires an assessment per MSFD broad habitat type (or other habitats defined by Member States) at biogeographically-relevant scales (e.g. southern North Sea). This needs an output which is the proportion (%) of the habitat in the assessment area which is in a good state (above a specified threshold value for habitat quality). Evaluating whether a MSFD habitat type in a regional sea is in a good environmental state will require defining a threshold beyond which its quality is considered to be in a good state, and a second threshold, which is the proportion of the habitat in the assessment area (e.g. southern North Sea) that needs to be beyond the first threshold for the habitat type to be considered in a good state.

A process of setting thresholds that define when good state becomes a degraded state is not yet established. Whilst reference to unfished areas, historical baselines, biological function or ecological response may play a role (ICES, 2019), the setting of thresholds also requires societal decision. Here, contemporary conservation or management targets are as much a social as an ecological decision, balancing, as they must, the socio-economic needs provided by the contemporary or degraded state against measures required to restore systems towards less impacted states.

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5 Demonstration assessment – North Sea

5.1 Introduction

In this chapter we describe generic methodologies that can be applied at the scale of ecoregion to assess the four principal pressure types (abrasion, removal, deposition and sealing) giving rise to seabed loss (D6C1) and physical disturbance (D6C2). These pressure types were selected as the main pressures affecting seabed integrity (D6) during the WKBEDPRES1 and WKBEDLOSS process and which can be operationally demonstrated at the regional scale with available data and methods. Combinations of selected human activities and pressures have been identified based upon work undertaken by WKBEDPRES1, WKBEDLOSS and WGFBIT; namely, abrasion caused by bottom trawl/dredge fisheries (physical disturbance), removal caused by aggregate extraction (physical disturbance), sealing caused by the placement of hard structures (physical loss) and deposition caused by dredge material disposal.

Within the assessment process for the North Sea, only the primary pressure associated with a selected activity has been evaluated. For example, in relation to bottom trawl/dredge fisheries, the principal pressure is abrasion, whereas the known secondary pressure of sediment deposition has not been assessed. However, the assessment methodology presented with chapter 5 is regarded as being general enough to allow such pressures to be included in the future if appropriate data flows and model parameters are developed.

The methodology used to determine the benthic community impact presented within this demonstration product is not dependent on the scale or accuracy of the habitat maps. For example, seabed sensitivity (derived from longevity of benthic organisms) is mapped as a continuous variable against which a pressure layer is combined in order to assess impact at the scale of the assessment unit – in this case MSFD broadscale habitat types. Improved habitat maps will, therefore, serve to improve the resolution of the assessment unit without further need to adjust the assessment method itself. In addition, to increase accuracy and allow appropriate application in different regions, model/community parameters (e.g. longevity) should be also tested and validated.

5.2 A summary of the assessment process

The assessment process (Fig. 5.1) links activity data through to the benthic, physical disturbance model and the aggregated loss layer via four, main pressure-subtypes (defined in Chapter 2). The data requirements and model parameters required to assess physical disturbance and loss, relevant to each pressure, are outlined in sections 5.3.1 – 5.3.4. Within each pressure class, cases where loss occurs, both unsealed and sealed, are separated out and are aggregated into a single loss layer that serves D6C1 / D6C4. Pressures relating to physical disturbance are then made available to the benthic, physical disturbance model.

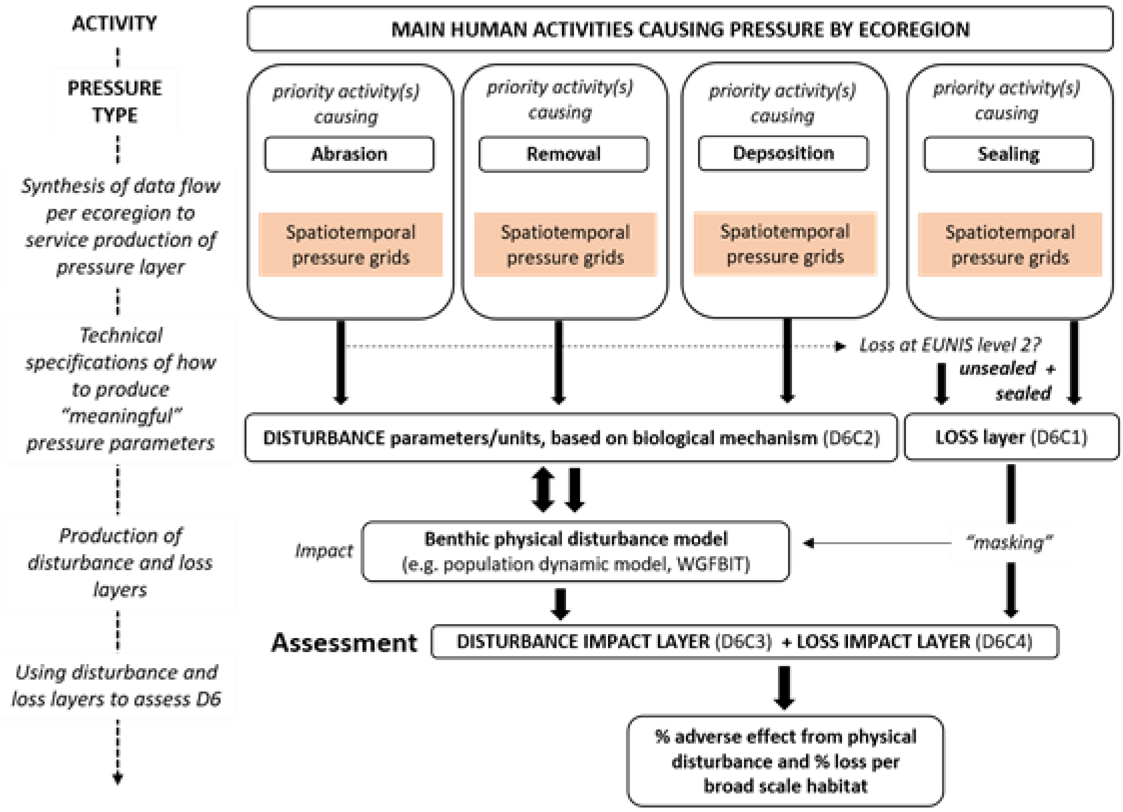

Figure 5.1 a flow diagram of the assessment process from activity to broadscale habitat assessment.

Loss: The assessment process collates unsealed and sealed loss, identified across the four pressures into a single layer. This layer can then be used as to assess loss under D6C1 and D6C4. The loss layer is also used as a mask in the benthic, physical disturbance model. In this instance, areas that are assigned to loss are not available to the model, allowing the model to refine its geographical extent of disturbance.

Physical disturbance: Physical disturbance in the assessment process is the derived output of a benthic, physical disturbance model. The chosen underlying disturbance model should be able to parameterise the wide range of data flows that are associated across the three disturbance pressure classes that provide input and should be able to function at different spatial scales. Throughout the WKBEDPRES process the Population Dynamic Model (Chapter 4; Hiddink *et al.*, 2018) was used in this capacity. The rationale behind this selection is that this method provides a quantitative estimate of the impact on the seabed over a continuous scale by using parameters that incorporate aspects relating to the depletion (mortality) and recovery.

Assessment output: The output of the assessment process is presented at the regional level by MSFD broadscale habitat type. It is important to note that the regional assessment methodology presented in WKBEDPRES and WKBEDLOSS runs complimentary to national reporting and should not be seen as competing with it. Indeed, the outlined process of reporting with WKBEDPRES and WKBEDLOSS provides a benchmark that allows Member States to harmonise outputs across national boundaries, where comparison is required, and to standardise required data flows.

5.3 Guidance for assessing pressure types

The following sections aim to provide generic guidance in relation to the assessment methodologies, applied to specific activity pressure combinations and in a specific ecoregion (i.e. the Greater North Sea), which have been used to generate assessment outputs in the form of tables and maps.

5.3.1 Pressure type: abrasion

Abrasion, caused by bottom fishing

Bottom trawl fisheries (trawls and dredges) which cause seabed abrasion disturbance due to fishing gear being pulled along the seabed scraping the substrate surface.

Data collection process:

ICES

Data type and Ecoregion specificities

BALTIC	G. NORTH	CELTIC	MED	BLACK
	VMS + logbooks			

Data flow

Fishing pressure data that ensures individual fishing vessel anonymity are available online at the ICES website for MSFD regions within the HELCOM and OSPAR areas, i.e. for the Baltic Sea, the Greater North Sea, the Celtic Sea and the Bay of Biscay & Iberian Coast.

VMS and log book data is collected and stored by the national fishery agencies. Data that ICES receive is processed using standardized methods to produce data layers to describe the fishing intensity per c-square/grid cell (0.05 × 0.05 degrees) per year (e.g. for HELCOM [2009 – 2013] and e.g. for OSPAR [2009-2015]). The swept area ratio (SAR, also defined as fishing intensity) is the swept area divided by the surface area of the grid cell. SARs are provided both as surface and subsurface components; surface abrasion is defined as the damage to seabed surface features (top 2cm), and subsurface abrasion is the penetration and/or disturbance of the substrate below the surface of the seabed (below 2cm) – however, the combination of these two categories may benefit future assessment (see section 4.4.). The relevant data workflow is illustrated in figure 5.2.

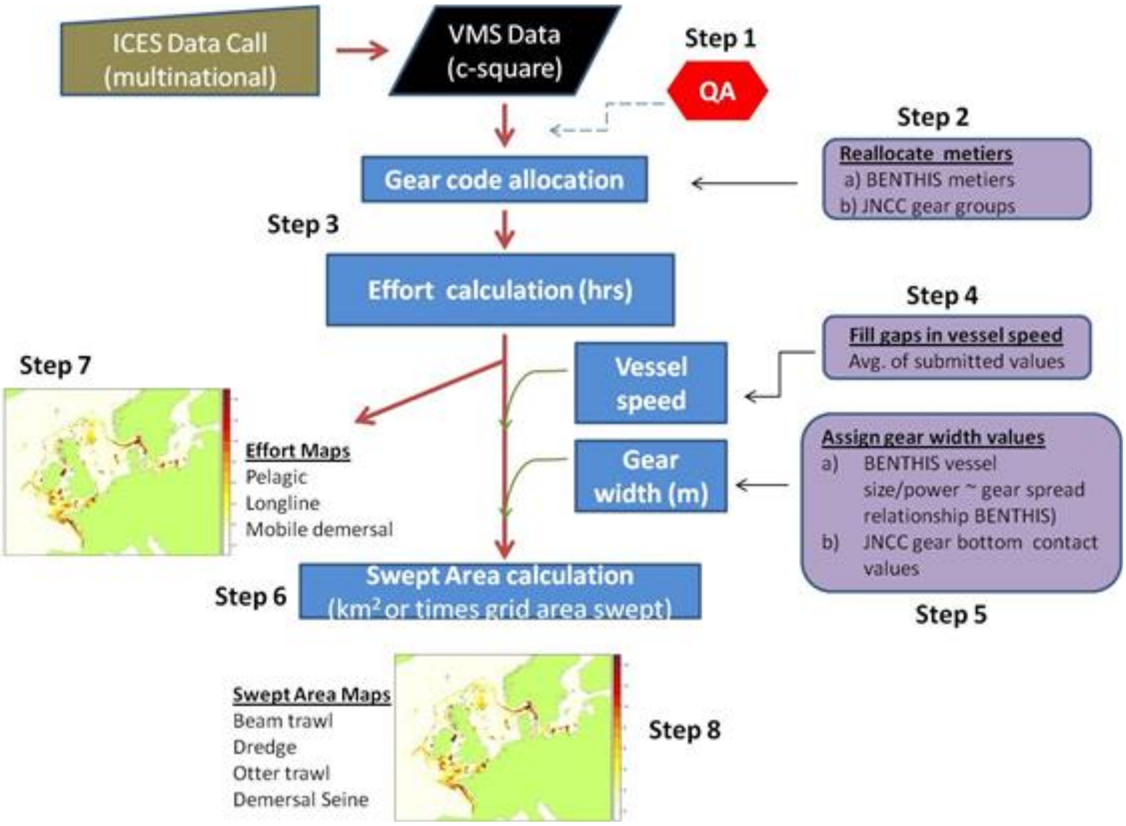

Figure 5.2 Workflow for production of swept area ratio (SAR) maps from aggregated VMS and logbook data in c-squares of 0.05x0.05 degrees (ICES 2015).

Recommended assessment method including data processing

Pressure Analysis

ICES (2017a) defines the swept area of bottom trawling as the cumulative area contacted by a fishing gear within a grid cell over one year. To calculate SAR, the area contacted by fishing gear is provided by geographically distinct vessel monitoring system (VMS) points, for which speed and course are available at intervals of maximum 2 hours, coupled with information on vessel size and gear used derived from EU logbooks (Lee *et al*., 2010; ICES, 2017a; Eigaard *et al*., 2016).

Vessel speeds representing fishing activity are assigned to a 0.05° × 0.05° grid (c-square approach), each covering about 15 km^2 at 61°N latitude, which is the spatial resolution adopted by ICES.

Estimates on total SAR within each grid cell are calculated by métier and habitat. In the applications of this approach so far (ICES, 2017b), a total of four métiers (otter trawl, beam trawl, dredge, and demersal seine) and four broadscale habitat types (coarse, sand, mud, and mixed) were specifically considered. The integration of habitat type and VMS data creates a single surface abrasion pressure data layer at a spatial resolution meaningful for assessments. The temporal resolution is on a yearly basis and can be used to assess trends within a MSFD 6-year cycle.

Impact Analysis

The impact analysis is the link of the pressure analysis to the Population Dynamics (PD) Model. The PD method is a mechanistic model that estimates the total reduction in community biomass (B) relative to carrying capacity (K), corresponding to the estimated fishing intensity. Total community biomass relative to carrying capacity (B/K) describes the equilibrium state, i.e. the interaction between the depletion caused by fishing and the recovery of the benthic community. The impact is given by 1−B/K (Pitcher *et al*., 2017). The depletion rates are estimated from a meta-analysis providing gear-specific depletion rates (Hiddink *et al*., 2017), while recovery rates are derived from a longevity-specific meta-analysis (Hiddink *et al*., 2019). This method assumes that the sensitivity to trawling depends on the longevity of species and communities. This approach, therefore, requires estimates of the longevity of all species in a community. In section 8.6 of the 2018 WKFBIT report (ground truthing) an explanation of how to derive habitat specific longevity values for a (sub-) region is provided. The biomass component of the PD method provides a proxy for ecosystem (functioning) processes, for example, nutrient cycling or energy flow through food webs.

The habitats in the Greater North Sea are well characterized and the PD longevity relations are established (Rijnsdorp *et al*. 2018). However, biogenic habitats (reefs) are not taken into account, which are in some cases difficult to detect or predict their distributions realistically (e.g. Sabellaria reefs). Nevertheless, it is expected that over time as more observational benthic community-based data becomes available and integrated into functional habitat mapping that sensitivity mapping will achieve greater spatial resolution.

Future development of assessment methodology and data availability to reduce uncertainty

The data-policy based spatial and temporal restrictions that apply to VMS data represent the main obstacle for conducting pressure and impact assessments at fine scales (e.g. when assessing biogenic reefs and vulnerable marine ecosystems, VMEs). Moreover, reliable information is almost non-existent for the fishing vessels of lengths less than 12 m. The unrestricted provision of VMS data for all vessels sizes would represent a significant improvement in coverage and quality of small scale fisheries activities, and consequently, it is strongly recommended that EU and national data policies are revised to enable publication of VMS data at a higher spatial and temporal resolution than is currently the case. In addition, a better understanding and parameterisation of the depletion and sub-lethal stresses associated with near- and far-field effects of bottom fishing sediment deposition on benthos is required, together with quantifying the limits of when repeated bottom trawling seabed disturbances becomes habitat loss.

Although, AIS data have the potential to supplement or even replace VMS data for future high-resolution fisheries impact assessments, at present these data have substantial shortcomings in terms of variable availability, quality and coverage. However, in some areas, local / subregion-wide tests show that some of these shortcomings could be, at least partially, controlled for (section 3.4).

For the Mediterranean, the Black Sea and Macaronesia, a similar data workflow to the North East Atlantic region is not yet in place and fishing pressure data are not readily available. However, VMS data do exist within national jurisdictions from these regions that provide an opportunity to potentially include the Mediterranean and Black Sea EU countries into the established annual ICES calls currently serving OSPAR and HELCOM. As an alternative, collaboration with Barcelona Convention and Black Sea Convention (or the relevant RFMO, the GFCM) might be established.

5.3.2 Pressure type: removal

Removal of seabed substrate (sediment), by suction-trailer aggregate extraction

Aggregate extraction (by suctional-trailer dredger) directly removes sand or mixtures of sand and gravel from the seabed by dragging a suction pipe along the seabed.

Data collection process:

ICES WGEXT

Data type and Ecoregion specificities

BALTIC	G. NORTH	CELTIC	MED	BLACK
	EMS/AIS and permitted area			

Data flow

Follow-up of aggregate extraction differs per country. In UK, Belgium and the Netherlands ships have an Electronic Monitoring System (EMS, aka black box) on board, while for other countries, AIS is collected from dredging vessels (e.g. Denmark), or no control system is in place. EMS data show where and when has been extracted. AIS data from extraction vessels can also be used to visualize extraction footprints when filtering for speed and doing some further processing. Both AIS and EMS data can be processed via GIS spatial analysis (see Fig. 5.3), e.g., on a 50x50 m grid with time (min) extracted in each grid cell during one year. The grid layer is then used as input in the PD model.

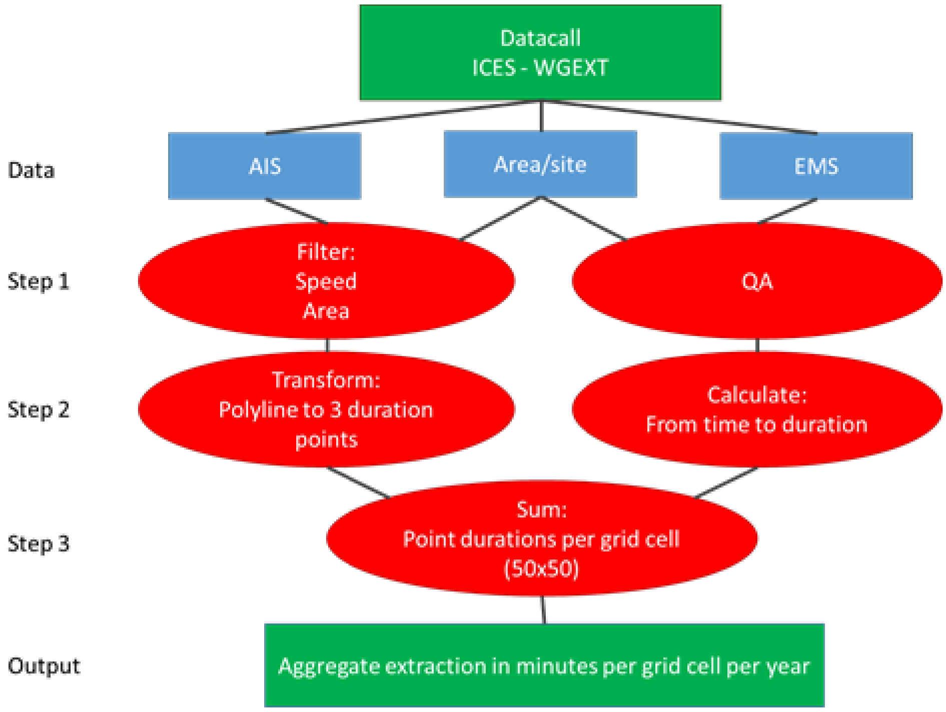

Figure 5.3 New workflow for production of duration maps of aggregate extraction from aggregated EMS/AIS data per grid cell (e.g., 50 m x 50m).

Recommended assessment method including data processing

Pressure Analysis

To account for removal by aggregate extraction, the 'actual' aggregate extraction footprint needs to be known. This can be deduced from EMS or AIS data. Permitted extraction areas should be delivered as polygon layer enabling subtraction of the areas of extraction. Some Member States process the data already as a grid that can be used immediately. Otherwise, Member States have to deliver yearly EMS or AIS data, together with permitted extraction areas. AIS and EMS data should preferably be a point layer or csv-file with attribute table (minimally unique trip ID, XY coordinates (WGS84), date, time (hh:mm:ss)), allowing for a standardised processing of the data into a grid layer. With ping rates of 30 sec, data grids are best processed at 50 x 50 m for most meaningful assessments. Each grid cell represents duration, measured in minutes of extraction. Instead of duration, volumes could be represented per grid cell if such data are available.

Impact Analysis

The impact analysis is the link of the pressure analysis to the Population Dynamics (PD) Model. A model that relates removal pressure to the fraction of fauna removed (d) and recovery rate (r) would be similar to already existing trawling impact models.

The estimation of benthic state for aggregate extraction can then be calculated as:

$$RBS = \left(1 - E\,\frac{d_{removal}}{R}\right)$$

where the recovery rate R is longevity dependent, E is the ratio between the area of the site that is extracted each year and the total area of the site (extracted area ratio), and $d_{removal}$ is the proportional depletion mortality by removal.

Future development of assessment methodology and data availability to reduce uncertainty

Data limitations

Representing the dredging footprint as time dredged per area, per period of time, is only an approximation of the actual area of seabed disturbed or lost. The footprint is also dependent on dredger characteristics and method, as well as penetration depth. Better proxies for assessing disturbance and loss are the volume of aggregate extracted, per area, per period of time, which then allows an estimate of possible lowering of the seabed to be determined. However, this approach is presently limited by a lack of detailed, harmonised reporting of aggregate extraction activities by Member States. The broadscale habitat type pre- and post-extraction period needs to be known to assess habitat loss. Hitherto, indirect (secondary) effects such as increased turbidity, deposition from sediment plumes, and changes in currents are not yet accounted for at the regional scale, again hampered by a lack of standardised detailed assessment and reporting approaches and methods.

Whilst polygons provide a record of the area of seabed dredged in any one year, it is important to recognise that the spatial extent of these areas, in so far as they are linked to areas of 'impact', will likely shrink over time as a result of benthic community recolonization and recovery in those areas which have ceased to be dredged. Given the range of factors affecting recovery (e.g. nature of local environment, faunal assemblage type, intensity of dredging, proximity of ongoing operations), caution must be applied, particularly when aggregating annual dredging footprints to create a cumulative footprint. Equally, it should be recognized that areas of seabed falling outside an annual footprint may have been subject to dredging in the past and may therefore still be recovering. Due to this, the assessment period over which dredging activity is reported is likely to be multi-annual and on a similar 5 year reporting cycle as fishing pressure disturbance and loss

The assessment procedure (population dynamic model) can be used to assess aggregate extraction impacts, albeit with an assumed depletion rate (e.g. as a precautionary value we can assume 100%). An accurate parameterisation with regard to aggregate extraction benthic community biomass depletion rates would improve the assessment. In this respect, ICES note a large number of studies available that could be used in the estimation of both the biomass depletion (benthic mortality) parameter and recovery upon cessation of dredging (d and r, in the population dynamic model). A meta-analysis of existing impact (before-after-control-impact-design) and recovery studies performed in different MSFD broad habitat types would allow better estimation of both parameters in the model and is recommended.

Standard operational workflow required

The present assessment exercise was performed by way of demonstrating the utility of the overall approach within a restricted area and time frame. However, there is currently no EU standardised data workflow for marine aggregate extraction with sufficient spatial resolution that would enable realistic estimates of associated pressures, losses and impacts. Accordingly, a standardised format, in which countries provide quality checked and processed data on an agreed temporal and spatial scale, is needed. To ensure long-term stability and traceability of data, it is proposed that the ICES aggregate extraction working group (WGEXT) work in collaboration with the ICES data centre and national agencies carrying out reporting to further develop its database and to incorporate the necessary additional data-fields. The national reporting agencies would be responsible for ensuring that reported data are provided in the agreed format.

Data is not presently included from either the Mediterranean or the Black Sea regions, despite there being data available for these two regions. The existing network of organisations represented by WGEXT, in collaboration with EMODNet-Human Activities and national MSP Portals, could reach out to the responsible licensing authorities and national agencies within the Mediterranean/Black Sea region with the aim of initiating ICES Data Calls.

Recommendations

- Full fleet coverage using EMS or AIS is recommended for all regions.
- A synthesis/meta-analysis of existing studies to estimate relationships between dredging activity (spatial extent and depth of the area affected) and benthic mortality (d, before-after-control-impact design) is needed.
- Recovery dynamics (r-parameter in PB model) in relation to aggregate extraction is needed. To this end, a meta-analysis of existing studies to estimate relationships between dredging activity and community recovery is also required.

5.3.3 Pressure type: deposition

Navigation dredge material disposal is the main (presently assessed) activity causing deposition of organic and inorganic particulate matter (sediment) to the seabed. Dredge material disposal activities also include capital dredge material associated with specific coastal development and protection projects. Such operations can result in the disposal of rock or coarse (hard) sedimentary material which under certain circumstances can result in immediate seabed habitat loss. However, all seabed-altering human activities that cause the remobilisation of sediment and/or particulates (to a greater or lesser extent) will deposit within the near- and far-field environments of the activity: e.g., beam trawling, aggregate extraction, hard structures.

Data collection process:

MSFD competent Authorities; Permitting and Licensing Authorities

Data type and Ecoregion specificities

BALTIC	G. NORTH	CELTIC	MED	BLACK
	EMS + logbooks and permitted disposal area			

Data flow

Although, sediment deposition data flows are not yet operationalized for broadscale assessments (Fig. 5.4), some generic guidance can be provided to assist in the process. Licensed disposal sites can be obtained via OSPAR (EIHA) or EMODNet (http://www.EMODNet-humanactivities.eu). EMS data may be obtained via licensing authorities enabling the calculation of effective footprints similar to the approach used for the assessment of aggregate extraction disturbance. In some instances, activity-circumscribing polygons may be available.

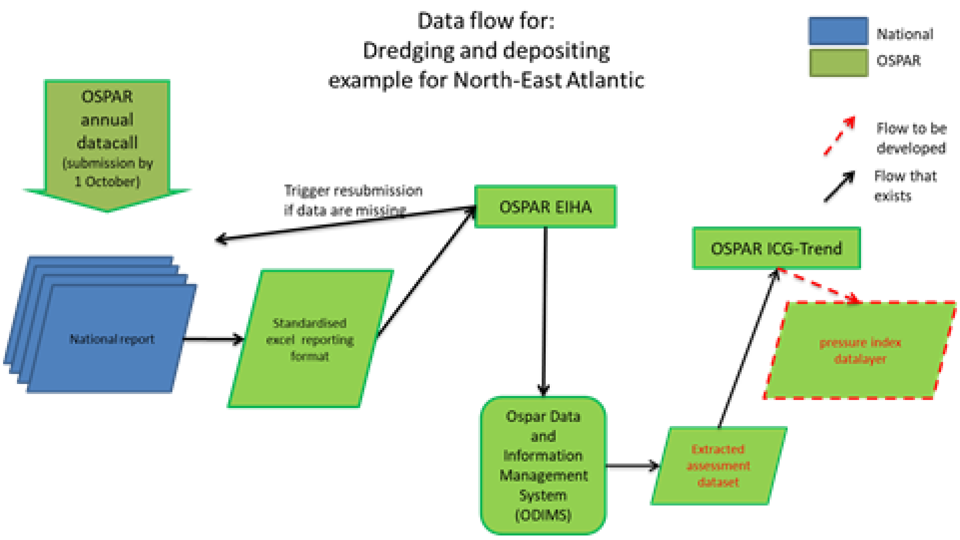

Figure 5.4 Example dataflow for dredging and depositing as used by OSPAR.

For predictions of sediment deposition in the far field, a number of datasets and modelling tools are needed that are currently only available on a case-by-case basis (e.g., Spearman *et al*., 2015). It would require data on the amount of sediment released per activity, as well as the size and nature of the material that is deposited and transported. Hydrodynamic and sediment transport models would then be required to estimate dispersal and predict deposition patterns. Impact assessments (in determining sub-lethal effects / recovery trajectories) would also require background levels of naturally suspended and resuspended sediments (e.g. from remote sensing and data from EIAs), as well as the sensitivity of benthic communities to various levels of deposition, hitherto largely unknown.

Recommended assessment method including data processing

Pressure Analysis

At the broad scale, sediment deposition is presently estimated using the spatial extent of licensed disposal sites (Kenny *et al*., 2017). However, a more detailed footprint analysis can be performed using a similar approach to that described for aggregate extraction, but this would require improved and standardised data acquisition and provision across Member States. Theoretical buffers can also be applied as a rough estimate of the sediment deposition in the near field for a range of sediment deposition sources (e.g., for aggregate extraction; Foden *et al*., 2011), but there are no proxies available to estimate sediment deposition in the far field. Such estimates are entirely dependent on having access to suitable hydrodynamic and sediment transport models.

Impact Analysis

There is currently no method available to adequately assess the impact of sediment deposition from disposal activities, as the current PD depletion/recovery method requires knowledge of generic biomass depletion and recovery rates associated with dredge material disposal. However, these are likely to be very much influenced by site specific and dredge material disposal conditions that are influenced by the local hydrodynamics. The current assessment model cannot therefore be used as the sensitivity of benthic communities to various levels of deposition is not known, and sub-lethal effects are not yet accounted for.

Future development of assessment methodology and data availability to reduce uncertainty

The broadscale assessment of the impact of sediment deposition currently lacks adequate and consistent data on the type and quantity of disposed material reported across Member States. Furthermore, and a uniform methodological framework that can take account of all the activities potentially generating suspended sediments in space and time using models is not available. The map of aggregated activities should consider a temporal dimension of the sediment deposition pressure as some activities will essentially be continuous (e.g. fishing), whereas others be a one-time event (e.g. off-shore construction).

5.3.4 Pressure type: sealing

Sealing, ***by hard structures***

Hard structures relate to the placement of coastal defence structures, infrastructure (e.g. harbours, radar tower, and measuring towers), wind turbines, cables/pipelines, oil and gas rigs, which give rise to a physical loss of habitat. In many cases overfill or protective covers are also placed on the seabed and these also give rise to a loss of habitat by sealing. .

Data collection process:

MSFD Competent Authorities

Data type and Ecoregion specificities

BALTIC	G. NORTH	CELTIC	MED	BLACK
	Polygons delineating hard structure placement			

Data flow

Data are available from the licensing and permitting authorities for such activities, but it is likely that industry reports and assessments can provide additional details of the operational phases of all constructions (including cabling). For some activities, regional or European-wide datasets exist (e.g., national MSP Portals, or via pan-European data portals such as EMODNet-Human Activities, HELCOM or OSPAR).

Recommended assessment method including data processing

Pressure Analysis

To account for sealing by hard structures, the location of hard structures must be known as well as the placement dimensions, including their protective jackets and footings, if appropriate. Member States need to provide polygon data on their actual footprint, i.e. the surface area (km^2) occupied by the structures. Ideally, the footprint will be an exact delineation of the hard structure placement, but it can also be estimated from knowledge of the generic types and size of structures typically placed. It is also recommended that a buffer zone - i.e. an area of potential impact beyond the physical structure - be included in the estimate of the sealing pressure footprint (Fig. 5.5). More detailed information can be found in the WKBEDLOSS 2019 report. Ultimately, a polygon shapefile delineating the loss areas needs to be created with INSPIRE-compliant attributes, including: activity, structure type, license information, timestamp of the operational phase. Sealed areas are typically small; hence polygons need sufficient detail and resolution especially when converting to high spatial resolution grids. Annual updates of the sealing pressure footprint are advisable, given the rate of change in the placement of structures in the marine environment. The total sealing pressure giving rise to physical loss is then relatively straightforward to calculate. This is done by summing up the activity specific sealing pressure footprints.

Impact Analysis

The impact arising from sealable pressure at one level is relatively easy to determine since the loss is 100%. However, at one level where the substrate is essentially the same as the placement material (concrete *vs* bed rock) it may be argued (under certain conditions) that this would not represent a physical loss, since the colonising community would essentially represent the pre-impacted state. In most cases (even including instances where the placement material is the same as the *in-situ* substrate type) there will be a permanent change to the benthic community structure, and therefore such placements would represent a permanent loss of habitat. The impact therefore should be determined by assessing how different the resulting benthic community state is compared to its pre-impacted condition. In this respect it was noted by Kenny *et al*., (2017) that the placement of hard structures in soft sedimentary habitats potentially represents a greater level of impact than placing a hard structure on to a hard seabed composed of gravel and rock. However, the methodology by which this type of pressure impact can be accurately estimated has not been established. In the present assessment, loss is separately assessed from disturbance and the loss layer is simply subtracted from the region that is assessed using the physical disturbance related population dynamic model.

Future development of assessment methodology and data availability to reduce uncertainty

Data limitations

In case where only point locations of structures are available, approximate dimensions can be taken from the literature (e.g. Foden *et al*., 2011). However, where licensed zone (polygon) data is only available, an estimate based upon the number and type of structures known to be licensed within an area should be used to determine the total sealing pressure footprint within a licensed zone. For cables and pipelines, there is potential uncertainty concerning the actual location of the structure on the seabed, which can lead to either an over- or under-estimate of habitat specific impacts.

Impact beyond the footprint

The placement of hard structures may lead to additional loss in the wake of the structure, due to long-term hydrographical changes from the water flow around a structure (Fig. 5.5). Pre- and post- EUNIS Level 2 types need to be known to assess loss in these buffer zones. It should be emphasised that placement of each hard structure comes in different operational phases, each disturbing the seabed. In the case of the installation of wind farms, many other activities also take place such as the trenching and laying of cables or the installation of transformation stations or socket plugs to streamline the electrical cabling. These cables may have a protective cover in navigation-intensive areas. In both cases, the scouring process may contribute to 'Removal'. The winnowed particulate matter may deposit further away and needs to be estimated under 'Deposition'.

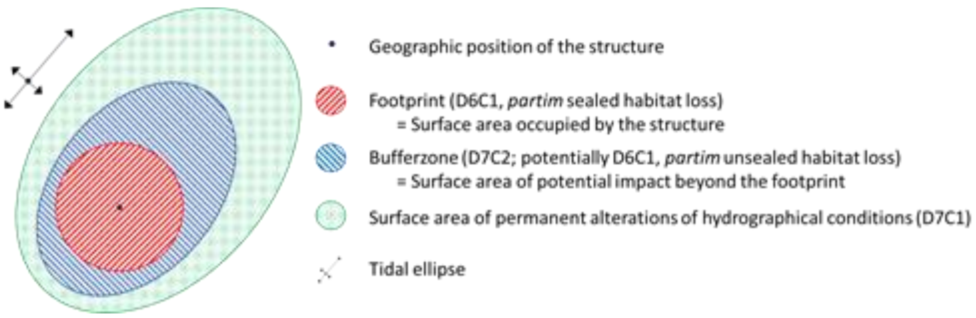

Figure 5.5 Area of influence around a structure with reference to physical loss (D6C1) and hydrographical alterations (D7C1 and D7C2).

Demonstration product outcome

5.3.5 Abrasion caused by bottom fishing

The spatial extent of abrasion by bottom fishing disturbance was estimated for the North Sea ecoregion and exclusive economic zones (EEZ) and subregions with the North Sea using 2016 data from the latest ICES VMS and logbook data call. Spatial extent was assessed for the entire region and by MSFD broadscale habitat type.

An overview of bottom fishing abrasion is shown in figure 5.6. The spatial extent of abrasion by bottom fishing for other regions (and based on available fishing abrasion data) will be produced for the consideration of ICES Advice Drafting Group (ADGD6PRES) for inclusion in the final ICES Advice.

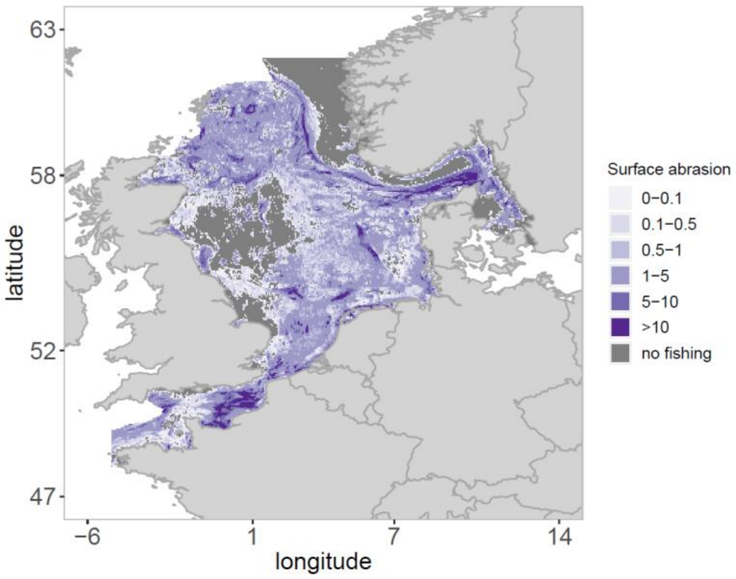

Figure 5.6. Geographic distribution of surface abrasion (swept area ratio per year) from mobile bottom-contacting gears in the North Sea ecoregion in 2016. The swept area ratio shows the ratio between the area of the site that is trawled each year and the total area of the site.

Summary statistics of fishing abrasion in the North Sea ecoregion and for each MSFD habitat type is presented in Table 5.1. Annex 4 presents additional summaries split by each EEZ within the North Sea. Annex 5 presents additional summaries split by subregion within the North Sea.

Table 5.1 Fishing abrasion for the North Sea ecoregion and for each MSFD habitat type. Fishing abrasion was calculated as the sum of swept area in km^2 across all grid cells in a considered area, where swept area in a specific grid cell cannot be greater than the area of that grid cell.

Habitat	Abrasion (km2)	Abrasion (%)	Total area (km2)
Total region	356013.2	54.5	652799.9
Offshore circalittoral sand	129673.0	53.6	242124.6
Offshore circalittoral mud	89179.7	82.5	108043.5
Offshore circalittoral coarse sediment	43929.3	57.3	76719.5
Circalittoral sand	44586.8	65.0	68621.7
Upper bathyal sediment	14423.2	23.5	61407.2
Circalittoral coarse sediment	11507.6	38.0	30287.7
Infralittoral sand	6605.2	44.5	14835.8
Unknown (Na)	1751.4	18.1	9676.5
Offshore circalittoral mixed sediment	4636.6	60.2	7701.7
Circalittoral mud	3879.0	56.2	6900.5
Circalittoral mixed sediment	1965.7	40.8	4822.7
Offshore circalittoral rock and biogenic reef	723.9	15.3	4734.6
Infralittoral coarse sediment	1638.2	49.7	3299.0
Circalittoral rock and biogenic reef	393.5	12.9	3058.6
Upper bathyal sediment or Upper bathyal rock and biogenic reef	104.5	4.1	2552.9
Upper bathyal rock and biogenic reef	189.0	7.9	2406.2
Infralittoral mud	529.2	22.3	2372.8
Infralittoral rock and biogenic reef	248.5	13.1	1901.4
Infralittoral mixed sediment	48.8	3.7	1333.0

5.3.6 Removal from aggregate extraction

For the purposes of demonstration, the spatial extent of removal by aggregate extraction in 2017 was estimated for the North Sea ecoregion and for different exclusive economic zones (EEZ) and subregions within the North Sea ecoregion. Figure 5.7 shows the aggregate extraction footprint (in minutes dredged) for the Swedish, Dutch, UK, Belgian, and Danish Exclusive Economic Zones. Spatial extent and benthic community state by ecoregion are given in Table 5.2. Similar summaries for each EEZ are shown in Annex 4 and each subregion in Annex 5.

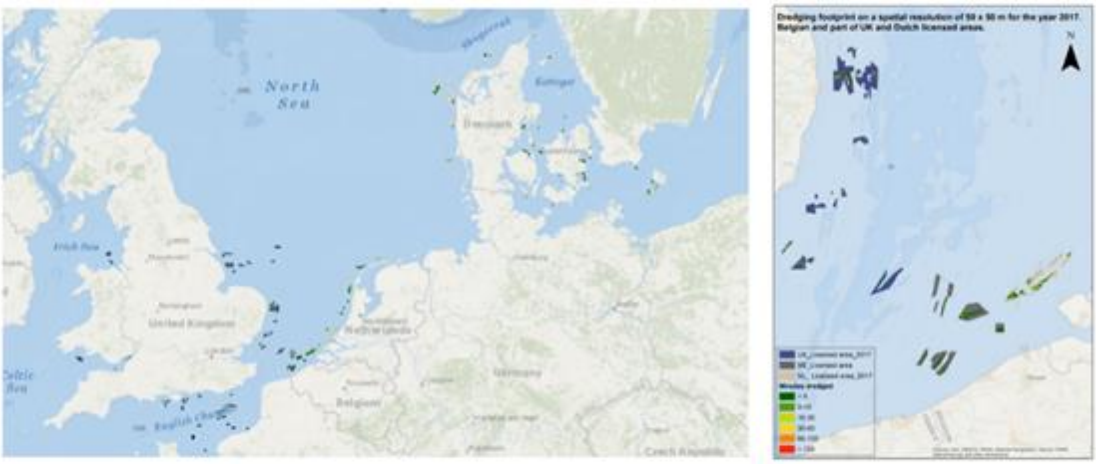

Figure 5.7 Aggregate extraction footprint (in minutes dredged) on a spatial resolution of 50 x 50 meter for the year 2017. Data is available for the Swedish, Dutch, UK, Belgian, and Danish Exclusive Economic Zone.

Table 5.2 The spatial extent of removal by aggregate extraction calculated as the sum of all 50 x 50 meter grid cells with dredging activity for the North Sea ecoregion and for each MSFD habitat type. Each 50 x 50 meter grid is (for computational reasons) linked to an MSFD habitat type assigned at a c-square resolution of 0.05° x 0.05°. A value of 0.0 means larger than zero and smaller than 0.05.

Habitat	Removal (km²)	Removal (%)	Total area (km²)
Total region	441.9	0.1	652799.9
Offshore circalittoral sand	62.4	0.0	242124.6
Offshore circalittoral mud	10.0	0.0	108043.5
Offshore circalittoral coarse sediment	38.2	0.0	76719.5
Circalittoral sand	157.5	0.2	68621.7
Upper bathyal sediment	0	0	61407.2
Circalittoral coarse sediment	49.4	0.2	30287.7
Infralittoral sand	6.6	0.0	14835.8
Unknown (Na)	0	0	9676.5
Offshore circalittoral mixed sediment	1.0	0.0	7701.7
Circalittoral mud	71.4	1.0	6900.5
Circalittoral mixed sediment	27.0	0.6	4822.7

Habitat	Removal (km^2)	Removal (%)	Total area (km^2)
Offshore circalittoral rock and biogenic reef	0	0	4734.6
Infralittoral coarse sediment	0	0	3299.0
Circalittoral rock and biogenic reef	0.7	0.0	3058.6
Upper bathyal sediment or Upper bathyal rock and biogenic reef	0	0	2552.9
Upper bathyal rock and biogenic reef	0	0	2406.2
Infralittoral mud	0.5	0.0	2372.8
Infralittoral rock and biogenic reef	0	0	1901.4
Infralittoral mixed sediment	17.1	1.3	1333.0

5.3.7 Sealing of the seabed by hard structures

The spatial extent of sealing by hard structures (restricted to data from offshore wind farms, wave and tidal energy, and oil and gas) was assessed for the North Sea ecoregion and different exclusive economic zones (EEZ) and subregions within the North Sea ecoregion. Figure 5.8 shows the locations of sealed loss. The spatial extent of sealing by hard structures for the entire North Sea ecoregion and by MSFD broadscale habitat type is shown in Table 5.3. The spatial extent of sealing by hard structures for each EEZ is shown in Annex 4 and each subregion in Annex 5.

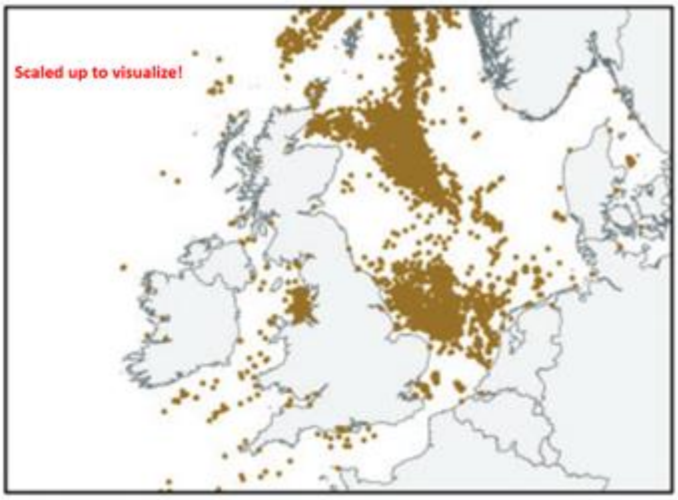

Figure 3. The locations of sealed loss by hard structures as collated by Kenny *et al*. (2017).

Table 5.3 The spatial extent of sealed loss by hard structures for the North Sea ecoregion and by MSFD habitat type. Each hard structure is linked to an MSFD habitat type assigned at a c-square resolution of 0.05 x 0.05. A value of 0.0 means larger than zero and smaller than 0.05.

Habitat	Sealed loss (km²)	Sealed loss (%)	Total area (km²)
Total region	161.7	0.0	652799.9
Offshore circalittoral sand	85.8	0.0	242124.6
Offshore circalittoral mud	46.3	0.0	108043.5
Offshore circalittoral coarse sediment	9.9	0.0	76719.5
Circalittoral sand	11.7	0.0	68621.7
Upper bathyal sediment	0.0	0.0	61407.2
Circalittoral coarse sediment	5.0	0.0	30287.7
Infralittoral sand	1.6	0.0	14835.8
Unknown (Na)	0.1	0.0	9676.5
Offshore circalittoral mixed sediment	0.4	0.0	7701.7
Circalittoral mud	0.4	0.0	6900.5
Circalittoral mixed sediment	0.3	0.0	4822.7
Offshore circalittoral rock and biogenic reef	0	0	4734.6
Infralittoral coarse sediment	0.1	0.0	3299.0
Circalittoral rock and biogenic reef	0	0	3058.6
Upper bathyal sediment or Upper bathyal rock and biogenic reef	0	0	2552.9
Upper bathyal rock and biogenic reef	0	0	2406.2
Infralittoral mud	0	0	2372.8
Infralittoral rock and biogenic reef	0	0	1901.4
Infralittoral mixed sediment	0	0	1333.0

5.3.8 Cumulative assessment

The overall impact of abrasion from mobile bottom-contacting fishing gears, removal from aggregate extraction and seabed loss is estimated for the North Sea ecoregion and different exclusive economic zones (EEZ) and subregions within the North Sea ecoregion.

All areas that are assigned as loss are excluded from the physical disturbance assessment and, hence, the physical disturbance model is refined in its geographical extent to the region without loss. To assess cumulative disturbance, it can be assumed that different physical disturbance pressures do not overlap spatially. Hence, in a c-square of 0.05° x 0.05° with abrasion and removal present, abrasion is redistributed to the area without removal. For example, a c-square grid cell with a swept area ratio of 1.5 and with removal in 20% of the grid cell will result in a swept area ratio of 1.5/ (1-0.2) = 1.75 in 80% of the c-square.

An overview of physical loss and cumulative disturbance is shown in Table 5.4 for the entire North Sea ecoregion and by MSFD broadscale habitat type. A similar overview for each EEZ is shown in Annex 4 and each subregion in Annex 5.

Table 5.4 The spatial extent of physical loss and the cumulative physical disturbance (from abrasion and removal) for the North Sea ecoregion and by MSFD habitat type. Each hard structure and each 50 x 50 meter grid for aggregate extraction is linked to an MSFD habitat type assigned at a c-square resolution of 0.05° x 0.05°. A value of 0.0 means larger than zero and smaller than 0.05.

Habitat	Loss (km^2)	Loss (%)	Cumulative disturbance (km^2)	Cumulative disturbance (%)	Total area (km^2)
Total region	161.7	0.0	356109.6	54.6	652799.9
Offshore circalittoral sand	85.8	0.0	129653.7	53.5	242124.6
Offshore circalittoral mud	46.3	0.0	89148.8	82.5	108043.5
Offshore circalittoral coarse sediment	9.9	0.0	43949.4	57.3	76719.5
Circalittoral sand	11.7	0.0	44624.5	65.0	68621.7
Upper bathyal sediment	0.0	0.0	14423.2	23.5	61407.2
Circalittoral coarse sediment	5.0	0.0	11548.0	38.1	30287.7
Infralittoral sand	1.6	0.0	6607.5	44.5	14835.8
Unknown (Na)	0.1	0.0	1751.3	18.1	9676.5
Offshore circalittoral mixed sediment	0.4	0.0	4637.4	60.2	7701.7
Circalittoral mud	0.4	0.0	3906.0	56.6	6900.5
Circalittoral mixed sediment	0.3	0.0	1971.4	40.9	4822.7
Offshore circalittoral rock and biogenic reef	0	0	723.9	15.3	4734.6
Infralittoral coarse sediment	0.1	0.0	1638.2	49.7	3299.0
Circalittoral rock and biogenic reef	0	0	394.2	12.9	3058.6
Upper bathyal sediment or Upper bathyal rock and biogenic reef	0	0	104.5	4.1	2552.9
Upper bathyal rock and biogenic reef	0	0	189.0	7.9	2406.2
Infralittoral mud	0	0	529.7	22.3	2372.8
Infralittoral rock and biogenic reef	0	0	248.5	13.1	1901.4
Infralittoral mixed sediment	0	0	60.5	4.5	1333.0

5.4 The picture as a whole

5.4.1 The applicability of the outlined assessment process

The underlying process that produced the operational products outlined in this chapter is generally applicable for each ecoregion (Fig. 5.1 flow diagram). However, for most ecoregions, due to lack of data - including, among others, data for the assessment and validation of community sensitivity parameters and ground-truthing of modelling - assessment will be attenuated in terms of the pressures examined or the spatial coverage. The operational products, shown here, focus on the direct (primary) pressures of each activity. Indirect (secondary) pressures, such as the deposition of particulates resulting from fishing and aggregate extraction, will also require the construction of further models and model parameters before they can be included into the assessment. Such models could conceivably be incorporated into a wider population dynamic model through the use of a common currency such as depletion.

5.4.2 Temporal aspects and assessment reporting cycles

Physical disturbance: Appropriate assessment and reporting cycles are required for the purposes of management. Fishing abrasion data extractions have been chosen to match a MSFD six-year policy cycle. The presented demonstration model is run using data from fishing activity collected within a single year. The model can be run on a multi-year basis, averaging activity over years, or on a lower temporal resolution to capture more precisely intra-annual population dynamics; however, parameters for the latter option are not currently available.

For the most accurate assessment of the ecological state, the assessment should use pressure data averaged over a similar time-scale over which recovery of the benthic state is expected. Hiddink *et al*. (2017, Figure 3B) showed that recovery of benthic communities can be expected within 6 years, even from heavily depleted states. Whilst recovery times may be wider for some sensitive/fragile species, biogenic habitats aside (see section 4.3), we therefore recommend that the assessment proceeds on a 6 years reporting cycle.

Since removal (caused by activities such as extraction) is likely to require ecological recovery trajectories similar to fishing, the assessment period over which dredging activity is reported to sea bed assessment should be multi-annual and on similar 6 year reporting cycle.

Loss: An appropriate assessment for sealed loss is straightforward, requiring only annual polygon layers of hard structures to be aggregated into one cumulate loss layer for each of the different ecoregions over a six-year MSFD cycle. This cumulative layer will retain structures that remain from previous reporting cycles. Determining if unsealed loss has occurred needs further development and is currently a caveat in reporting. For example, the assessment of whether aggregate extraction causes disturbance or loss is reliant on monitoring of the physical habitat or on modelled severity of the activity (the latter acting as a proxy of loss in the absence of monitoring data and being scientifically validated). This type of monitoring might be available for some Member States but is not yet in a state to allow for appropriate assessment.

5.4.3 The prioritisation of the assessment process

Not all activities can as yet be incorporated into pressures within the assessment process due to lack of data. This observation applies across all ecoregions. Moreover, data for some ecoregions is sparser than others, meaning that such shortfalls will need to be addressed if the minimum, whole-region assessment is to be achieved.

Given the difficulties of collecting relevant data, it is reasonable that priority should be given to data that can be used to estimate the largest pressures on the seabed. The ranking processes in WKBEDPRES1 and WKBEDLOSS identify data relating to fishing abrasion, extraction and, sealing due to hard structures as being the most impactful. Indeed, the operational product suggests that, of these three primary drivers, fishing is by far the most important component (Chapter 5). Hence, any attempt to produce a regional assessment should prioritise data that underpin seabed abrasion caused by fisheries over all others. Refinement to the data going into the assessment of fishing activity – such as inclusion of a wider subset of vessels or the increase in spatial resolution (Chapter 3) – would provide the greatest improvement to the assessment as it currently exists and should be prioritised.

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6 Conclusions

ICES has been requested to investigate the main physical disturbance pressure(s) causing benthic impact on habitats per EU ecoregion. The main aim of the WKBEDPRES2 workshop was to develop EU-wide guidance on how to assess and report human activities that cause physical disturbance to the seafloor and loss of benthic habitats. Within WKBEDPRES2 suitable data streams relating to activities thought to be the main causes of physical disturbance were identified, as were the links from activity to pressure and then impact. To allow this work to proceed, key pressures drivers and activities were identified within the WKBEDPRES1 / WKBEDLOSS process and have been reported upon here. Definitions of what constitutes physical disturbance and loss, including further definitions required in their assessment, were also set out. The methodology laid out in WKBEDPRES2 was found to be generally applicable to each ecoregion and pressure type thought to have a main impact upon seabed integrity. The presentation of a demonstration product indicates the availability of reliable methods that can implement such an assessment and the data requirements needed to serve such methods. The implementation of such methods presents the possibility of further activities being included into the assessment framework in a cumulative and biologically relevant manner: appropriate to assessment of adverse effects under D6C3 and D6C5, both for the single pressure and the cumulative of all pressures. The main findings of WKBEDPRES2 were:

- Definitions were refined and agreed for physical disturbance D6 C2 and physical loss and D6 C1/C4.
- Main pressure types resulting in physical disturbance and loss to the seabed can be identified as abrasion, removal, deposition and sealing. These physical pressure groupings relate directly to physical disturbance D6 C2 and physical loss C1/C4, they also represent the main pathways of change (easily related to impact in a meaningful way), and are easily communicated and understood by broad suite of managers and stakeholders.
- There are inherent difficulties in collecting all relevant data. WKBEDLOSS and WKBEDPRES1 after a scoping exercise linking activities to pressures were able to identify priorities, and priority should be given to data that can be used to estimate the largest pressures on the seabed.
- For each physical pressure (abrasion, removal, deposition and sealing), the same activities across the regional areas had the most widespread/significant effect, although these patterns and intensities were variable between the regional areas.
- In terms of the D6 assessment requirements, it was noted that the requirements to assess at MSFD broad habitat scale (based on EUNIS level 2) may overlook that an activity/pressure may have a disproportionate effect on specific biological habitats (EUNIS higher level 4+). National or local scale assessments of these habitats may be carried out where necessary and disturbance/loss effects managed in accordance with relevant policy requirements.
- WKBEDPRES2 recognised that some cumulative impact assessment approaches simply add up different activities (or mixtures of activities and pressures), without consistently considering what pressures these activities are causing, and the biological mechanisms through which the activities may be affecting marine ecosystems. However, assessing impact within a quantitative methodological framework (as presented in Chapter 5) is more reasonable and is therefore recommended.
- While the focus of D6 C2 and D6 C1/C4 relate to pressures, it is vital that these pressures relate to the overall aim of Descriptor 6, that: "sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected (Directive 2008/56/EU)." When identifying

relevant pressures, and considering their future management, it is thus important to also consider their links from activity to pressure to impact. Data collated and processed to inform impact assessments should reflect this aim.

- Single activities give rise to multiple pressures/subtypes and multiple activities give rise to the same pressure/subtype. Grouping similar pressure data relates to impact and the way pressures mediate change acting on biological processes.
- With regard to physical disturbance (D6C2), approaches to translate activities to pressure subtypes to impact, exist for abrasion, and these methods, as shown in the demonstration product of this report, are applicable to removal. However, while several studies have documented the negative effects of sediment deposition on the seafloor, a standardized approach for the quantification of the pressure and impact by sediment deposition does not yet exist and requires further development.
- Various scale, accuracy and resolution issues were identified within the assessment process. It is additionally noted that some care must be taken when using EMODNet maps with MSFD Benthic Broad Habitat Types with respect to accuracy and resolution, especially in areas that have been widely modelled rather than sampled. This should not just be seen as a finished product but one requiring future improvements, particularly in accuracy, through ground-truthing, and in how such refinements relate to pressure layers.
- A number of potential data limitations were identified within WKBEDPRES2 (e.g. resolution of available benthic data and pressure/activity footprints) along with areas that will serve to reduce uncertainty in the assessment (e.g. better habitat mapping for linking to pressure layers, improved model parameterisation for some regions).
- With regard to physical loss (D6 C1/C4), approaches for assessing loss from sealing do exist. Standard methods to quantify physical disturbance that also result in physical loss are still required, as it was recognized that loss does occur if abrasion, removal and deposition are sufficiently intensive, extensive enough or deep enough and/or of persistent frequency.
- It has been demonstrated that the physical disturbance (comprising multiple subtypes) and loss can be assessed both separately and in combination under the assessment requirement for physical disturbance D6 C2 and physical loss C1/C4 at a regional level.
- Harmonized physical loss layers (see guidance in chapter 5) should be produced at the national level for MSFD reporting cycles. These spatial data should also be collated per region. This would allow for the subsequent assessment of physical disturbance pressures and impact on the regional scale as this assessment also takes loss into account.
- Abrasion by fishing activity was found to be the most extensive physical pressure subtype acting on the seafloor across regions. For the North Sea demonstration product, pressure resulting from fishing was several orders of magnitude higher than other pressures (e.g. removal as a consequence of aggregate extraction).
- To improve data relating to abrasion caused by fishing, it is noted that AIS data alone to describe fishing pressure is problematic (e.g. lack of gear information, incomplete coverage, and a lack of unique vessel identifiers for merging with logbook data). It is thus not recommended that AIS data is used at a regional scale if VMS and logbook data are unavailable, although these data may serve requirements at the local scale if documented methodologies exist.
- It is recommended that the VMS ping frequency is increased to a 10 minute interval (from the current 2 hour interval), enabling fishing pressure maps to be produced at a finer scale. It is essential that this recommendation is included in the ongoing and future revisions of the EU Fisheries Control Regulation (COM/2018/368 final). This would also ensure that that present spatial overestimating of fishing pressure at the regional scale can be improved for a more accurate picture. It is also noted that the EU Fisheries Control

Regulation should ensure that VMS is also included for vessels <12 m to ensure full fleet coverage.
- For aggregate extraction, it is recommended that data collection from electronic monitoring system (EMS) or AIS from dredgers should be mandatory, along with the collation of data on the licensed area, for all regions.
- While they may not be currently, fully operational in all regions, the methods depicted within the WKBEDBRES2 report and demonstration product are applicable to all EU regions.
- The process of assessment outlined within the WKBEDBRES2 report is such that incremental improvements to the process – such as the parameterisation of additional activity/pressures links – can be made. Such changes can be incorporated within the existing framework in a biologically meaningful manner, as required under D6.
- Regional assessments of this kind (as shown in the demonstration product) facilitate regional comparison and are complementary to national assessments, further highlighting disturbance and issues of national or local importance. Complementarity and comparability of outputs will depend on data standardisation and baseline/threshold setting across Member States.

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Annex 2: Resolutions

WKBEDPRES2 – Evaluation and operational application of human activities causing physical disturbance and loss to seabed habitats (D6C1-C4)

2019/2/FRSG50 **WKBEDPRES2** – Evaluation and operational application of human activities causing physical disturbance and loss to seabed habitats (D6C1-C4).

The *Workshop to evaluate and test operational application of human activities causing physical disturbance and loss to seabed habitats (D6C1-C4) (WKBEDPRES2)*, chaired by Phillip Boulcott, Scotland will meet in Copenhagen, Denmark, 30 September – 2 October 2019. Given the findings of WKBEDPRES1 and WKBEDLOSS and the data collected, the workshop is tasked to:

a) Prepare guidance on the appropriate spatial and temporal scales for assessing physical disturbance and loss, and how this relates to benthic impact. This should include guidance on the benefits of knowing the variation and trends in the data during a six-year assessment periods (e.g. for environmental status or management purposes), and on the most appropriate spatial resolution for the data (e.g. in relation to spatial variation in the broad habitat types)
b) Prepare guidance on the possibilities and limitations of how collected pressure layers can be used to determine benthic impact. This should include guidance on how to interpret surface and subsurface abrasion from different human activities and on different seabed habitat types.
c) Demonstrate operational use of collected pressure layers to assessing spatial extent and distribution and to determine benthic impact, by:
    i. producing an assessment of spatial extent and distribution of physical disturbance and loss by broad benthic habitat types for at least one ecoregion (assessment of D6C1-C4)
    ii. suggest ways to combine different human activities that cause physical loss/ disturbance to determine benthic impact and/or to report on the spatial extent and distribution of physical disturbance/loss
    iii. recommend any key improvements needed in the proposed methods and/or associated data needed.
d) Prepare generic EU-wide technical guidance on how to assess and report on both disturbance (based on WKBEDPRES1) and loss (based on WKBEDLOSS) using the demonstration product.
e) Assess the applicability of AIS and VMS data derived products (produced by WGSFD) to increase spatial and temporal coverage of fishing pressure layers. This should include technical guidance of how AIS and VMS data derived products can be used (together) for assessing physical disturbance from different fishing activities.

In preparation for the workshop, the Chair Phillip Boulcott (Scotland), together with ACOM approved invited attendees (tbc) will facilitate coordination and consolidation of work on TOR a-d from respective working groups (WGSFD, WGEXT, WGFBIT). This group will also help ensure that the workshop report is finalized.

WKBEDPRES2 will report to the attention of ACOM by 18 October 2019.

Supporting information

Priority	High, in response to a special request from DGENV on the Common Implementation (CIS) of the MSFD. The advice will feed into ongoing efforts to provide guidance on the operational implementation of the MSFD.
Scientific justification	This workshop focuses on the requirement of D6C1-C4 to assess the spatial extent and distribution of human activities causing physical loss and disturbance on the seabed (including the intertidal area) for each subdivision and per MSFD broad habitat type within each subdivision. Physical disturbance and loss by all relevant human activities should be considered, following the work in WKBEDPRES1 and WKBEDLOSS. Central to this is to identify methods that express the intensity of the pressure in a way appropriate to: 1) derive the cumulative of all disturbance pressures, and 2) assess adverse effects under D6C3, D6C4 and D6C5, both for the single pressure and the cumulative of all pressures. Given the findings of WKBEDPRES1 and WKBEDLOSS and the resultant data collected, WKBEDPRES2 will evaluate the work done and demonstrate its operational application. The following supporting material is provided to guide the interpretation of TORs a-d: a) Provide guidance on the benefits of knowing the variation and trends in the data during a six-year assessment period (e.g. for environmental status or management purposes), and on the most appropriate spatial resolution for the data (e.g. in relation to spatial variation in the broad habitat types). b) Provide guidance on the relevance of distinguishing surface and subsurface abrasion for different human activities (including dredging, depositing of materials, extraction of minerals, fish and shellfish harvesting), given that the demonstration advice for fishing impact (ICES advice sr.2017.13) only used surface abrasion to assess benthic impact. c) Demonstrate the application of the methods based on the WGFBIT assessment approach to give the distribution and extent of physical disturbance and loss for each MSFD (sub)region (i.e. assessment of D6C1-C4). Provide estimates of the total extent of physical disturbance and loss, in km^2 and as a proportion (%), per subdivision/subregion and per MSFD broad habitat type. Distinguish the proportion of the total extent of the pressure which is attributable to each activity, including the different fishing métiers separately. Provide an indication of the data precision, accuracy and likely data gaps for the areas used in the demonstration. d) An assessment of applicability to D6C2 of the work done by WGSFD in the comparison of AIS and VMS data. WGSFD were tasked to compare the use of VMS and AIS data, listing associated data required to determine fishing effort and type, such as fishers' logbooks, in the context of use for MSFD D6 assessments. This should include a side-by-side comparison against a number of parameters, including source of the data (who holds the raw data), availability (e.g. legal requirements, including vessels to be covered), accessibility (including any costs, restrictions such as due to data sensitivity, ease of access), use (e.g. restrictions on its release), spatial coverage in European waters, temporal coverage (historic, and within year), resolution (spatial granularity), accuracy, tech-

	nical requirements for processing (to define when vessels are physically disturbing the seabed), resources needed (e.g. technical expertise, time per unit area). The comparison should include maps showing the distribution of bottom-fishing activity from the two data sources for the same time period, indicating where the distribution overlaps and where not, with an associated quantification of this (e.g. number/proportion of grid cells per subdivision for AIS only, VMS only and both) and explanations for any differences. Note: this work will be carried out in close collaboration with EMODNet and JRC Bluehub
Resource requirements	ICES data centre, secretariat and advice process.
Participants	Workshop with researchers and RSCs investigators If requests to attend exceed the meeting space available ICES reserves the right to refuse participants. Choices will be based on the experts' relevant qualifications for the Workshop. Participants join the workshop at national expense.
Secretariat facilities	Data Centre, Secretariat support and meeting room
Financial	Covered by DGENV special request.
Linkages to advisory committees	Direct link to ACOM.
Linkages to other committees or groups	Links to WGSFD, WGFBIT, WGEXT, WGMHM, and SCICOM.
Linkages to other organizations	Links to OSPAR, HELCOM, Barcelona Convention, Bucharest Convention

Annex 3: Overview of abrasion, removal and physical loss within the North Sea ecoregion specified per EEZ

Table A4.1. Overview of abrasion, removal and physical loss for the United Kingdom Exclusive Economic Zone (within the North Sea ecoregion) and by MSFD habitat type. All areas that are assigned as loss are excluded from the physical disturbance assessment. A value of 0.0 means larger than zero and smaller than 0.05.

Habitat	Abrasion (km2)	Abrasion (%)	Removal (km2)	Removal (%)	Sealed loss (km2)	Sealed loss (%)	Cumulative disturbance (km2)	Cumulative disturbance (%)	Total area (km2)
Total region	120396.9	46.1	82.9	0.0	134.3	0.1	120458.2	46.1	261189.9
Offshore circalittoral sand	49919.6	37.5	6.0	0.0	72.7	0.1	49923.0	37.5	132984.8
Offshore circalittoral mud	38996.4	85.7	0.3	0.0	40.3	0.1	38996.4	85.7	45524.0
Offshore circalittoral coarse sediment	16624.7	43.8	38.1	0.1	7.6	0.0	16647.9	43.8	37979.4
Circalittoral coarse sediment	2798.2	20.5	30.8	0.2	4.8	0.0	2825.2	20.7	13657.3
Circalittoral sand	4578.8	34.6	2.8	0.0	6.7	0.1	4581.6	34.6	13229.1
Infralittoral sand	2744.8	59.6	0	0	1.6	0.0	2744.8	59.6	4602.6
Offshore circalittoral mixed sediment	2274.0	62.4	1.0	0.0	0.3	0.0	2275.0	62.4	3644.3
Unknown (Na)	198.4	9.5	0	0	0.1	0.0	198.4	9.5	2093.4
Circalittoral mud	644.8	36.3	0	0	0.0	0.0	644.8	36.3	1774.6

Habitat	Abrasion (km2)	Abrasion (%)	Removal (km2)	Removal (%)	Sealed loss (km2)	Sealed loss (%)	Cumulative dis-turbance (km2)	Cumulative dis-turbance (%)	Total area (km2)
Circalittoral mixed sediment	344.6	20.3	2.7	0.2	0.1	0.0	347.3	20.4	1700.3
Circalittoral rock and biogenic reef	221.1	15.2	0.7	0.0	0	0	221.8	15.2	1458.2
Infralittoral coarse sediment	874.6	61.3	0	0	0.1	0.0	874.6	61.3	1427.1
Offshore circalittoral rock and biogenic reef	149.7	30.7	0	0	0	0	149.7	30.7	488.4
Infralittoral rock and biogenic reef	12.9	4.4	0	0	0	0	12.9	4.4	293.9
Infralittoral mud	13.9	5.8	0.5	0.2	0	0	14.4	6.0	241.8
Infralittoral mixed sediment	0.2	0.3	0	0	0	0	0.2	0.3	90.6

Table A4.2 Overview of abrasion, removal and physical loss for the Swedish Exclusive Economic Zone (within the North Sea ecoregion) and by MSFD habitat type. All areas that are assigned as loss are excluded from the physical disturbance assessment. A value of 0.0 means larger than zero and smaller than 0.05.

Habitat	Abrasion (km2)	Abrasion (%)	Removal (km²)	Removal (%)	Sealed loss (km²)	Sealed loss (%)	Cumulative disturbance (km²)	Cumulative disturb-ance (%)	Total area (km²)
Total region	8233.2	58.6	0	0	0.0	0.0	8233.2	58.6	14044.3
Offshore circalittoral mud	5265.8	69.6	0	0	0.0	0.0	5265.8	69.6	7562.1
Upper bathyal sediment	1492.7	80.3	0	0	0	0	1492.7	80.3	1858.9
Offshore circalittoral mixed sedi-ment	683.1	53.6	0	0	0	0	683.1	53.6	1274.4
Offshore circalittoral sand	278.5	49.9	0	0	0	0	278.5	49.9	558.3
Circalittoral mud	16.2	3.1	0	0	0	0	16.2	3.1	528.4
Circalittoral mixed sediment	0.4	0.1	0	0	0	0	0.4	0.1	404.1
Offshore circalittoral rock and bio-genic reef	130.6	36.5	0	0	0	0	130.6	36.5	358.1
Offshore circalittoral coarse sedi-ment	241.4	79.5	0	0	0	0	241.4	79.5	303.6
Circalittoral rock and biogenic reef	74.7	30.6	0	0	0	0	74.7	30.6	243.7
Infralittoral rock and biogenic reef	24.4	10.6	0	0	0	0	24.4	10.6	229.2
Circalittoral sand	0	0	0	0	0	0	0	0	203.8
Infralittoral mud	5.9	3.3	0	0	0	0	5.9	3.3	181.6
Circalittoral coarse sediment	0.9	0.6	0	0	0	0	0.9	0.6	152.4
Infralittoral sand	16.8	16.7	0	0	0	0	16.8	16.7	100.9

Habitat	Abrasion (km2)	Abrasion (%)	Removal (km²)	Removal (%)	Sealed loss (km²)	Sealed loss (%)	Cumulative disturbance (km²)	Cumulative disturb-ance (%)	Total area (km²)
Infralittoral coarse sediment	0.7	1.3	0	0	0	0	0.7	1.3	51.0
Infralittoral mixed sediment	1.0	3.1	0	0	0	0	1.0	3.1	33.9

Table A4.3 Overview of abrasion, removal and physical loss for the German Exclusive Economic Zone and by MSFD habitat type. There is no data available on removal by aggregate extraction. All areas that are assigned as loss are excluded from the physical disturbance assessment. A value of 0.0 means larger than zero and smaller than 0.05.

Habitat	Abrasion (km2)	Abrasion (%)	Removal (km²)	Removal (%)	Sealed loss (km²)	Sealed loss (%)	Cumulative disturbance (km²)	Cumulative disturb-ance (%)	Total area (km²)
Total region	26066.0	68.2	-	-	0.8	0.0	26066.0	68.2	38195.0
Circalittoral sand	8901.5	60.6	-	-	0.2	0.0	8901.5	60.6	14698.5
Offshore circalittoral sand	9000.7	71.7	-	-	0.3	0.0	9000.7	71.7	12554.8
Offshore circalittoral mud	5204.3	82.8	-	-	0.2	0.0	5204.3	82.8	6288.9
Infralittoral sand	1057.8	71.1	-	-	0.0	0.0	1057.8	71.1	1487.6
Circalittoral coarse sediment	479.9	47.8	-	-	0.0	0.0	479.9	47.8	1003.0
Circalittoral mud	630.7	68.0	-	-	0.0	0.0	630.7	68.0	927.8
Unknown (Na)	537.2	77.4	-	-	0	0	537.2	77.4	694.1
Offshore circalittoral coarse sediment	71.4	30.7	-	-	0	0	71.4	30.7	232.5
Offshore circalittoral mixed sediment	78.2	54.5	-	-	0	0	78.2	54.5	143.6
Infralittoral mud	82.5	75.2	-	-	0	0	82.5	75.2	109.8
Circalittoral mixed sediment	22.0	40.3	-	-	0	0	22.0	40.3	54.4

Table A4.4 Overview of abrasion, removal and physical loss for the Dutch Exclusive Economic Zone and by MSFD habitat type. All areas that are assigned as loss are excluded from the physical disturbance assessment. A value of 0.0 means larger than zero and smaller than 0.05.

Habitat	Abrasion (km2)	Abrasion (%)	Removal (km²)	Removal (%)	Sealed loss (km²)	Sealed loss (%)	Cumulative disturbance (km²)	Cumulative disturb-ance (%)	Total area (km²)
Total region	48992.2	79.2	163.2	0.3	11.8	0.0	49047.0	79.3	61830.0
Offshore circalittoral sand	18210.0	76.1	13.7	0.1	3.4	0.0	18212.6	76.1	23919.0
Circalittoral sand	13679.0	77.0	81.7	0.5	4.2	0.0	13702.4	77.1	17767.9
Offshore circalittoral mud	12086.2	87.1	9.6	0.1	3.2	0.0	12086.2	87.1	13871.9
Circalittoral coarse sediment	1302.5	67.5	0.7	0.0	0.1	0.0	1303.2	67.6	1929.1
Unknown (Na)	837.3	68.9	0	0	0	0	837.3	68.9	1215.9
Circalittoral mud	972.8	92.2	56.2	5.3	0.4	0.0	1000.1	94.8	1055.3
Offshore circalittoral coarse sediment	927.5	91.9	0	0	0.1	0.0	927.5	91.9	1009.7
Infralittoral sand	726.7	93.6	1.2	0.2	0	0	727.6	93.7	776.5
Infralittoral mud	145.3	94.2	0.0	0.0	0	0	145.3	94.2	154.3
Infralittoral coarse sediment	62.0	84.0	0	0	0	0	62.0	84.0	73.8
Circalittoral mixed sediment	23.9	63.6	0	0	0.2	0.6	23.9	63.6	37.5
Offshore circalittoral mixed sediment	19.0	100.0	0	0	0	0	19.0	100.0	19.0

Table A4.5 Overview of abrasion, removal and physical loss for the Danish Exclusive Economic Zone (within the North Sea ecoregion) and by MSFD habitat type. All areas that are assigned as loss are excluded from the physical disturbance assessment. A value of 0.0 means larger than zero and smaller than 0.05.

Habitat	Abrasion (km2)	Abrasion (%)	Removal (km^2)	Removal (%)	Sealed loss (km^2)	Sealed loss (%)	Cumulative disturbance (km^2)	Cumulative disturb-ance (%)	Total area (km^2)
Total region	49812.4	66.5	86.4	0.1	2.5	0.0	49858.8	66.6	74891.7
Circalittoral sand	13829.4	73.9	21.3	0.1	0.4	0.0	13845.6	74.0	18703.2
Offshore circalittoral mud	14946.8	84.2	0	0	1.3	0.0	14946.8	84.2	17744.9
Offshore circalittoral sand	11818.0	77.3	0.4	0.0	0.5	0.0	11818.4	77.3	15281.6
Infralittoral sand	907.8	14.9	5.4	0.1	0.0	0.0	909.9	15.0	6076.2
Circalittoral coarse sediment	2359.8	53.4	17.9	0.4	0.0	0.0	2372.8	53.7	4422.3
Circalittoral mixed sediment	1574.8	60.0	24.3	0.9	0.0	0.0	1577.8	60.1	2626.4
Offshore circalittoral mixed sediment	1441.9	60.5	0	0	0.0	0.0	1441.9	60.5	2382.2
Offshore circalittoral coarse sediment	1018.1	47.0	0.0	0.0	0.0	0.0	1018.1	47.0	2167.7
Circalittoral mud	953.8	51.0	0	0	0	0	953.8	51.0	1869.0
Infralittoral mud	0.2	0.0	0	0	0	0	0.2	0.0	1303.1
Infralittoral mixed sediment	47.5	3.9	17.1	1.4	0	0	59.2	4.9	1208.5
Upper bathyal sediment	861.2	87.4	0	0	0	0	861.2	87.4	985.7
Infralittoral coarse sediment	53.0	43.8	0	0	0.0	0.0	53.0	43.8	120.9

Table A4.6 Overview of abrasion, removal and physical loss for the Belgian Exclusive Economic Zone and by MSFD habitat type. All areas that are assigned as loss are excluded from the physical disturbance assessment. A value of 0.0 means larger than zero and smaller than 0.05.

Habitat	Abrasion (km2)	Abrasion (%)	Removal (km²)	Removal (%)	Sealed loss (km²)	Sealed loss (%)	Cumulative disturbance (km²)	Cumulative disturb-ance (%)	Total area (km²)
Total region	3980.5	99.5	109.4	2.7	0.2	0.0	3980.5	99.5	3999.9
Offshore circalittoral sand	1666.0	99.3	42.3	2.5	0.1	0.0	1666.0	99.3	1677.3
Circalittoral sand	925.5	99.5	51.8	5.6	0.1	0.0	925.5	99.5	930.0
Offshore circalittoral coarse sediment	520.9	100.0	0.1	0.0	0.0	0.0	520.9	100.0	520.9
Circalittoral mud	480.8	99.3	15.2	3.1	0	0	480.8	99.3	484.3
Infralittoral sand	116.6	100.0	0	0	0	0	116.6	100.0	116.6
Offshore circalittoral mud	96.4	100.0	0	0	0.0	0.0	96.4	100.0	96.4
Circalittoral coarse sediment	77.4	100.0	0	0	0	0	77.4	100.0	77.4
Infralittoral mud	38.7	100.0	0	0	0	0	38.7	100.0	38.7
Infralittoral coarse sediment	19.5	100.0	0	0	0	0	19.5	100.0	19.5
Unknown (Na)	19.4	100.0	0	0	0	0	19.4	100.0	19.4
Offshore circalittoral mixed sediment	19.3	100.0	0	0	0	0	19.3	100.0	19.3

Annex 4: Overview of abrasion, removal and physical loss within the North Sea ecoregion specified per subregion

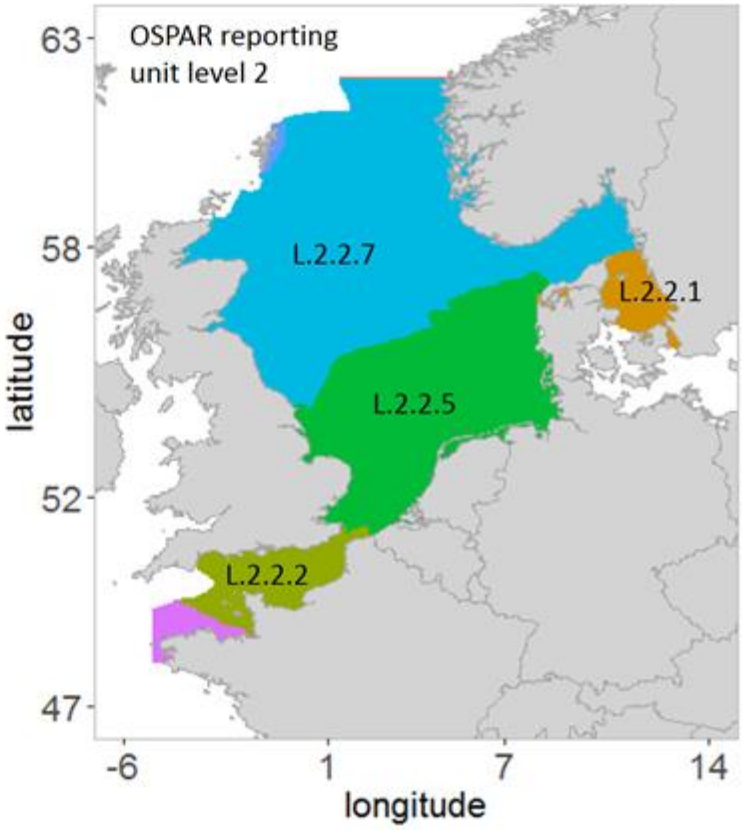

Figure A5.1 Map of subregions within the Greater North Sea ecoregion as defined by OSPAR (OSPAR reporting unit level 2) that are used for demonstration purposes.

Table A5.1 Overview of abrasion, removal and physical loss for OSPAR reporting region L.2.2.1 (within the North Sea ecoregion) and by MSFD habitat type. All areas that are assigned as loss are excluded from the physical disturbance assessment. A value of 0.0 means larger than zero and smaller than 0.05.

Habitat	Abrasion (km2)	Abrasion (%)	Removal (km²)	Removal (%)	Sealed loss (km²)	Sealed loss (%)	Cumulative disturbance (km²)	Cumulative disturb-ance (%)	Total area (km²)
Total region	8698.4	37.4	18.3	0.1	0.1	0.0	8713.5	37.4	23273.1
Offshore circalittoral mud	5766.5	71.2	0	0	0.0	0.0	5766.5	71.2	8097.1
Infralittoral sand	313.4	6.1	5.4	0.1	0.0	0.0	315.5	6.1	5138.2
Offshore circalittoral sand	1003.4	33.9	0.4	0.0	0.0	0.0	1003.7	33.9	2963.0
Offshore circalittoral mixed sedi-ment	600.5	41.9	0	0	0.0	0.0	600.5	41.9	1431.7
Infralittoral mixed sediment	35.9	3.0	7.3	0.6	0	0	43.2	3.6	1208.7
Circalittoral mud	434.2	36.8	0	0	0	0	434.2	36.8	1179.8
Infralittoral mud	0.2	0.0	0	0	0	0	0.2	0.0	1159.5
Offshore circalittoral coarse sedi-ment	383.2	49.8	0.0	0.0	0.0	0.0	383.2	49.8	768.7
Circalittoral mixed sediment	18.3	4.1	0	0	0	0	18.3	4.1	442.9
Circalittoral sand	65.2	15.3	0	0	0	0	65.2	15.3	426.1
Circalittoral coarse sediment	1.7	1.0	5.3	3.1	0	0	7.0	4.1	170.4
Infralittoral coarse sediment	49.4	36.1	0	0	0	0	49.4	36.1	136.8
Infralittoral rock and biogenic reef	1.2	1.7	0	0	0	0	1.2	1.7	67.1
Offshore circalittoral rock and bio-genic reef	25.6	38.5	0	0	0	0	25.6	38.5	66.5

Habitat	Abrasion (km2)	Abrasion (%)	Removal (km²)	Removal (%)	Sealed loss (km²)	Sealed loss (%)	Cumulative disturbance (km²)	Cumulative disturb-ance (%)	Total area (km²)
Circalittoral rock and biogenic reef	0	0	0	0	0	0	0	0	16.6

Table A5.2 Overview of abrasion, removal and physical loss for OSPAR reporting region L.2.2.2 (within the North Sea ecoregion) and by MSFD habitat type. There is no data included on removal by aggregate extraction from France EEZ. All areas that are assigned as loss are excluded from the physical disturbance assessment. A value of 0.0 means larger than zero and smaller than 0.05.

Habitat	Abrasion (km2)	Abrasion (%)	Removal (km²)	Removal (%)	Sealed loss (km²)	Sealed loss (%)	Cumulative disturbance (km²)	Cumulative disturb-ance (%)	Total area (km²)
Total region	35716.7	65.9	28.0	0.1	0.4	0.0	35731.7	65.9	54229.6
Offshore circalittoral coarse sedi-ment	21325.0	76.8	11.1	0.0	0	0	21325.1	76.8	27775.5
Circalittoral coarse sediment	5049.5	46.5	14.6	0.1	0.1	0.0	5062.0	46.6	10863.5
Circalittoral sand	3252.0	70.0	1.1	0.0	0.2	0.0	3253.1	70.1	4643.1
Offshore circalittoral sand	1915.9	93.0	0	0	0	0	1915.9	93.0	2060.6
Offshore circalittoral mixed sedi-ment	1394.4	76.5	0	0	0.1	0.0	1394.4	76.5	1823.9
Infralittoral sand	758.0	53.4	0	0	0.0	0.0	758.0	53.4	1420.2
Infralittoral coarse sediment	585.6	41.4	0	0	0	0	585.6	41.4	1416.0
Circalittoral rock and biogenic reef	106.3	11.7	0.7	0.1	0	0	106.9	11.8	909.1
Circalittoral mud	389.4	61.4	0	0	0	0	389.4	61.4	634.1
Offshore circalittoral rock and bio-genic reef	173.8	28.2	0	0	0	0	173.8	28.2	616.8
Circalittoral mixed sediment	132.0	21.6	0	0	0	0	132.0	21.6	610.7

Habitat	Abrasion (km2)	Abrasion (%)	Removal (km²)	Removal (%)	Sealed loss (km²)	Sealed loss (%)	Cumulative disturbance (km²)	Cumulative disturb-ance (%)	Total area (km²)
Infralittoral rock and biogenic reef	144.4	27.6	0	0	0	0	144.4	27.6	523.4
Unknown (Na)	60.2	16.2	0	0	0	0	60.2	16.2	373.0
Infralittoral mud	231.5	64.1	0.5	0.1	0	0	232.0	64.2	361.0
Offshore circalittoral mud	198.8	100.0	0	0	0	0	198.8	100.0	198.8

Table A5.3 Overview of abrasion, removal and physical loss for OSPAR reporting region L.2.2.5 and by MSFD habitat type. There is no data included on removal by aggregate extraction from Germany EEZ. All areas that are assigned as loss are excluded from the physical disturbance assessment. A value of 0.0 means larger than zero and smaller than 0.05.

Habitat	Abrasion (km2)	Abrasion (%)	Removal (km²)	Removal (%)	Sealed loss (km²)	Sealed loss (%)	Cumulative disturbance (km²)	Cumulative disturb-ance (%)	Total area (km²)
Total region	135994.0	65.4	391.2	0.2	49.5	0.0	136126.4	65.4	208063.9
Offshore circalittoral sand	46877.1	68.2	62.1	0.1	20.5	0.0	46883.1	68.2	68748.2
Circalittoral sand	37657.4	64.5	152.1	0.3	11.3	0.0	37698.6	64.6	58341.5
Offshore circalittoral mud	26003.1	87.6	10.0	0.0	5.0	0.0	26003.1	87.6	29681.9
Circalittoral coarse sediment	5467.4	33.7	29.5	0.2	4.8	0.0	5490.2	33.8	16247.7
Offshore circalittoral coarse sediment	7085.8	49.4	27.1	0.2	5.3	0.0	7108.9	49.6	14335.0
Infralittoral sand	4917.1	68.2	1.2	0.0	1.6	0.0	4917.9	68.3	7205.6
Circalittoral mud	2799.8	71.7	71.4	1.8	0.4	0.0	2827.1	72.4	3903.7
Circalittoral mixed sediment	1373.4	47.0	27.0	0.9	0.3	0.0	1379.1	47.2	2920.9
Unknown (Na)	1465.9	51.8	0	0	0	0	1465.9	51.8	2829.5

Offshore circalittoral mixed sediment	1208.8	60.7	1.0	0.1	0.2	0.0	1209.9	60.8	1990.6
Infralittoral coarse sediment	845.8	67.7	0	0	0.1	0.0	845.8	67.7	1248.9
Infralittoral mud	279.7	50.4	0.0	0.0	0	0	279.7	50.4	554.9
Infralittoral mixed sediment	12.6	22.7	9.8	17.7	0	0	17.0	30.6	55.6

Table A5.4 Overview of abrasion, removal and physical loss for OSPAR reporting region L.2.2.7 and by MSFD habitat type. There is no data included on removal by aggregate extraction from Norway EEZ. All areas that are assigned as loss are excluded from the physical disturbance assessment. A value of 0.0 means larger than zero and smaller than 0.05.

Habitat	Abrasion (km2)	Abrasion (%)	Removal (km²)	Removal (%)	Sealed loss (km²)	Sealed loss (%)	Cumulative disturb-ance (km²)	Cumulative disturb-ance (%)	Total area (km²)
Total region	166131.2	47.4	4.3	0.0	111.7	0.0	166131.2	47.4	350345.7
Offshore circalittoral sand	78698.2	47.1	0	0	65.2	0.0	78698.2	47.1	166927.6
Offshore circalittoral mud	57165.1	81.8	0	0	41.3	0.1	57165.1	81.8	69919.0
Upper bathyal sediment	14423.2	23.8	0	0	0.0	0.0	14423.2	23.8	60633.5
Offshore circalittoral coarse sediment	8416.9	35.2	0	0	4.5	0.0	8416.9	35.2	23917.5
Unknown (Na)	224.7	3.6	0	0	0.1	0.0	224.7	3.6	6280.3
Circalittoral sand	3562.0	70.1	4.3	0.1	0.2	0.0	3562.0	70.1	5083.3
Offshore circalittoral rock and biogenic reef	475.9	12.2	0	0	0	0	475.9	12.2	3910.7
Upper bathyal sediment or Upper bathyal rock and biogenic reef	104.5	4.1	0	0	0	0	104.5	4.1	2552.9
Upper bathyal rock and biogenic reef	189.0	7.9	0	0	0	0	189.0	7.9	2391.6
Offshore circalittoral mixed sediment	1158.0	53.5	0	0	0.1	0.0	1158.0	53.5	2165.7

Habitat	Abrasion (km2)	Abrasion (%)	Removal (km^2)	Removal (%)	Sealed loss (km^2)	Sealed loss (%)	Cumulative disturb-ance (km^2)	Cumulative disturb-ance (%)	Total area (km^2)
Circalittoral rock and biogenic reef	170.8	10.7	0	0	0	0	170.8	10.7	1601.0
Circalittoral mud	255.3	21.6	0	0	0	0	255.3	21.6	1182.9
Circalittoral coarse sediment	383.6	41.5	0	0	0.1	0.0	383.6	41.5	923.5
Infralittoral rock and biogenic reef	56.0	6.3	0	0	0	0	56.0	6.3	891.5
Circalittoral mixed sediment	442.1	52.1	0	0	0	0	442.1	52.1	848.2
Infralittoral sand	337.7	56.2	0	0	0	0	337.7	56.2	600.9
Infralittoral mud	17.7	6.0	0	0	0	0	17.7	6.0	297.4
Infralittoral coarse sediment	50.1	33.5	0	0	0	0	50.1	33.5	149.6
Infralittoral mixed sediment	0.2	0.4	0	0	0	0	0.2	0.4	68.8

Annex 5: Technical Minutes from the Review Group on methods to assess the spatial extent and distribution of physical disturbance (D6C2) and physical loss (D6C1/C4)

- RGD6Pres
- By correspondence November 2019
- Participants: Gerjan Piet (chair), Samuli Korpinen, Miquel Canals Artigas
- ICES Expert Groups and Workshops: WKBEDPRES1, WKBEDLOSS, and WKBEDPRES2

Aim

The Review Group on methods to assess the spatial extent and distribution of physical disturbance (D6C2) and physical loss (D6C1/C4) pressures on the seabed (RGD6PRES) task was to evaluate the response from the open workshop (WKBEDPRES1, WKBEDLOSS, and WKBEDPRES2) in collaboration with the Working Group on Spatial Fisheries Data (WGSFD). The aim is to focus on whether the working groups missed important points relevant to the original request and if the conclusions are sound.

Background

Commission Decision 2017/848/EU sets out criteria and methodological standards for Good Environmental Status (GES) in relation to the eleven MSFD Descriptors. The Decision sets out the following criteria to be used for benthic habitats:

- D6C1 Physical loss (pressure)
- D6C2 Physical disturbance (pressure)
- D6C3 Adverse effects of physical disturbance on habitats (impact)
- D6C4 Extent of habitat loss (state)
- D6C5 Extent of adverse effects on the condition of a habitat (state)

The two requests together cover D6C1, D6C2 and D6C4.

Request: D6C1 physical loss pressure and D6C4 habitat loss

Advise on appropriate methods to assess the spatial extent and distribution of physical loss pressures on the seabed (including intertidal areas, where relevant) in MSFD marine waters. Demonstrate the application of the advice by providing estimates of the spatial extent of physical loss per subdivision and per MSFD broad habitat type (where possible), together with associated distribution maps. The advice will provide information on gaps in data for physical loss activities/pressures and/or habitat types and recommend key methodological improvements which may be needed.

This request should:

1. Identify which are the main activities responsible for physical loss pressures, based on the uses and activities listed in MSFD Annex III (Directive (EU) 2017/845) or subtypes thereof, and distinguishing

these from activities that cause physical disturbance or which may lead to both loss and disturbance, accounting for potential (sub)regional differences;

2. Based on the definitions provided in the GES Decision, provide operational definitions of physical loss and physical disturbance which are relevant to the different activities causing each type of pressure, and to the different habitat types, and drawing from ICES advice on D6C2 (a separate ICES request);
3. Build upon the methods developed under the Regional Sea Conventions (e.g. HELCOM's SPICE) and Water Framework Directive, where appropriate, and take account of available data (e.g. habitats data in EMODnet);
4. Recommend appropriate methods to assess the distribution and extent of physical loss to the seabed, which should:
    a. Encompass the main activities contributing to this pressure (including permanent physical restructuring of the coast and seabed such as by land claim, certain coastal defence and flood protection measures, construction of coastal and offshore structures, restructuring of the seabed, extraction of minerals including gravel and sand, and placement of cables and pipelines);
    b. Be applicable to all EU waters (noting subregional variations where necessary due, for example, to data availability);
    c. Be suitable for assessment of the pressure for the 6-year MSFD reporting cycle;
    d. Be operational to derive demonstration products (point 7) with available data.
5. Recommend any key improvements needed in the proposed methods and/or associated data needed.
6. Where possible, express the typical extent of hydrological changes that could be associated with physical losses to the seabed (e.g. as an estimate of the area of influence around infrastructures), especially from modelling and mapping of relevant activities and their pressures for use in criterion D7C1); Demonstrate the application of the methods to give the distribution and extent of physical loss pressure in each MSFD (sub)region
7. Provide estimates of the total extent of physical loss pressure, in km2 and as a proportion (%), per subdivision/subregion and per MSFD broad habitat type. Distinguish the proportion of the total extent of the pressure which is attributable to each activity. Provide an indication of the data precision, accuracy and likely data gaps for the areas used in the demonstration.

Overview of relevant information available in the WKBEDLOSS, WKBEDPRES2 reports

Request	Information available
1	Human activities causing physical loss are identified and listed in Table 3 and Table 5 (left column on activities). Whether they cause loss, disturbance or both is indicated. Activities are classified as causing sealed or unsealed habitat loss, and characterised by the time lag for the physical loss to occur (instant/intermediate/ long). Seven EU ecoregions (Baltic Sea, Celtic Seas, Belgian EEZ, French Bay of Biscay (BoB), Romanian EEZ in the Black Sea, and Mediterranean Sea) have been considered. All of the activities causing loss were present in each of the 7 regions, with a few exceptions at present. Examples are provided from the Black Sea and the North Sea. <u>Specific comments:</u> It is to be noted that sewer pipes on the seafloor or in shallow trenches also cause loss and disturbance leading to the sealing of habitats with time lags ranging from instant for losses to long for disturbance. Sewer pipes of various types are common occurrence in many shallow areas adjacent to the coast (e.g. in the Mediterranean Sea). Waste treatment and disposal is identified as NDR, whereas there are examples showing that this activity can lead to seabed loss and disturbance, as illustrated by the dumping of mine tailings on several coastal sites in Europe including some Norwegian fjords (Koski, 2012), the discharge of

Request	Information available
	red mud from aluminium processing in the Gulf of Lion in France (Dauvin, 2010; Fontanier et al., 2014; Boury-Esnault et al., 2017; Fabri et al., 2017) or Antyjkira Bay in Greece (Poulos et al., 1996), or the disposal of coal fly ash and polluted industrial waste in the Eastern Mediterranean Sea (Kress et al., 1996, 1998; Herut et al., 2010). Extraction of salt, which requires infrastructure in coastal water and causes sealing of habitat, is not mentioned in relation to Physical loss. The fish and shellfish harvesting can cause loss (as correctly mentioned in the report) but it is unclear how to differentiate this, in practice, from disturbance. Bottom trawling, especially in soft bottom bathyal habitats, may lead to permanent loss involving major modifications of the original seafloor morphology (e.g. by meters to tens of meters in the vertical direction extending along 10’s to 100’s of square kilometres or even more according to the size of fishing grounds). This leads to complete restructuring of the original seascape, involving the formation of artificial contour-parallel terraces and the modification of natural seafloor drainage patterns. Morphology change causes change of sedimentation patterns. Recovery from those changes is impossible in practical terms (ref. Puig et al., 2012, Nature). This view is aligned with Commission Decision (EU) 2017/848, where it is noted that physical loss may also arise from permanent changes in seabed morphology, but may conflict with the WKBEDLOSS view that has constrained the definition of physical loss to EUNIS level 2 habitat change only. That’s a matter that could be worth reconsidering. According to WKBEDPRES2, there may be other pressure-activity combinations assessed nationally that lie beyond regional assessment, but are regarded as important when viewed at the smaller national (e.g. boating anchoring abrasion) or local scale; e.g. munition on-site demolition, firing ranges and pressures related to explosions (dumping grounds or military activities), or pressures related to research activities (abrasion and loss due to ballast weights, sampling, etc.).
2	In WKBEDLOSS, physical loss was defined by one sentence where the key term is ‘permanent alteration’. In WKBEDPRES2, the definition was sharpened to distinguish between ‘sealed physical loss’, ‘unsealed physical loss’ and ‘loss of biogenic habitat’. The definition mentions that ‘permanent alteration’ means that human intervention is required to allow habitat recovery. In case of ‘sealed loss’ this is obvious, but in case of ‘unsealed loss’ and ‘loss of biogenic habitat’ more questions arise of the time scale: very few things are permanent in this world, especially in nature. The COMDEC defines it as follows: “*Physical loss shall be understood as a permanent change to the seabed which has lasted or is expected to last for a period of two reporting cycles (12 years) or more*”. This gives an entirely different time horizon as ‘permanent’. As the COMDEC allows for longer time scales, it is probably not a legal problem, but in relation to activity impacts, one should operate with more practical time scales such as 12-100 years. The request asks for definitions “*which are relevant to the different activities […], and to the different habitat types*”. This is actually lacking from both reports as only a general definition is given. Clearly the EC request aims towards a practical approach where ‘loss’ could mean different things for different habitats (which have different recovery times if any) or even different activities (for reasons that are not always self-evident). The habitat-specific definitions become clearer by some examples: a loss of hard bottom reef does not return by its own means, but a more mobile substrate slowly redistributes over the seabed. In practice, one could define ‘permanent alteration’ with habitat-specific time scales varying from 12 years to more (e.g. 100). The habitat-specific loss definition clearly has scientific value and is lacking from the report. We would recommend that EUNIS2-specific time scales are explored based on their features (abiotic or biotic).
3	The title of the report itself refers to “methods to operational data products”. It is understood that methodologies need to be quantitative. Five generic steps are identified to assess sealed and unsealed physical loss, whereas three steps are identified to assess the loss of biogenic habitat (cf. data flows). How to distinguish unsealed physical loss from disturbance is also addressed.

Request	Information available
	Advised (Table 5) and potential (Table 7) data sources are considered within section 4 on "Description of data flows", where the need of applying footprints and buffer zones to point location and lines is addressed together with a proposal for data formats and attribute information (section 4.1.2). For activities causing "sealed" physical loss it is recognised that the relevant licensing authorities within Member States will hold most sealed loss data. For some activities, existing regional or European-wide datasets from Member States can be used too. It is noted that methods for assessing unsealed loss resulting from sealed loss have been developed (O'Hara Murray and Gallego, 2014), but how such model results relate to loss as defined in WKBEDLOSS is, as yet, unclear. Both for sealed and unsealed loss national data calls could be an option or, if not possible, data can be extracted from national reporting through RSCs, and also from EMODNET. Examples are provided for specific cases. Data flows and associated methods are provided for biogenic habitats as well (section 4.3).
4	The report gives practical examples of assessment methods for sealed and unsealed seabed in different marine regions. Referring to points a), b), c) and d) in this request (see above), items in a) are considered to variable extents in the report. For b) it is assumed that the methods are applicable to all EU waters even though data availability could be an issue in some subregions. Concerning c), the methods are suitable for assessment of the pressure for the 6-year MSFD reporting cycle. Finally, for d) the methods are operational and demonstration products could be derived (see examples in the report itself).
5	The report provides step-wise methods for sealed seabed, unsealed seabed and biogenic habitats to carry out physical loss assessments. In that respect, the report recommends an improvement to previous methods (e.g. SPICE). <u>Specific comments:</u> The data needed for the assessments could be obtained from national data calls or, if not possible, they can be extracted from national reporting through RSCs, and also from EMODNET and eventually other databases and portals. Crossing high-resolution multibeam bathymetry data with VMS and AIS data is needed to assess large-scale morphological change (and subsequent loss) in soft bathyal habitats due to recurrent bottom trawling. It is unclear if the needed high-resolution multibeam bathymetry data could be obtained from existing databases and portals to the required extent.
6	The extent of hydrological changes is not addressed in the report. Local and subregional examples of the application of the methods are included (Black Sea, North Sea, for renewable energy infrastructure, and for extraction of oil and gas) but not at the scale of each MSFD (sub)region. Examples of hydrographical change pressure causing physical loss were given for seabed around offshore structures.
7	Two case studies are presented for Romanian waters and Belgian waters. In both cases, the loss was also attributed to different activities. The report did not cover the marine regions/subregions and did not provide indication of data precision, accuracy and likely data gaps.
Additional observation	Likely related to the request #2 (definition of loss): the WKBEDLOS report builds on the assumption that the physical loss is assessed only on EUNIS level 2, but WKBEDPRES2 correctly adds that '*…activities/pressures [can] have a disproportionate effect on specific biological habitats (EUNIS higher level 4+)*' and states that these can be assessed on Member State level. It should be stressed that the biotic components should not be left out of the definitions of physical loss. On the other hand, one can argue that the biogenic habitats on EUNIS 2 level can contain relatively many substrate-forming species, but there is no clear definition which habitats could

Request	Information available
	be counted into these. In this report, it is understandable that the focus is in the broader picture, but I would still recommend adding text explaining how loss of biologically defined habitats could be assessed. This could be added to the definitions section where habitat-specific definitions are presented.

Request: D6C2 physical disturbance pressure

Advise on appropriate methods to assess the spatial extent and distribution of physical disturbance pressures on the seabed (including intertidal areas) in MSFD marine waters. Demonstrate the application of the advice by providing estimates of the spatial extent of physical disturbance per subdivision and per MSFD broad habitat type (where possible), together with associated distribution maps. The advice will provide information on gaps in data for physical disturbance activities/pressures and/or habitat types and recommend key methodological improvements which may be needed.

1. Identify which are the main activities responsible for physical disturbance pressures, based on the uses and activities listed in MSFD Annex III (Directive (EU) 2017/845) or subtypes thereof, and distinguishing these from activities that cause physical loss;
2. Compare the use of VMS and AIS data, and associated data required to determine fishing effort and type, such as fishers' logbooks, in the context of use for MSFD D6 assessments. This should include a side-by-side comparison against a number of parameters, including source of the data (who holds the raw data), availability (e.g. legal requirements, including vessels to be covered), accessibility (including any costs, restrictions such as due to data sensitivity, ease of access), use (e.g. restrictions on its release), spatial coverage in European waters, temporal coverage (historic, and within year), resolution (spatial granularity), accuracy, technical requirements for processing (to define when vessels are physically disturbing the seabed), resources needed (e.g. technical expertise, time per unit area). The comparison should include maps showing the distribution of bottom-fishing activity from the two data sources for the same time period, indicating where the distribution overlaps and where not, with an associated quantification of this (e.g. number/proportion of grid cells per subdivision for AIS only, VMS only and both) and explanations for any differences. Note: this work will be carried out in close collaboration with EMODnet and JRC Bluehub
3. Advise on the relevance of distinguishing surface and subsurface abrasion for different human activities (including dredging, depositing of materials, extraction of minerals, fish and shellfish harvesting), given that the demonstration advice for fishing impact (ICES advice sr.2017.13) only used surface abrasion to assess benthic impact.
4. Advise on the benefits of knowing the variation and trends in the data during a six-year assessment periods (e.g. for environmental status or management purposes), and on the most appropriate spatial resolution for the data (e.g. in relation to spatial variation in the broad habitat types);
5. Take account of methods in Regional Sea Conventions (e.g. HELCOM's SPICE), RMFOs and available data (e.g. habitats data in EMODnet);
6. Recommend appropriate methods to assess the distribution and extent of physical disturbance to the seabed, which should:
   a. Encompass the main activities contributing to this pressure (including dredging and depositing of materials, extraction of minerals, and use of bottom-contacting fishing gear per metier;
   b. Be applicable to all EU waters (noting subregional variations where necessary due, for example, to data availability);
   c. Be suitable for assessment of the pressure over a 6-year MSFD reporting;

   d. Express the intensity of the pressure, where appropriate (e.g. as needed to assess adverse effects under D6C3 and D6C5);
   e. Be operational to derive demonstration products (point 8) with available data.
7. Recommend any key improvements needed in the proposed methods and/or associated data needed, such as the data coverage for smaller coastal fishing vessels and the spatial scope of fishers' logbook data
8. Demonstrate the application of the methods to give the distribution and extent of physical disturbance pressure for each MSFD (sub)region. Provide estimates of the total extent of physical disturbance pressure, in km2 and as a proportion (%), per subdivision/subregion and per MSFD broad habitat type. Distinguish the proportion of the total extent of the pressure which is attributable to each activity, including the different fishing metiers separately. Provide an indication of the data precision, accuracy and likely data gaps for the areas used in the demonstration.

Overview of relevant information available in the WKBEDPRES1, WKBEDPRES2 reports

Request	Information available
1	For each pressure, key activities (green highlight) in the assessment process were identified for each of the regional seas along with lesser activities still thought to be important (yellow highlight), either due to their severity or areal extent (Tables 2.1 to 2.4). For each physical pressure related to physical disturbance and loss (abrasion, removal, deposition and sealing), the same activities across the regional areas were judged to cause the most widespread/significant effect, although their magnitude is likely to be variable between the regional areas. No formal assessment was conducted for the prioritisation. This is now entirely based on expert judgement. <u>Specific comments:</u> In some cases, understanding disturbance and loss as a continuum is a wise approach as disturbance can lead to loss in certain circumstances, especially for highly sensitive habitats (cf. section 2.1 in WGBEDPRES report). Examples of this are aggregate extraction or bottom trawling, where, if severe or recurrent enough or of sufficient duration, may remove a surface sediment type (marine soil) exposing a different subsurface sediment type or lead to smothering and ultimately sealing of areas by sediment deposition.
2	This is the core of chapter 3 of WKBEDPRESS2 report, where all key points are adequately addressed. This chapter is specifically focussed on fishing activity, which is a major cause of physical disturbance (via abrasion) on the sea floor in EU waters. For the North East Atlantic and Baltic Sea there is an annual ICES data call for VMS/logbook data to all ICES/EU countries. This allows standardizing, harmonizing and aggregating the different national datasets. The ICES datacentre has a workflow to calculate swept area ratios (SAR) based on hours fished, average fishing speed and gear width. The VMS/logbook data call requests that data are aggregated on the 0.05 degrees c-squares level (corresponding to 15 km2 at 61 °N); this resolution was chosen to reflect the ping rate and the normal speed of a vessel during fishing activities, and reduces the possibility that a vessel can traverse grid cells without being recorded. Data confidentiality can cause problems in the use of VMS data if individual vessels can be identified from the data or maps. This problem is exacerbated at the edge of fishing areas or where finer resolutions in aggregated data are required. WGSFD suggested that SAR is not considered sensitive information that can relate back to an individual vessel. However, if steps towards higher data resolutions are taken in the future, issues around data confidentiality should be considered. AIS data sources are identified (e.g. in WGSFD 2019 report) and the difficulties and limitations to access to those data are highlighted. It is to be noted that the primary purpose of AIS is improving

Request	Information available
	maritime safety. Since May 2014, AIS has been compulsory for all fishing vessels larger than 15 m overall length (class A); smaller vessels can have AIS class B installed voluntarily. Data challenges when working with the AIS data include lack of gear information, irregular coverage, lack of unique vessel identifier for merging with logbook data (i.e. AIS device is identified, but not necessarily the vessel) and time zone. It is noted that AIS could be used to supplement the VMS and logbook data, but AIS is not yet a standardised product in most ICES countries (cf. Table 3.1). An AIS North Sea case study is presented for 2017 with maps showing differences between the spatial distributions based on AIS/fleet register data and based on ICES VMS/logbook data (cf. Fig. 3.1). It is concluded that in general, AIS data underestimate fishing activity, showing lower maximum fishing hours. For example, comparison shows that in the central North Sea, away from the coastlines, registrations based on AIS data are missing. In some cases the maps show a misclassification of gears in the AIS/fleet register data. It is also concluded for fisheries assessment on a regional scale that AIS data should be merged with logbook at a national level to minimise errors. However, issues relating to vessel ID to ensure correct coupling with logbooks remain a major restriction in their applicability. Clearly, in regions where VMS/logbook data are available, the VMS data gives a more reliable data product, even though the frequency position data is lower than AIS. Also, several case studies around Europe where AIS data have been used successfully at a local scale are mentioned. It is noticed that raising methods applied locally to a regional scale is still problematic. A cost benefit summary of methods to improve the assessment of the extent of fishing activities is presented (cf. Table 3.2) together with some recommendations (see point 7 below).
3	This is the focus of section 4.4 of the WGBEDPRES2 report. Surface abrasion is defined as the damage to seabed surface features (top 2cm), and subsurface abrasion is the penetration and/or disturbance of the substrate below the surface of the seabed (below 2cm). The seabed abrasion pressure and physical disturbance caused by mobile fishing gears needs to take into account the penetration depth of the gears. For visualisation on maps, separating abrasion into two classes (surface and subsurface) may be useful, but the assessment of the pressure will be more accurate if the actual penetration of each gear (or gear component) is used to quantify pressure, and when penetration depth dependent depletion is used in impact assessment (as in the PD assessment method). An alternative way of presenting abrasion pressure that takes account of both the footprint (SAR) of the fisheries using different gear types and the depletion (d) of the gear used, would be to sum the product of SAR and d for all different gear types used. This product would directly correlate with the abrasion pressure by mobile fishing. For the HELCOM and OSPAR areas, ICES already provides SARs both as surface and subsurface components. It is noticed that the combination of these two categories may benefit future assessments. <u>Specific comments:</u> The proposal to use the actual penetration of each gear sounds promising and is considered an improvement to the current use of surface and subsurface. In a similar way that the soil layer on land plays a pivotal role as growing substrate and for ecosystem functioning, including biogeochemical exchanges, there is a soil layer on the seafloor that plays an equivalent role. The depth of subsurface abrasion directly relates to the potential destruction of marine soils and, therefore, measuring it will allow for better-informed assessments. Likely, this is relevant to the recovery potential (or reversal of loss) of benthic ecosystems too. Whenever possible, crossing subsurface abrasion depth and intensity with ecosystem recovery could provide new valuable clues to address this issue.
4	Temporal resolution is adequately addressed in WKBEDPRES2 Chapter 4.6, whereas spatial resolution is adequately addressed in WKBEDPRES2 Chapter 4.5. Having trends during 6-year cycles allows assessment to:

Request	Information available
	Identify increases or decreases of the pressure. Identify the existence of episodic pressures. Evaluate the effectiveness of management measures. If there is potential for recovery and the pressure is variable in space and time, taking account of variations in pressure between years will help to get to most accurate estimate of impact. If no recovery occurs, or the pressure is constant in space and time, taking account of temporal variation in pressure over time will not make a difference in assessing the impact. Therefore, impact assessments for all pressures, except sealing resulting in loss, would benefit from taking account of variations in the pressure. The distribution of fishing and aggregate extraction effort becomes less patchy and more homogeneous over longer time scales, within cells and between cells. Evaluating pressures over longer timescales will therefore result in a higher, and probably more realistic, estimate of the impact of these activities. Pertaining to the most appropriate spatial resolution, the VMS/logbook data call requests that data are aggregated on the 0.05 degrees c-squares level (corresponding to 15 km2 at 61 °N) in ICES outputs; this resolution was chosen to reflect the ping rate and the normal speed of a vessel during fishing activities, and is intended to reduce the possibility that a vessel can traverse grid cells without being recorded. It is advised to step towards higher data resolution in the future (i.e. to 0,01 degrees c-squares as a general rule). Using interpolation methods or increasing the ping rate of tracking systems, primarily VMS, could help to increase resolution. This would allow relating pressures to habitat distribution and sensitivity, as there are often several habitats within a single 0.05 degrees c-square. This will ultimately lead to better assessment of pressures. Specific comments: Current practice is that pressure data are usually collected on a yearly basis through ICES data calls. Aggregated data over the whole year prevent analysis of any seasonality in spatial patterns including pressures that might have a pronounced seasonal character in some ecoregions and habitats with seasonal patterns in the benthic community. Wherever seasonality can be considered relevant, then seasonal spatial distributions are required. Seasonally resolved data may be required to assess impact on ecosystem components with seasonal spatial distributions. Note that this is recognised in WGBEDPRESS1 report, page 32.
5	Regional activities are explicitly addressed in section 2.3 of the WGBEDPRES2 report for the four major pressures identified (abrasion, removal, deposition and sealing). Methods for abrasion assessment are summarized for the relevant regions in tables 2.1, 2.2, 2.3 and 2.4 of the same report. Abrasion resulting largely from fishing is assessed from the same methods in all five regions considered. Specific weaknesses refer to the lack of knowledge on parameterising/modelling abrasion from turbulence or anchoring. Similarly, there is no methodology available to assess the extent of abrasion due to static gears, which may be important in countries with large, small scale fisheries (SSF). This also applies to aggregate extraction, the construction phase of structures, and dredging, all of which have relatively small footprints when assessed at the (sub)regional scale. Removal is assessed similarly in all regions but not exactly the same. It is mostly caused by aggregate extraction, which is much less extensive in the Mediterranean and Black Seas, where information is not available. Deposition is dominated by dredge disposal in all regions. Pressure data on deposition to depict positioning/extent beyond the position of the vessel is available from only a few Member States. It is noted that the deposition of sediments after resuspension (e.g. from bottom-contacting fisheries) has not, as yet, been modelled as there is no agreed method, and its incorporation into regional assessments is unlikely despite it extending beyond the activity footprint. Sealing is mostly caused by the placement of permanent structures as part of a variety of activities. The methodological approach to data collection for sealing and its assessment is similar in all regions. A point relevant to all the pressures above is the need for better mapping products that relate to pressure layers. EMODNet maps with MSFD Benthic Broad Habitat Types, with respect to accuracy

Request	Information available
	and resolution, particularly from areas that have been widely modelled rather than sampled, should not just be seen as a finished product, with future efforts needed to improve accuracy, particularly through groundtruthing.
6	The most significant interactions (green highlights in the overall tables within the report) were further considered in a more detailed regional analysis that looked at the availability of data, relevant metrics, methods to assess the pressure, and data flows, as well as the identification of gaps and potential limitations (cf. section 2.4 of WGBEDPRES2 report, and tables 2.5, 2.6, 2.7 and 2.8 therein). These are: Abrasion caused by mobile bottom contacting fishing gears (cf. Table 2.5). Removal caused by aggregate extraction (Table 2.6). Deposition caused by disposal of (dredged) material (Table 2.7). Sealing caused by physical structures (Table 2.8). Impact can be calculated for abrasion (cf. section 5.3.1 of WGBEDPRES2 report). For removal (cf. section 5.3.1 of WGBEDPRES2 report) the intensity of the pressure is duration expressed in minutes, which may not be the most appropriate metric to calculate impact. Volume would be better but is presently limited by a lack of detailed, harmonised reporting of aggregate extraction activities by Member States. Standard operational workflow is still required. There is no method available for deposition (cf. section 5.3.3 of WGBEDPRES2 report). Intensity of the pressure is not relevant for sealing. However, at one level where the substrate is essentially the same as the placement material (concrete vs bed rock) it may be argued (under certain conditions) that this would not represent a physical loss, since the colonising community would essentially represent the pre-impacted state. The impact therefore should be determined by assessing how different the resulting benthic community state is compared to its pre-impacted condition. Overall, the methods to assess the distribution and extent of physical disturbance to the seabed encompass the main activities, are potentially applicable to all EU waters with explicit references to data gaps and availability where deemed relevant, are suitable for assessment of the pressure over a 6-year MSFD reporting, express the intensity of the pressure, and are operational to derive demonstration products with available data. The demonstration assessment in chapter 5 of WGBEDPRES2 report shows the preferred methodologies for one region, namely the North Sea.
7	Several key improvements were mentioned in the reference documents: spatio-/temporal scale, VMS or AIS, and coverage of the fleet including small vessels. These are considered in more detail below: ICES, which is collecting VMS data for the Baltic Sea and the Northeast Atlantic, indicates that one data gap apparent in VMS data is that it is only mandatory for vessels larger than 12 m (overall length) since 2012 and the interval between positions is recorded at a maximum of 2 hours (varying between 15 minutes and 2 hours on EU level). Improved spatial resolution of aggregated VMS data from current 0,05 degrees c-squares to 0,01 degrees c-squares is suggested. Data aggregation on a 0.01 degrees resolution without using interpolation would require the ping rate to be increased accordingly with a five times higher frequency. In the proposal for amending the fisheries control regulation (COM/2018/368 final) it is stated that, “All vessels including those below 12 metres’ length must have a tracking system”. If this proposal is approved, it would greatly improve the ability to document fishing pressure from SSF from vessels below 12 meters (overall length). The ICES VMS/logbook data call does not cover the Mediterranean

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	Sea and Black Sea regions. Additionally, in these regions, a large proportion of the fleet is below 12 meters, and does therefore not currently have VMS on-board. <u>Specific comments</u>: Need to homogenise spatial resolution for VMS data in all EU ecoregions. There is a need to implement the use of VMS to fishing vessels < 12 m length in all EU regional seas. It is necessary to solve the problems in accessing VMS data in some countries, and confidentially issues that are directly related to spatio-temporal resolution of the data. Mediterranean EU MS are not submitting any VMS data. Seasonal spatial distributions accounting for seasonal benthos dynamics might improve future impact assessments. Specifics of different fishing gear to be integrated in swept area ratios (SAR) as estimated by WGSFD. Technological creeping to be considered too. Benthic habitat maps to be produced at EU scale following common methodology and with equal resolution (i.e. there is a lack of benthic community maps from the Mediterranean Sea, for instance). Existing maps (e.g. EMODNET) to be refined both in terms of resolution and habitat discrimination. There is a need to develop an indicator equivalent to SAR for static fishing gear for which disturbance levels are currently unknown. It is, however, unlikely that this will be a major contributor to physical disturbance. Waste treatment and disposal are identified as NDR, even though sewer pipe discharges are relevant for seafloor disturbance. This is also the case for the disposal of industrial waste.
8	A comprehensive demonstration assessment is provided for the North Sea in section 5 of the WGBEDPRESS2 report, where the above-mentioned four main pressures (abrasion, removal, deposition and sealing) have been addressed. This includes quantification per physical disturbance pressure in km2 and as a proportion (%), also in relation to the total areas of the region and per broad habitat type (Tables 5.1, 5.2 and 5.3 of the referred report). The cumulative physical disturbance is also accounted for in Table 5.4 and a critical discussion on the applicability of the assessment process outlined in the demonstration is included (section 5.5 of WGBEDPRESS2 report). It is also recognised that for most ecoregions, due to lack of data - including, among others, data for the assessment and validation of community sensitivity parameters and groundtruthing of modelling -, assessment is not feasible for all the pressures examined at the spatial coverage required. The operational products reflect the direct (primary) pressures of each activity. Indirect (secondary) pressures, such as the deposition of particulates resulting from fishing and aggregate extraction, require the construction of further models and model parameters before they can be included into the assessment. <u>Specific comments:</u> Further refinements and improvements pending, the methods depicted are considered appropriate to inform on the distribution and extent of physical disturbance pressure for each MSFD subregion and for most habitats. Notwithstanding the importance of scale in habitat disturbance (and loss) as aptly pointed out in WGBEDPRES2 report section 2.6. This may be particularly relevant when the national/regional extent of the affected habitat is small and the pressure footprint proportionally large. At small scales, disturbance can lead to habitat degradation or loss, but may not be reported or assessed. The situation could eventually become critical for specific sensitive or priority habitats that should be assessed and resolved separately in the first instance. WGBEDPRES1 report recognises that some specific habitats, in particular in coastal areas, may be strongly affected at a local scale by pressures that were not ranked as being important on a regional scale, e.g. seagrass beds that may be affected by anchoring (cf. section 2.4 of WGBEDPRES1 report).

Synthesis and conclusion

The review will need to evaluate if the work has been done so that ICES can base its advice on it with regard to two EU (DGENV) special requests, one on physical disturbance pressures and the other on physical loss pressures. More specifically ICES has been requested to:

A) Advise on appropriate methods to assess the spatial extent and distribution of physical disturbance pressures and physical loss pressures on the seabed (including intertidal areas) in MSFD marine waters.

B) Demonstrate the application of the advice by providing estimates of the spatial extent of physical disturbance and physical loss per subdivision and per MSFD broad habitat type (where possible), together with associated distribution maps.

C) The advice will provide information on gaps in data for physical loss and physical disturbance activities/pressures and/or habitat types and recommend key methodological improvements which may be needed.

Based on the review our overall response to the ToRs is given below:

ToR A

The three workshops have provided the methods to do an assessment, at least in some of the

MSFD regions, of (some of) the main pressures contributing to Physical Loss or Physical Disturbance. Even though the reviewers found pressures that were not considered in the workshops these are not expected to be major contributors to Physical Loss or Physical Disturbance and hence do not prevent a first assessment of the spatial extent of physical disturbance and physical loss.

ToR B

The methodology laid out in WKBEDPRES2 for the North Sea is adequate to demonstrate the application of the advice. It was found to be generally applicable to each ecoregion and pressure type thought to have a main impact upon seabed integrity making future assessments and advice for the other ecoregions possible.

ToR C

All the major gaps in relation to the methodology applied are mentioned and adequately discussed. Key methodological improvements were proposed.