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Workshop on scoping for benthic pressure layers D6C2 – from methods to operational data product (WKBEDPRES1)

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ICES HQ, Copenhagen, Denmark

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Executive summary

The workshop on scoping benthic pressure layers D6C2 – methods to operational data products (WKBEDPRES1), chaired by Phillip Boulcott (UK, Scotland) – met at ICES Headquarters on 24 October – 26 October 2018. The workshop was attended by 24 participants from 10 countries, including representatives from DGENV, the EEA, HELCOM, OSPAR and various EU-funded projects, as well as the ICES Data Centre and various ICES Working Groups.

WKBEDPRES is part of a stepwise process to delivering advice on sea-floor integrity for the Marine Strategy Framework Directive (MSFD). In collaboration with its strategic partners, the high level objectives undertaken by ICES within the project were: 1) to identify benthic physical disturbance pressure layers available within ICES and the European and wider marine community across four EU 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 Oct); 2) to collate benthic physical disturbance pressure layer data (Oct 2018 – Aug 2019) in collaboration, using identified sources and targeted data calls; and 3) to evaluate and test operationally the application of compiled benthic physical disturbance pressure layers (WKBEDPRES2, *tbc* in Sept/Oct 2019).

WKBEDPRES1 focused on objective 1, the requirement of MSFD GES Decision criterion D6C2 to assess the spatial extent and distribution of physical disturbance pressures for each MSFD broad habitat type, within each ecoregion and subdivision. Where information on activities was missing, or where the data collected was not suitable to this task, data requirements were highlighted by workshop participants. This process necessitated input from many sources, bringing together research science, marine spatial planning, and indicator research required for the delivery of MSFD. The resultant collated information needs to be appropriate for the assessment of benthic habitats (D1) and seafloor integrity (D6) as set out in the Commission Decision (EU) 2017/848.

The scoping exercise employed within WKBEDPRES1 used expert led discussion groups, variously split according to subject, to address four ToRs laid out in the request. Where rankings of activities and pressures were required, expert judgement was relied upon. Through this process the workshop identified the main human activities relevant to benthic physical disturbance, mapped potential data sources and flows that could inform the extent of this pressure, set out criteria necessary for the assessment of physical disturbance, and examined the possible assessment units used within the assessment.

WKBEDPRES1 found that the key human activities that resulted in physical disturbance on the seabed were similar for the 4 EU regions examined, with fishing found to be the most extensive cause of physical abrasion, with aggregate extraction and dredging also of relevance in most regions but much less extensive. Data flows and quantitative methodologies for the processing of physical disturbance from bottom fishing currently exist within ICES and were deemed appropriate by WKBEDPRES1 for the purposes of assessment. These methodologies are in line with previous ICES guidance (ICES 2016, 2017), as they utilise quantitative metrics in their estimation, and are operable over different assessment units.

It is recommended that where only qualitative activity data is available, the assessment of such activities should be run in parallel to the quantitative assessment. How-

ever, further model parameterisation could enable the inclusion of additional abrasion activities into the assessment, allowing the assessment of physical disturbance activities in a cumulative manner. Smothering effects of human activities can also be included in quantitative assessment method given suitable parameterisation and the development of relevant data flows.

Prior to the second workshop, WKBEDPRES2, in August 2019, the necessary steps will be taken to collate benthic physical disturbance pressure layers using sources and targeted data calls in section 4.2-4.6. This data call will be tested within WKBEDPRES2 and within WGFBIT.

1 Introduction

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 D6C2 criterion of Commission Decision (EU) 2017/848, the spatial extent and distribution of physical disturbance pressures for each MSFD broad habitat type, within each ecoregion and subdivision, must be assessed. To meet this requirement, EU funded projects have made advances in the cataloguing of human activities and their associated pressures on the benthic environment. In light of this, the EU (DG ENV) have requested guidance from ICES that identifies human activities occurring within four EU regions, with the aim of further defining which associated pressure layers are responsible for the physical disturbance of the seabed within MSFD marine waters. The data collected are required to be appropriate to the assessment of benthic habitats (D1) and seafloor integrity (D6) as set out in the Commission Decision 2017/848/EU. Within ICES, a stepwise process occurring over a 10 month time-frame will be followed to ensure that suitable methods are identified to assess the spatial extent and distribution of physical disturbance pressures on the seabed (including intertidal areas) in MSFD marine waters. During this process ICES, in collaboration with its strategic partners, will:

1) Identify benthic physical disturbance pressure layers covering four EU regions in a workshop (WKBEDPRES1, ICES HQ 24-26 Oct), including mapping of data flow and establish criteria to ensure the practical use of the data in assessing benthic impact.
2) Collate benthic physical disturbance pressure layer data (Oct 2018 – Aug 2019) in collaboration, using identified sources and targeted data calls.
3) Evaluate and test operational application of benthic physical disturbance pressure layers in a second workshop, WKBEDPRES2 (ICES HQ Sept/Oct 2019)

The two workshop reports will be peer-reviewed. As part of this review, collated pressure layers will be tested within a benthic impact assessment context by two ICES working groups (WGFBIT and WGECO). This will build on the assessment framework (see Figure 1) and methods from previous ICES guidance to the EU (DG ENV) in 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*"

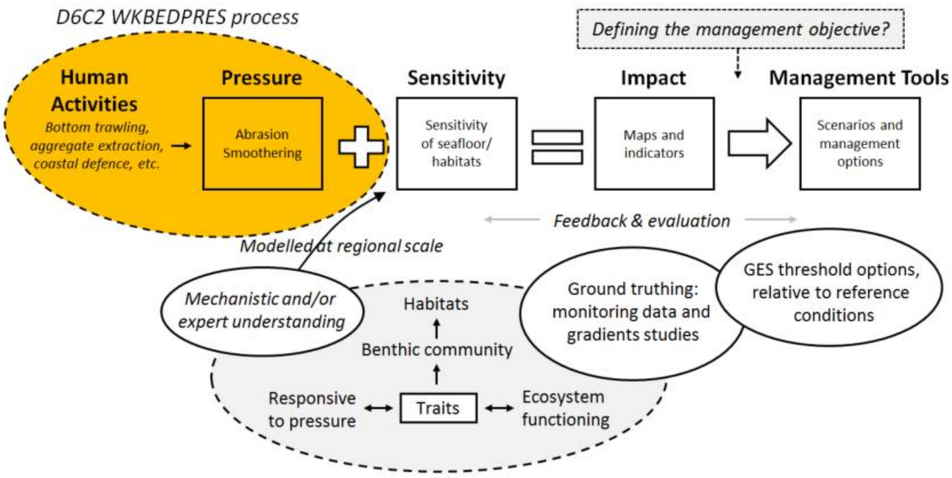

Figure 1 Conceptual diagram of the steps taken in developing management tools for assessing pressure and impact on the seafloor from human activities.

The aim of WKBEDPRES1 was to provide a wider insight into the usability of data available within ICES and the European and wider marine community for the assessment of the cumulative impact of human activities on the seabed. WKBEDPRES1 focuses on the requirement of D6C2 to assess the spatial extent and distribution of physical disturbance pressures for each MSFD broad habitat type, within each ecoregion and subdivision. Where information on activities was missing, or where the data collected was not suitable to this task, required data was highlighted by the relevant experts in the workshop. This process necessitated input from many sources, bringing together research science, marine spatial planning, and indicator research required for the deliverance of MSFD. To this end, WKBEDPRES1 was able to draw from the wide range of expertise represented by the 24 attendees from across 10 countries. This included:

- Experts involved in the national level implementation (and reporting) of MSFD, D1 and D6 for Romania (Black Sea), Greece and Malta (Mediterranean), Sweden and Denmark (North Sea and Baltic), and Ireland, Scotland and UK (Celtic and North Sea).
- Expertise from regional seas conventions (RSCs) with both experts and secretariat insight operating in the Baltic, North-East Atlantic, Mediterranean and Black Sea areas.
- Higher level guidance from an EU (DG ENV) policy officer with regard to the revised Commission Decision, 2017/848/EU, and the requirements for benthic habitats (D1) and seafloor integrity (D6).
- Insight from the EEA (European Environment Agency) on the ongoing European wide sustainability marine assessments process.
- EU and ICES experts supporting the MSFD's Marine Strategy Coordination Group via TG DATA / WG DIKE on Data, Information, and Knowledge Exchange.
- Experts working within the EEA's consortium ETC/ICM (European Topic Centre on Inland, Coastal and Marine waters) working towards providing the knowledge base required for European Union and other EEA member countries to implement marine environmental policy.

- ICES Data Centre experience with regard to establishing the data requirements and best practices to ensure TAF (transparent assessment framework). This included experience in coordinating regional scale data calls, quality assurance, data bases and data privacy/policies (e.g. VMS/logbook data, gravel extraction).
- Representation from ICES working groups with relevant expertise, including the: Working Group on Spatial Fisheries Data (WGSFD), Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem (WGEXT), ICES Data and Information group (DIG), Working Group on Integrated Assessments of the North Sea (WGINOSE), Working Group on Economics (WGECON), Working Group on Fisheries Benthic Impact and Trade-offs (WGFBIT), and the Working Group on Comparative Analyses between European Atlantic and Mediterranean Marine Ecosystems to move towards an Ecosystem-based Approach to Fisheries (WGCOMEDA).
- Workshop attendees were able to draw knowledge from their involvement in several EU-funded/EU-wide project such as BENTHIS (e.g. Eigaard *et al*. 2016, Amoroso *et al*. 2018), EMODnet, HELCOM (TAPAS, SPICE, Baltic Boost, Baltic Scope, HASPS), EU funded OSPAR EcApRHA and Intermediate Assessment 2017 project, SYMPHONY, MERCES project (Dailianis *et al*. 2018), DEVOTES project (Smith *et al*. 2016), ODEMM (Knights *et al*. 2015), VECTORS project (Elliott *et al*. 2017), MEDTRENDS Project (Piante & Ody 2015), MEDCIS Project, MSP projects (various countries and EU regions) shown on msp-platform.eu, EU MINOUW EU H2020 project (VMS data in western Mediterranean countries), and global projects such as Trawling Best Practice: https://trawlingpractices.wordpress.com

Photo of WKBEDPRES1 participants

This WKBEDPRES1 report begins with an exploration of the main human activities affecting the seabed (including the intertidal area) for each MSFD broad habitat type for each ecoregion and subdivisions within, ranked by importance (Chapter 2). The subsequent chapter then suggests operational ways in which to incorporate the pressures identified as having the greatest effect (fishing abrasion, aggregate dredging abrasion and smothering from a variety of activities) into a benthic assessment. Central to this is the identification of methods that express the intensity of the pressure in a way appropriate to the derivation of the cumulative of all disturbance pressures, and to express the intensity of the pressure in a way appropriate to the assessment of adverse effects under D6C3 and D6C5, both for the single pressure and the cumulative of all pressures (Chapter 3).

In Chapter 4, a description of data flows is presented for the most common human activities that cause physical disturbance within the 4 EU regions. Chapter 5 then discusses the appropriate assessment units upon which the spatial extent and distribution of physical disturbance should be assessed.

The main findings from WKBEDPRES1 are presented in Chapter 6. These findings, and the associated pressure layers that follow from them, will also be used as inputs into the advice drafting group phase of the ICES advisory committee (ACOM) process to provide an ICES response to the EU request.

2 Main pressure(s) on the seabed per ecoregion

2.1 Scoping of the main pressure(s) on benthic impact per EU ecoregion.

WKBEDPRES1 considered the physical effects of a wide range of human activities across 4 EU ecoregions, further split by regional/component seas. The scoping exercise employed by WKBEDPRES1 started from a position where all activities drawn from the revised MSFD Annex III Table 2b (Commission Directive (EU) 2017/845) classifications were initially considered. These activities were characterised and ranked by the workshop according to two different methods using various criteria drawn from the literature (e.g. Knights *et al*., 2015). The first method considered multiple metrics such as: whether the pressure resulted in physical disturbance, the area of the seabed impacted, temporal frequency, the degree of intensity, and whether the impact was acute or chronic (an acute impact was taken to be one that damages a large proportion of the feature in a single event). The rankings for the Mediterranean Sea are shown in Table 2.1.1

Table 2.1.1 Ranking of activities in the Mediterranean Sea using 5 characteristics as criteria. The top 5 activities causing physical disturbance (Di or L/Di) are shown in green according to their higher rank/outcome. Activities resulting solely in physical loss (Lo) or viewed as not directly relevant (N.D.R) to physical disturbance were not included in the ranking exercise. Rankings of the activities are based on 4 further activity characteristics (the most damaging ranking cited first); the spread of the activity within the region - Widespread (W) / Localised but Widespread (Loc-W) / Localised (Loc) /Absent (Abs); its temporal frequency - Persistent (P) / Infrequent (I) / Rare (R); the intensity of the activity in terms of the pressure exerted on the seabed -High (H) / Moderate (M) / Low (L); and whether the degree of impact damages a large proportion of the feature in a single event – Acute (A) / Chronic (C). Further criteria were also identified but were not used in the ranking: whether the activity had a Direct (D) / Indirect (I) impact or homogenising (Hom) or heterogenising (Het) effect on the substrate. Note: each activity includes various sub-activities that would/could be assessed separately (as opposed to a broad assessment of a category).

Activity	Loss or Disturbance	Area of the Seabed	Temporal Frequency	Intensity	Acute/ Chronic	Direct/ Indirect	Substrate Complexity
Fish and shellfish harvesting (professional, recreational)	Di	W	P	H	C	D	Hom
Restructuring of seabed morphology, including dredging and depositing of materials	Di	Loc-W	P	H	A	D	Hom
Extraction of minerals (rock, metal ores, gravel, sand, shell)	Lo/Di	Loc	R	H	A	D	Hom
Transport — shipping (including anchoring)	Di	Loc	P	M	A	D	Hom
Transport infrastructure	Lo	Loc	R	H	C	D	Het
Aquaculture — marine, including infrastructure	Lo/Di	Loc	P	M	C	D	Hom
Research, survey and educational activities	Di	W	R	M	A	D	Hom
Renewable energy generation, including infrastructure	Di	Abs					
Tourism and leisure infrastructure	Lo	Loc -W	P	H	C	D	Het
Coastal defence and flood protection	Lo/Di	Loc -W	P	H	A	D	Het
Land claim	Lo	Loc	R	H	C	D	Het
Tourism and leisure activities (including anchoring)	Di	Loc -W	P	L	A	D	Hom
Canalisation and other watercourse modifications	Lo	Loc -W	R	H	C	D	Het
Military operations (subject to Article 2(2))	Di	Loc -W	R	H	A	D	Hom
Waste treatment and disposal	N.D.R				C		
Transmission of electricity and communications (cables)	Lo/Di	Loc -W	R	M	A	D	Het
Marine plant harvesting	Di	Abs			C		
Hunting and collecting for other purposes	Di	Loc	P	L	A	D	Hom

Activity	Loss or Disturbance	Area of the seabed	Temporal Frequency	Intensity	Acute/ Chronic	Direct/ Indirect	Substrate complexity
Extraction of oil and gas, including infrastructure	Lo/Di	Loc	R	H	A	D	Het
Offshore structures (other than for oil/gas/renewables)	N.D.R						
Extraction of salt	Di	Loc	P	L		I	Hom
Extraction of water	Di	Loc	P	L		I	Hom
Non-renewable energy generation	N.D.R						
Fish and shellfish processing	N.D.R						
Aquaculture — freshwater	N.D.R						
Agriculture	N.D.R						
Forestry	N.D.R						
Transport — air	N.D.R						
Transport — land	N.D.R						
Urban uses	N.D.R						
Industrial uses	N.D.R						

However, due to lack of time, the availability of comprehensive spatial data (available at the time of the meeting), and remaining gaps knowledge (e.g. Dailianis *et al*. 2018), this process proved impossible to replicate with any certainty for all regional seas. Appropriate data-streams have not yet been collated within ICES (or all RSCs) that assign quantitative and/or qualitative values relating seabed impact to each and every activity by EU ecoregion. As this lack of precision made it difficult to assign precise weighting values to regional activities within the selection process, the decision was made within WKBEDPRES1 to adopt a second, simpler system of ranking based on a reduced number of criteria, albeit guided by caveats (see section 2.2). The adopted ranking system considered the extent of activity footprint (e.g. from widespread to very site-specific), its distribution within this footprint (e.g. the extent of an activity within an area of operation), and the degree of impact (severe biomass depletion/impairments to minor biomass reduction/impairments). The output from this exercise is shown for 5 regional or subregional sea areas in Table 2.1.2.

Table 2.1.2 Ranked marine activities (through expert opinion: see section 2.2) in 5 EU exemplar sub- and regional seas (Baltic Sea, North Sea, Celtic Seas, Mediterranean and Black Sea) causing habitat loss (L) or disturbance (D). Numbers denote the ranking of each activity in each region, with 1 denoting the activity that was deemed to cause the greatest amount of physical disturbance in that region. The equal = symbol shows activities were assigned an equal ranking (were scored equally in the exercise) with another activity in the same region. The top 5 activities causing pressures are highlighted in green. Activities that were judged to cause solely loss (e.g. port infrastructures) are highlighted in grey and were discounted from further consideration. N.D.R: denotes activities that are not directly relevant to D6/physical pressures and were also excluded from the ranking exercise.

Theme	Activity	Physical Loss/ Disturbance	Baltic	North	Celtic	Med	Black
Extraction of living resources	Fish and shellfish harvesting (professional, recreational)	D	1	1	1	1	1
Physical restructuring of rivers, coastline or seabed (water management)	Restructuring of seabed morphology, including dredging and depositing of materials	D	2	3	3	3	2
Physical restructuring of rivers, coastline or seabed (water management)	Coastal defence and flood protection	L	9=	2	4=	2	3=
Extraction of non-living resources	Extraction of minerals (rock, metal ores, gravel, sand, shell)	L/D	3	6=	2	6	8=
Transport	Transport — shipping (incl. anchoring)	D	4	5	11=	4	4
Transport	Transport infrastructure	L	5	4	17=	8	8=
Tourism and leisure	Tourism and leisure infrastructure	L	8=	11	12	7	6
Extraction of non-living resources	Extraction of oil and gas, including infrastructure	L/D	15	7	4=	15=	7
Cultivation of living resources	Aquaculture — marine, including infrastructure	L/D	6	16=	6=	10	11
Physical restructuring of rivers, coastline or seabed (water management)	Canalisation and other watercourse modifications	L	11=	13	17=	9	3=
Production of energy	Renewable energy generation (wind, wave and tidal power), including infra structure	Lo/Di	8=	6=	5	19=	15=
Tourism and leisure	Tourism and leisure activities	Di	10	16=	17=	5	5
Urban and industrial uses	Waste treatment and disposal	Di/ N.D.R	12	15=	7	11	9
Security/defence	Military operations (subject to Article 2(2))	Di	11=	9	9	15=	12

Theme	Activity	Physical Loss/ Disturbance	Baltic	North	Celtic	Med	Black
Physical restructuring of rivers, coastline or seabed (water management)	Land claim	Lo	9=	12=	8	14	15=
Production of energy	Transmission of electricity and communications (cables)	Lo/Di	13	10	13	12	10
Education and research	Research, survey and educational activities	Di	7	8	14	16	13
Physical restructuring of rivers, coastline or seabed (water management)	Offshore structures (other than for oil/gas/renewables)	Lo	16=	12=	6=	15=	15=
Extraction of living resources	Hunting and collecting for other purposes	Di	14=	14	16	13	14=
Extraction of living resources	Marine plant harvesting	Di	14=	17=	10	19=	15=
Production of energy	Non-renewable energy generation	N.D.R	16=	15=	11=	19=	15=
Extraction of non-living resources	Extraction of water	Di	16=	17=	17=	17	14=
Extraction of living resources	Fish and shellfish processing	Di	16=	17=	15	19=	15=
Extraction of non-living resources	Extraction of salt	Di	16=	17=	17=	18	15=
Cultivation of living resources	Aquaculture — freshwater	N.D.R	16=	17=	17=	19=	15=
Cultivation of living resources	Agriculture	N.D.R	16=	17=	17=	19=	15=
Cultivation of living resources	Forestry	N.D.R	16=	17=	17=	19=	15=
Transport	Transport — air	N.D.R	16=	17=	17=	19=	15=
Transport	Transport — land	N.D.R	16=	17=	17=	19=	15=
Urban and industrial uses	Urban uses	N.D.R	16=	17=	17=	19=	15=
Urban and industrial uses	Industrial uses	N.D.R	16=	17=	17=	19=	15=

The outcome of the second ranking exercise was sense checked against regional seas reports and assessments published by RSCs (e.g. HELCOM, OSPAR) or EU and international teams working on activity-pressure-impact and risk assessments across regions (Halpern *et al*., 2008; Korpinen *et al*., 2013; Korpinen and Andersen, 2016, Knights *et al*. 2015, Coll *et al* 2012, Micheli *et al*. 2013, Piante and Ody 2015, Goodsir *et al*., 2015, Eastwood *et al*. 2007, Kenny *et al*. 2018, Foden *et al*. 2011) and was consistent with their findings. The experts within WKBEDPRES1 are aware of various issues surrounding these assessments, including, assumptions on types of activity-impact responses and related uncertainty/knowledge gaps (e.g. HELCOM 2018, Smith *et al*. 2016, Cormier *et al*. 2018). These methods have been/are applied mostly at the generic level and at the level of very broad habitat types, as is the case in the two approaches adopted here. It should be noted that a number of assessments have also been successfully compiled which look at the overlap of pressures with major ecosystem components/groups, at the intensity of pressures and the sensitivity of specific habitats/benthic groups/traits (Knights *et al*. 2015, Eigaard *et al*. 2016, 2017, MARLIN 2017, Kenny *et al*. 2018).

The two approaches tested here point to the same top ranking activities/pressures when applied to the same regional sea (Mediterranean Sea), and are in agreement with published findings for the region by Knights *et al*. (2015 - see Figure 3, their paper). Knights *et al*. looked at a wide array of pressures (not just D6-relevant), concluding that fishing was, for all 4 regional seas, the sector posing the greatest risk ('impact risk' scores), indicating widespread and frequent impact chains with severe consequences. This was also the main finding of the second exercise. In addition, Eigaard *et al*. (2016, 2017) and Amoroso *et al*. (2018) working on numerical (VMS) extent data highlight the large areas of seabed that are being used by the sector, while Kenny *et al*. (2017) indicate an order of magnitude difference in extent/footprint between fishing and aggregates and other sectors. However, it is important that such assessments are performed at the appropriate scale, both in terms of its ecological relevance and in terms of its scale of resolution within the assessment area (Amoroso *et al*., 2018; Borja *et al*., 2014; Borja *et al*., 2016).

2.2 Guidance criteria used when ranking human activities.

<u>Physical Loss or Disturbance</u>: denotes whether an activity results in physical disturbance (Di), physical loss (Lo), both (Li,Do), or not directly relevant (N.D.R.). Those activities deemed as purely loss should not be put forward for further consideration for D6C2 but considered under criteria D6C1 and D6C4. A note on the definition of physical loss is given in Chapter 3, section 3.1 of this report. Separate pathways/elements of physical disturbance were considered with the intention of noting if an activity caused abrasion or smothering or both. Splitting the physical disturbance pressure (MSFD, Com. Dec. 2017/848/EU) to report on the abrasion and smothering pressures (MSFD prior to 2017 revision) was deemed necessary in order to account for lethal and sub-lethal effects on benthos (i.e. from mortality to growth impairment) as you move through pressure mechanisms to progressive state changes (Smith *et al*. 2016 DPSIR paper, Figure 2.1). This is further explained in section 3.2

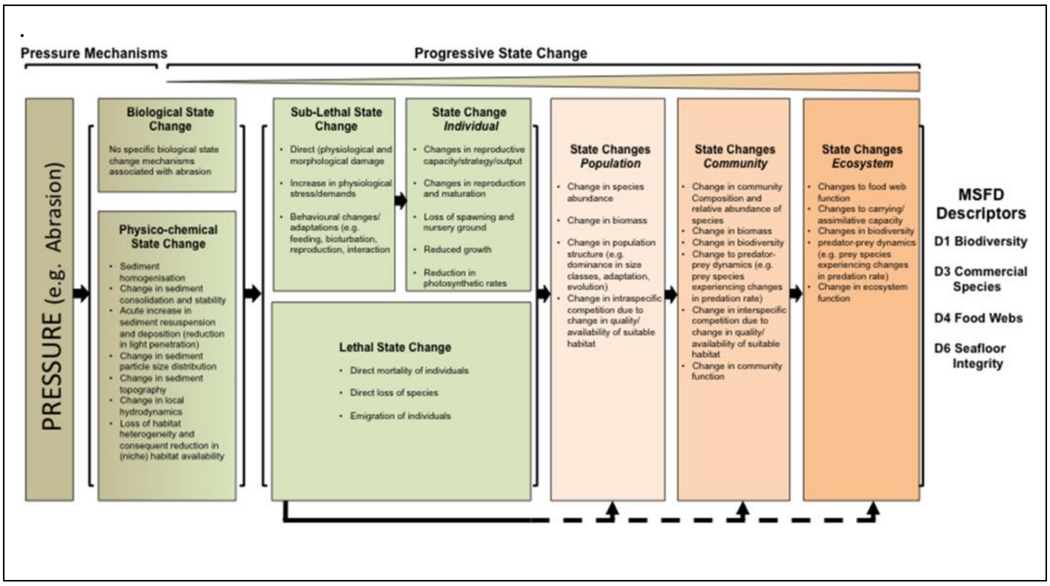

Figure 2.1. Conceptual model from Smith *et al.* (2016) showing the progression of physico-chemical and biological State changes arising from Pressures in the marine environment. The black arrows under the diagram indicate the way in which Pressure can cause a biological State change at any level: either (1) progressively through a sub-lethal response at the individual level which, over time, can lead to State changes at higher levels or (2) directly by acting at a higher level, leading to more immediate community and ecosystem State changes. Example details are given for the Pressure of abrasion from benthic trawling in a subtidal sedimentary habitat and links to the MSFD descriptors (e.g., through physico-chemical, structural or functional indicators at different levels from individual to ecosystem for descriptors D1 biological diversity, D3 commercial fish species, D4 food webs and D6 seafloor integrity).

Degree of impact: The level of impact on the seabed should be considered in the ranking; where low impact activities are ranked below high impact activities for the same level of spatial/temporal coverage. Low impact activities are those which cause minor direct mortality/damage on benthic organisms, resulting in adverse effects/impacts that lie within the bounds evidenced across cycles of natural variation. High levels of impact can be considered to have occurred where the activity results in adverse effects/impacts to the benthic habitat and its communities beyond what might be expected from natural disturbances. Issues on sensitivity/resilience/recovery of specific benthic groups (faunal or traits) and functional habitats are discussed in section 3.2 on modelling and smothering.

Areal coverage: This must consider two aspects: the spread of the activities footprint at a regional scale and its spatial coverage within the footprint. For example, for a given degree of impact, if an activity occurring throughout the region is split into small, discrete areas, this would rank lower than similarly impactful activities that have a higher areal coverage but are not as widespread across the region. Activities that occur over the entire region, and are continuously distributed throughout this area, would be regarded as having the maximum areal coverage possible.

Activity: a human action or endeavour that has the potential to create pressures on the marine environment (e.g. aquaculture or tourism); where activities are usually grouped in sectors, each one of which encompasses many activities and sub-activities (e.g. fishing, bottom trawling, etc.) (Smith *et al*. 2016, Elliott *et al*. 2017).

Pressure: the mechanism through which an activity has an actual (or potential) impact on the ecosystem (e.g. for otter trawling or beam trawling fishing activity, one pressure would be abrasion to the seabed) (Robinson *et al* 2008, Smith *et al*. 2016, ICES 2016).

Impact: The effects (or consequences) of a pressure on an ecosystem component. The impact is determined by both exposure and sensitivity to a pressure (ICES 2016).

2.3 Data flows: an overview per ecoregion

This section summarizes initial sub-group work on ecoregion-specific data flows and gaps preventing practical application. WKBEDPRES1 has summarised findings for the Baltic Sea, North Sea, Norwegian Seas, Celtic Sea, Mediterranean, and the Black Sea region. A similar overview for: Faroes, Iceland, Bay of Biscay, Iberian Coast, and Macaronesia would require further input beyond the expertise within WKBEDPRES1. Based on feedback, all regions can be revised at a later stage in the ICES process.

Baltic Sea

Activity: Bottom trawling
Data flows: VMS per vessel to national agency, linked with logbook and aggregated to ICES, to processed data product. Swept-area-ratio per gear type available for small cell sizes. Link to landings via logbooks often used but not directly needed unless trade-offs with catches are considered.
Describe gaps for practical use: Vessels < 12 m length don't have VMS (Vessel Monitoring data by Satellit, see section 4.1). AIS (Automatic Identification System, see section 4.5) from some vessels is available but 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.
Activity: various activities that lead to smothering by sediments
Data flows: Identification of all activities that result in release of sediments. Quantification of spatial pattern of sediment release is needed for each activity. Hydrodynamic modelling of the sediment distribution may be able to identify the location of settlement site for the sediments, thereby enabling modelling of the benthic impact of these materials on the benthos.
Describe gaps for practical use: HELCOM has some recommendations and some spatial maps of activities. None of the above information in the data flows relating to smothering is readily available. No model or parameter estimates are available to convert smothering into an estimate of the state of the seabed. Regional level perspectives may be possible. Scale of reported activities differs between the different coastal states.
Activity: Abrasion from static gears
Data flows: aerial/satellite imagery and AIS possible data flows.
Describe gaps for practical use:. Pressure impact parameters require development

North Sea

Activity: Bottom trawling
Data flows: VMS per vessel to national agency, linked with logbook and aggregated to ICES, to processed data product. Swept-area-ratio per gear type available for small cell sizes. Link to landings via logbooks often used but not directly needed unless trade-offs with catches are considered.
Describe gaps for practical use: Vessels < 15 m length do not have VMS. AIS from some vessels is available but not used at present. Benthic impact assessment methodologies are well established. Some countries (e.g. Faroe Islands, Greenland, Russia) does not supply VMS but might be derived from AIS.
Activity: Dredge disposal leading to smothering by sediments
Data flows: Identification of all activities that result in release of sediments. Quantification of spatial pattern of sediment release is needed for each activity. Hydrodynamic modelling of the sediment distribution may be able to identify the location of settlement site for the sediments, thereby enabling modelling of the benthic impact of these materials on the benthos.
Describe gaps for practical use: Some of the above information in the data flows relating to smothering can be made available. It was noted that OSPAR does collect some information on dredging and deposition of dredged material (it is not known if this data is suitable, and if made available will require further testing at WKBEDPRES2). At the moment no model or parameter estimates are available to convert smothering into an estimate of the state of the seabed.
Activity: Aggregate extraction
Data flows: Ships have a black box and licencing system. This system shows where and how much sediment has been extracted. However, the volume extracted needs to be converted into a depth of extraction: if the depth is too deep it could be considered habitat loss rather than abrasion. A model that relates depth to the fraction of fauna removed (d) and recovery rate (r) would be similar to already existing trawling impact models.
Describe gaps for practical use: A synthesis of rates of d and r for aggregate extraction activities has not been carried out, although lots of individual studies may exist (but may be company owned).

Norwegian Seas

Activity: Bottom trawling
Data flows: VMS per vessel to national agency, to ICES, to processed data product. Swept-area-ratio per gear type available for small cell sizes. Link to landings via logbooks often used but not directly needed unless trade-offs with catches are considered.
Describe gaps for practical use: Russia does not supply VMS. AIS is problematic because of low satellite coverage.
Activity: Aquaculture leading to the release of smothering material in fjords
Data flows: Identification of all facilities that result in release of sediments. Quantification of spatial pattern of sediment release is needed for each point source. Hydrodynamic modelling of the sediment distribution may be able to identify the location of settlement site for the sediments, thereby enabling modelling of the benthic impact of these materials on the benthos.
Describe gaps for practical use: EMODnet supplies locations but intensity and active time period of aquaculture activity is not always known. Hydrodynamic models to predict where the material ends up exist in some areas but not others. The running of, and output from, these complex and varied models can make these products challenging to use on a regional scale. Model or parameter estimates are available to convert smothering into an estimate of the state of the seabed but these are currently not very sophisticated and well-evidenced.

Celtic Sea

Activity: Bottom trawling
Data flows: VMS per vessel to national agency, linked with logbook and aggregated to ICES, to processed data product. Swept-area-ratio per gear type available for small cell sizes. Link to landings via logbooks often used but not directly needed unless trade-offs with catches are considered.
Describe gaps for practical use: Vessels < 12 m length don't have VMS. AIS from some vessels is available but 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.
Activity: Dredge disposal leading to smothering by sediments
Data flows: Identification of all activities that result in release of sediments. Quantification of spatial pattern of sediment release is also needed. Hydrodynamic modelling of the sediment distribution may be able to identify the location of settlement site for the sediments, thereby enabling modelling of the benthic impact of these materials on the benthos.
Describe gaps for practical use: Some of the above information in the data flows relating to smothering can be made available. It was noted that OSPAR does collect some information on dredging and deposition of dredged material (it is not known if this data is suitable, and if made available will require further testing at WKBEDPRES2). Improvements would be required to get a more accurate idea of spatial release locations. At the moment no model or parameter estimates are available to convert smothering into an estimate of the state of the seabed.
Activity: Aggregate extraction
Data flows: Ships have a black box and licencing system. This system shows where and how much sediment has been extracted. However, the volume extracted needs to be converted into a depth of extraction. If the depth is too deep it could be considered habitat loss rather than abrasion. A model that relates depth to the fraction of fauna removed (d) and recovery rate (r) would be similar in mechanics to trawling impact models already developed.
Describe gaps for practical use: A synthesis of rates of d and r for aggregate extraction activities has not been carried out, although lots of individual studies may exist (but may be company owned).

Black Sea

Activity: Bottom trawling
Data flows: Black Sea EU MS (Bulgaria & Romania) are submitting some aggregated effort data to JRC. VMS data are not open access. There were no Black Sea partners involved with VMS work under the BENTHIS project. Existence/availability of log book data unknown by group.
Describe gaps for practical use: Unknown by the group. Could use AIS. Benthic impact assessment methodologies very well established, however, lack of benthic community maps (and in general spatially-explicit data).
Activity: Shipping and Leisure/tourism: boat/vessel anchoring
Data flows: aerial/satellite imagery and AIS (commercial vessels) possible data flows.
Describe gaps for practical use: Link between the activity (which is used as a proxy for abrasion) and pressure is unclear. Pressure impact parameters also require development.
Activity: Removal of aggregates/dredging
Data flows: Unknown by the group.
Describe gaps for practical use: Unknown by the group.
Activity: Abrasion from static gears
Data flows: aerial/satellite imagery and AIS possible data flows. Data flows: aerial/satellite imagery and AIS possible data flows.
Describe gaps for practical use: Pressure impact parameters require development

Mediterranean

Activity: Bottom trawling
Data flows: Mediterranean EU MS are not submitting any VMS data (raw or processed data) to JRC or other central/relevant EU agency (there is no obligation to do so). Mediterranean EU MS are submitting some aggregated effort data by geographical sub-regions to JRC (according to DCF data call). In order for ICES to be able to analyse and process the VMS data a dedicated data call should be made and a request made by DG MARE to the EU MS. EU MS that have worked with BENTHIS project have experience of processing the data and have access to confidential VMS data. They can be part of the process and process and provide the Swept-Area-Ratio per gear type for fine spatial cell sizes (e.g. 1x1 km) if requested. There is a link to landings via logbooks for fishing vessels >12 m which includes all trawlers. Data are confidential (same as with VMS), data flow is similar for VMS. However biological data from DCF can be obtained by formal requests to DG MARE (a recent example of following this approach was the MINOUW project which received VMS and DCF data although the process was slow and not uniform for all MS).
Describe gaps for practical use: The majority of coastal fishing vessels are not equipped with VMS. The spatial resolution of VMS is now much better (20 min as opposed to 2 hr ping resolution in 2014). 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).
Activity: Shipping and Leisure/tourism: boat/vessel anchoring
Data flows: aerial/satellite imagery and AIS (commercial vessels) possible data flows.
Describe gaps for practical use: Link between the activity (which is used as a proxy for abrasion) and pressure is unclear. Pressure impact parameters also require development. Some knowledge exists for seagrasses (*Posidonia* beds, area affected, abrasion effects), less knowledge on biogenic reefs and vulnerable marine ecosystems (VMEs).
Activity: Removal of aggregates/dredging
Data flows: licence/permits. Completed environmental impact assessments and AIS (relevant to the sector) could be used.
Describe gaps for practical use: Existence of log book data relating to extraction unknown by group.
Activity: Abrasion from static gears
Data flows: aerial/satellite imagery and AIS possible data flows.
Describe gaps for practical use:. Pressure impact parameters require development

2.4 Justification for the exclusion of local pressures that may be important for specific habitats

WKBEDPRES1 has listed the most important activities in each of the regional seas and ranked the pressures resulting from these. The most important activities that were identified were fishing, aggregate extraction and a variety of activities leading to smothering (i.e. navigational dredging/depositing of dredge material). These activities were identified as being the most important because they have a wide footprint, occur in the majority of broad scale soft sediment habitats in the regional seas, and contribute to the most important pressures covering up to 95% of the total surface area of EU regions/regional seas. Indicators of the impacts of these pressures, resulting from this work, will therefore be able to capture the main impacts in the main habitats in the regional seas.

Nevertheless, some specific habitats, in particular in coastal areas, may be strongly affected by pressures that were not ranked as being important on a regional scale, e.g. seagrass beds that may be affected by anchoring. MFSD requires the assessment of impacts at the EUNIS 2 level (see below section 5.1), and this level does not differentiate between such specific habitats. Therefore, such pressures may be better dealt with through an alternate management mechanism at the national level (e.g. spatial management), as MFSD requires an assessment of GES at a regional scale, which can further be sub-divided to biogeographically-relevant sub-divisions of each MSFD region or subregion. Combining the assessment of such specific habitats and activities in a regional assessment will result in the main pressures in the main habitats drowning out these more localized effects. Even though we did consider the pressures in such localized habitats, it was decided that including them in a regional assessment in the initial assessment round was not appropriate. Impacts on specific sensitive or priority habitats should be assessed and resolved separately in the first instance, although it is possible that these may be integrated into regional assessments later in the process.

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3 Benthic pressures and practical use in benthic assessment

WKBEDPRES1 listed the most important human activities in each of the regional seas and ranked the pressures resulting from these. The most important human activities that cause physical disturbance to the seafloor were identified as fishing, which causes abrasion, aggregate extraction, which causes abrasion, and a variety of activities causing smothering (i.e. navigational dredging/depositing of dredge material). In this chapter, we discuss for each of these pressures how to express the intensity of the pressure in a way appropriate to derive the cumulative of all disturbance pressures, and how to express the intensity of the pressure in a way appropriate to assess adverse effects under D6C3 and D6C5, both for the single pressure and the cumulative of all pressures. We start the chapter by defining how we distinguished physical disturbance from physical loss.

3.1 How is physical loss distinguished from physical disturbance?

The Commission Decision (EU) 2017/848 of 17 May 2017 defines physical loss and physical disturbance as:

> *"3. 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.*
>
> *4. Physical disturbance shall be understood as a change to the seabed from which it can recover if the activity causing the disturbance pressure ceases."*

Point 3 could be interpreted as any change to the benthic biota that takes more than 12 years to recover should be defined as physical loss, but point 4 conflicts with point 3 because it says that if recovery is possible, it is disturbance and not loss.

The Decision does not specify that full recovery needs to occur in 12 years, and refers to changes to the 'seabed'. If 'seabed' under point 3 is interpreted as the seabed substrate rather than the biota that live on the seabed, the interpretation becomes more straightforward: permanent changes in seabed substrate count as loss, while changes in benthic biota for which recovery is possible count as disturbance. Given that the 12 year limit was chosen based on political reporting cycles rather than ecological relevance, it seems reasonable to assume this was just chosen to represent a degree of permanency rather than a recovery time of biota.

In conclusion, the group defined physical loss as any activity that results in a permanent alteration of the habitat from which recovery is impossible, such as construction activities and changes in substrate composition after aggregate extraction. Activities that disturb benthic biota, but do not change the benthic substrate permanently, were considered as disturbance, even when full recovery would take longer than 12 years, as long as recovery to the original state can be expected given enough time. This interpretation allows a practical distinction between activities which lead to physical disturbance (D6C2) and those which lead to physical loss (D6C1), noting that activities involving infrastructures being placed in the sea or on the coast and thus leading to physical loss may also give rise to physical disturbance pressures (abrasion and/or smothering) during the construction phase, as well as to associated hydrological changes on a more permanent basis.

3.2 Benthic pressures, their data requirements, methods for practical use in benthic assessment, and future work required for operationalisation

3.2.1 Abrasion by Bottom trawling

Assessment methodologies for bottom-contacting fishing gears are well established, and ICES has provided several pieces of guidance on how to conduct benthic impact assessments (ICES, 2016, 2017a). The text here is partly based on this guidance.

From activity to pressure

Bottom trawling causes abrasion. ICES (2017a) defines swept area of bottom trawling as the cumulative area contacted by a fishing gear within a grid cell over one year. The swept area ratio (SAR, also termed 'fishing intensity') is the swept area divided by the surface area of the grid cell. 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 (ICES, 2017a; Eigaard *et al.*, 2016). The pressure also depends on the penetration depth of fishing gears, with deeper penetrating gear, such as dredges, causing a larger pressure than, for example, otter trawls that penetrate less deep into the sediment.

Spatially and temporally explicit prediction of the pressure

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. It should be noted that ICES does not have access to information on vessel position at a finer scale than this, due to national confidentiality reasons.

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. These habitat types were chosen as the Commission Decision (EU) 2017/848 of 17 May 2017 on the MSFD was not available when the expert work was undertaken.

How does bottom trawling affect the growth and mortality of benthos?

Only effects on mortality are considered within the assessment framework as no clear effects on growth have been identified. Mobile bottom gears cause mortality of benthos, ranging from 6% for otter trawls to 41% for hydraulic dredges (Hiddink *et al.*, 2017). Shorter-lived fauna have higher population growth rates than longer-lived fauna, and as a result are less affected by similar intensities of trawling (*Hiddink et al.*, 2018).

Assessment methodology

Methods for converting pressure to benthic impacts for mobile gears are very well established and are based on a synthesis of all available evidence (Pitcher *et al.*, 2017; Hiddink *et al.*, 2018; Sciberras *et al.*, 2018). A quantitative method for assessing the risks to benthic habitats by towed bottom-fishing gears is available. The 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).

Data layers

The method requires a detailed layer of SAR by mobile bottom gears on small spatial scales, as larger scales overestimate the impact (see Amoroso *et al*., 2018). Information on the sensitivity to bottom trawling is quantified based on the longevity of the benthic community, and this longevity distribution can be predicted for some regional seas based on environmental drivers.

Specifications for projects or requests to service the indicator

Limitations for rolling out this methodology for all EU regions are caused by the absence of predicted longevity distributions for regions outside the Baltic and North Sea regions. Further research is required to provide these, e.g. by analysing the drivers of longevity distributions using sample data from other regions.

It might be possible to apply this approach to static gears such as pots and gill nets, but authoritative estimates of the mortality of the benthos caused by the deployment of static gears are currently not available, and a synthesis of existing studies to estimate the depletion caused by these deployments is needed as well as a method to quantify the footprint of the fisheries.

3.2.2 Abrasion by aggregate dredging

From activity to pressure

Aggregate dredging is used for the collection of sand and gravel (Newell *et al*. 1998; Desprez 2000). Aggregate dredging typically disturbs the seabed up to about 50 cm depth per dredge activity; the dredge head penetrating to about 25 cm. The depth of disturbance can be increased due to cumulative dredging. Aggregate dredging abrasion can be described as the area affected (swept area ratio) and the depth to which the area is affected.

In the case that the winnowing of sediments leads to finer sediments replacing the aggregates (Desprez 2000), aggregate dredging may be defined as loss (there is a permanent change in habitat). In other cases, the extraction of sediments from pits may cause long-term hypoxia (and potentially loss).

Spatially and temporally explicit prediction of the pressure

Aggregate dredging occurs within spatially assigned areas. Dredging within the assigned area is sometimes chronic, dredging multiple times over the same area of seabed, but in other cases moves within the licensed area causing single disturbance events, within the licensed area (up to maximally an area of several km^2). In case of chronic dredging, the dredging drag-head may follow previous furrows. This means that to derive the area affected within a grid cell (e.g. c-square), the amount of aggregation (chronic activity) within a particular grid cell needs to be quantified.

How does it affect growth and mortality of benthos?

Mortality induced by aggregate dredging abrasion is predicted to be high due to the penetration depth of the gear and the extraction of sediment. In some cases, aggregate dredging removes, and discards, the top layer first (to harvest "clean" (non-biota) sediment). There are a large number of studies available that may allow estimating direct mortality from abrasion of aggregate dredging. Recovery dynamics may be the same as for fishing as there are still intact seabed patches available that allow for the inflow of larval recruits and the arrival of mobile adult individuals.

Assessment methodology

The population-dynamic model used to estimate trawling impact (Hiddink *et al.*, 2018) can potentially be used for aggregate dredging. There are a large number of studies available that could be used in the estimation of the mortality parameter (*d*, in the population dynamic model). Recovery dynamics may be similar to those associated with fishing as there are still intact seabed patches available that allow for the inflow of larval recruits and the arrival of mobile adult organisms.

Data layers

1) Area affected by dredge activity and the depth to which this area is affected.
2) Characterisation of the benthic community by the traits that define their vulnerability (this process can potentially follow the methodology developed for fishing disturbance).

Specifications for projects or requests to service the indicator

A synthesis 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 may be the same as for fishing. To validate this, a synthesis of existing studies to estimate relationships between dredging activity and community recovery is also required.

3.2.3 Smothering by various human activities

Smothering is caused by the release of sediment as suspended sediment into the water column which subsequently accumulates on the seabed (Spearman 2015). 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 (Newell *et al.*, 2002; Waye-Barker *et al.*, 2015). It is worth noting that some degree of sedimentation does occur naturally, while in other areas there is very little. Resilience to this pressure may thus depend on the recipient benthic community and/or habitat type.

From activity to pressure

Different activities create different amounts of sediment that need to be estimated in order to rank the activities in a continuous scale depending on the potential pressure generated (amount of sediment settling to smoother the seabed). The effects on the seabed are probably not linear, as low sediment deposition rates would be non-relevant, whereas peak rates would cause significant effects. In one extreme, we have disposal of dredge material that would generate high sediment deposition rates, on the other extreme, there are more diffuse sources of stress (like sediment run-off) that might not cause significant impacts on the fauna. 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 vs gravel would have a different effect over the faunal component (Cooper *et al.*, 2011).

The main human activities that cause smothering were identified (defined here as the generation of suspended sediment that can accumulate on the seabed):

- **Bottom trawling**, as part of the extraction of living resources, which results in the re-suspension of sediments due to the contact of the (mobile) fishing gear with the substrate.
- **Aggregate extraction** resulting in the re-suspension of sediments.
- The **construction** phase of fixed structures (wind-farms, piers, etc.) resulting in the re-suspension of sediments.
- **Shipping** (vessels operating) in shallow water - both recreational and commercial – resulting in the re-suspension of sediments due to propeller wash and pressure waves
- **Leisure activities** within shallow coastal and littoral areas (collecting, trampling etc.) affecting re-suspension.
- **Forestry and agriculture** affecting sediment run-off from land.

Spatially and temporally explicit prediction of the pressure

In order to quantify the spatiotemporal extent of the smothering pressure, there is a need to take account of (and aggregate) all the activities potentially generating suspended sediments in space and time. The map of aggregated activities should consider a temporal dimension as some activities would be continuous (e.g. fishing), whereas other activities would be a one-time event (e.g. off-shore construction), which limits the scale and severity of impact.

The spatial pattern of sediment release and subsequent sedimentation would be strongly conditioned by local hydrodynamics, as sediment deposition might occur at a distance from sediment release (Spearman 2015). Quantification of the spatial extent of pressure needs to use hydrodynamic modelling for each region (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.

How does it affect growth and mortality of benthos?

Available trawling assessment models (e.g. Hiddink *et al.*, 2018) cannot be used in their current form because these approaches only capture the effects of additional mortality on the benthos, while for smothering sub-lethal effects, for example on growth, are likely to be important, and not only mortality. In order to assess the impact level of sediment deposition, there is a need to estimate how it affects growth and mortality of benthos. Field experiments to assess mortality and growth rates over sediment deposition gradients and over habitat types should be considered, as several issues still need to be addressed:

1) The derivation of a deposition threshold for fauna mortality (mortality caused by burial), this is probably linked to organisms' traits like mobility and position in sediment (Bolam *et al.*, 2006);

2) The quantification of the increase in energetic costs because of filtering and respiration clogging up and/or dilution of edible material by inedible inorganic material;

3) The quantification of the reduction in photosynthesis in shallower areas.

This knowledge will assist the definition of an appropriate model for the benthic response to sediment deposition.

Assessment methodology

The trawling assessment model cannot be used because sub-lethal effects are likely to be important. A potential model is:

Relative benthic state (RBS) ~ pressure * sensitivity

Where

sensitivity ~ traits benthos + background sediment deposition rate + difference in sediment present vs. sediment deposited

The response of the benthic community will in such a methodology be dependent on biological traits. Candidate traits discussed are:

- Ability to photosynthesise, as sediment deposition will reduce photosynthetic rates
- Burrowing ability and mobility (ability to move away, subsurface position in the sediment or ability to burrow deeper)
- Feeding mode (suspension feeders are potentially more vulnerable due to their filtering apparatus, while deposit feeders and predators may be less affected).

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).

Data layers

1) Location of activities and amount of sediment released per activity.
2) Background levels of naturally suspended sediments affect sensitivity. Remote sensing. Data from EIAs.
3) Seabed sediment type map.
4) Hydrodynamic model to predict the movement and deposition of sediments within a region.
5) Characterisation of the benthic community by the traits that define their vulnerability.

Specifications for projects or requests to service the indicator

There is a need to conduct a review to synthesis existing studies to estimate relationships between growth/mortality and sediment deposition rates and interactions with environmental conditions. It is possible that some information produced by the Water Framework Directive is available for some activities. Depending on the level of existing knowledge, new studies should be conducted to provide information on the sensitivity of the communities (potentially linked to the biological traits of the fauna) and mortality rates. This will enable the development of a mechanistic population dynamic model that can capture the effect of sediment deposition on growth and mortality.

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4 Description of data flows

4.1 Practical steps needed for collecting pressure data

Benthic physical disturbance pressure layer data shall be collated in collaboration using identified sources and targeted data calls. As a first step towards defining practical steps that are needed in the collation of pressure data (ToR C), all activities identified as relevant to describe human activities and their associated pressures on the benthic environment are listed for each MSFD (sub-) region in Table Annex 4. To produce data flows for each activity and MSFD region, available catalogues/sources of regional specific human activities/pressures affecting the seafloor are noted. Those activities and regions where information on activities is missing, or where the data collected is not suitable to this task, are indicated and, where feasible, steps are indicated that can be taken to provide these data.

The criteria below have been adopted by WKBEDPRES as a basis for describing the practical steps needed to collect pressure data for the following benthic abrasion pressures in MSFD waters:

i) Fisheries,

ii) Aggregate extraction of minerals,

iii) Dredging & depositing of materials,

iv) Shipping & anchoring

v) Physical restructuring (Coastal defence).

These criteria have been shaped by general data principles set out by the workshop in addressing ToR B, stating that data formats selected should: make biological sense, be quantitative, have a common currency, and match a MSFD six-year policy cycle. The adopted criteria below are based on a balancing of methodological requirements, data policy considerations, data availability and data operability.

Data Criteria:

- Spatial resolution: maximum is ICES-WGSFD c-squares of 0.05 degrees (approx. 15 km^2 at 61°N latitude)
- Data security: temporal and spatial resolution should comply with EU data policies
- Pressures included: i), ii), iii), iv) and v) above
- Applicability: All EU waters:
- Temporal availability: Continuous on a yearly scale
- Compatibility with other pressures: SARs at different c-square levels/sizes that can be joined at the most course resolution
- Appropriateness for translating into impact: Can directly feed into, for example, the PD2 impact indicator (ICES 2017)
- Suitability: Fits directly into the ICES assessment methodology in 2017 advice

The adopted criteria are the result of a number of trade-offs and as such several caveats and improvement potentials were identified during the process, some of these are listed below. These caveats and improvement potentials should be kept in mind when reading the individual pressure sections on practical steps needed for data collection.

Caveats and improvements in relation to spatial resolution:

- The maximum spatial resolution is currently set at a c-square of 0.05 degrees, which follows the grid resolution of the swept area ratio from Vessel Monitoring data by Satellite (VMS) from fishing. This resolution is the limiting resolution for the confidentiality issue around VMS data. For fishing, we have some indication that assuming a uniform distribution within this size of grid cell is reasonable. Before aggregating other pressures to this c-square size, we should investigate if the same uniform assumption can be applied.
- The 0.05 degrees grid is potentially driving artefacts within the data, e.g. grids can encapsulate both water and land at the coastline and more than one habitat type.

Caveats and improvements in relation to temporal resolution:

- The temporal resolution is currently set on a yearly scale. There are a variety of arguments to suggest that lower temporal resolution would be advantageous, e.g. a quarterly or monthly scale. This is mostly related to the inherent seasonal benthos dynamics in recruitment, population structure (age, size) and in the vertical position of some benthic animals in the seabed (overwintering in deeper sediment layers). This may potentially vary the vulnerability of benthos to the pressure due to the timing of the pressure event. Besides seasonal patterns in benthos, fishing effort allocation is also seasonal; for example, due to fish migration and quotas becoming limited.
- After quantifying/synthesizing the seasonal variation of the impact on benthos, the depletion/recovery model could potentially be refined.

Caveats and improvements in relation to VMS data

- The swept area ratios (SAR) estimated by WGSFD do not integrate all the specifics of different fishing gear and do not include technological creeping. These exclusions in SAR mean that the current technique is potentially underestimating the true pressure. Several parameters are also assumed in the calculation of SAR and therefore could introduce further error: for example, we do not know the actual fishing speed, because it is not sampled, and we use modelled gear dimensions, not the observed ones. It is also possible that the valuation of landings has been treated differently by different countries, potentially introducing bias.

4.2 Collection of fishing pressure

4.2.1 Fishing pressure data

Fishing pressure data that meet the above criteria are available online at 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. Vessel monitoring systems (VMS) are mandatory on fishing vessels larger than 12 m in EU waters. From this, collected data on location and heading at predetermined time intervals (typically 1-2 hours), when coupled with EU logbook information, can be used to quantify fishing pressure/intensity for the purposes of assessing benthic fishery impacts at fine spatial resolution (ICES 2017).

As this spatially accurate data is linked to individual fishing vessels, it is commercially sensitive, and there are some considerable obstacles in making this data openly available. Currently, ICES provides aggregated data at a grid size of 0.05 x 0.05 degrees. This level of resolution has been adopted by ICES as it has been deemed acceptable by member states in terms of confidentiality.

VMS and log book data is collected and stored by the national fishery agencies. These data are submitted to ICES in response to a data calls to the national agencies (also non-EU countries). ICES aggregates all national level data received to a regional scale is Data that ICES receives is processed using standardized methods to produce data layers to describe 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). These analysed data products can be downloaded directly from the ICES web site and the data workflow is illustrated in Figure 4.2.1.

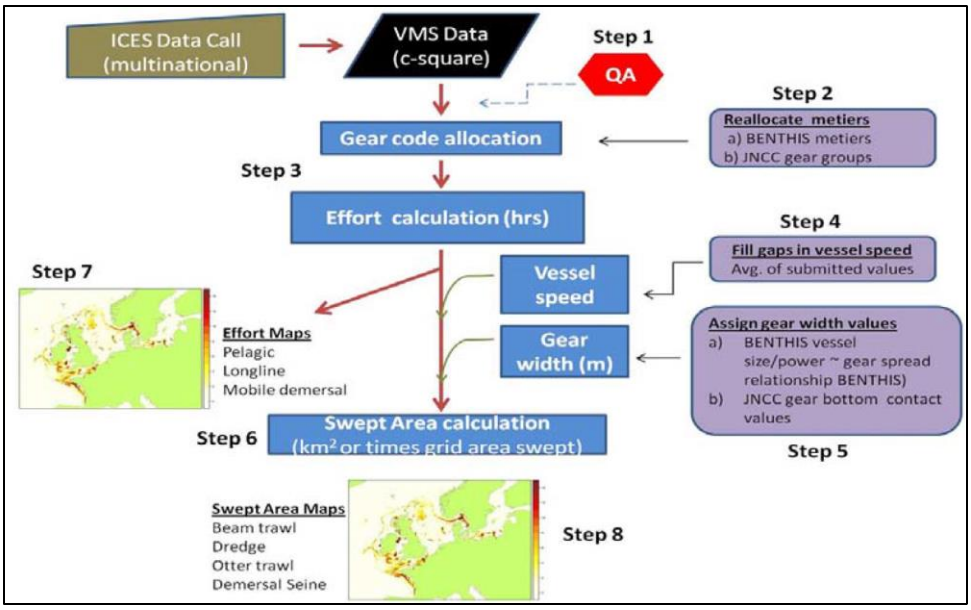

Figure 4.2.1. Workflow for production of swept area ratio (SAR) maps from aggregated VMS and logbook data in c-squares of 0.05x0.05 degrees (ICES 2015)

For the Mediterranean, the Black Sea and Macaronesia, a similar workflow is not in place and fishing pressure data are not readily available. Data do exist at national levels and it seems that the most obvious way forward is to add also the Mediterranean and Black Sea EU countries (e.g. EU's DCF channels) in to the established annual ICES calls currently serving OSPAR and HELCOM. Macaronesia will also need to be better covered within the data submissions made by Spain and Portugal. The chair of ICES-WGSFD and/or ICES Secretariat would be a suited initiator and facilitator.

4.2.2 Improvement potentials

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). More-over, 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, and consequently, it is strongly recommended that EU and national data policies are revised to enable publication of aggregated VMS data at a higher spatial and temporal resolution than is currently the case.

AIS data have potential to supplement or even replace VMS data in future high-resolution fisheries impact assessments, but at present these data have substantial shortcomings in availability, quality and coverage.

4.3 Collection of aggregate extraction data

An assessment of dredging intensity can provide the actual footprint of actively dredged areas. Although, it is recognized that intensity is related to volume/area/time period, a harmonized 'intensity' measure within the ICES area is only achievable as dredging hours/area/year, because of the existence of different analytical procedures between countries. A pilot study using UK, Belgian and a subset of Dutch data has shown that this measure gives a good view of the actual dredging footprint and can be used in regional assessments. This assessment could be done with data from EMS data ("black boxes"), as is done in the Netherlands, Belgium and UK, if available, but it is also possible using AIS data, as has been done in Denmark and the US.

The datasets needed for this are derivable from reporting on the volume of extracted material, extracted area and times of active dredging.

The approach for assessing and collecting these data would be applicable to the whole MSFD region. A proposal is presented below (Fig. 4.3.1) on how to harmonise the dataflow based on expert level input from the ICES working group WGEXT. This should be operationally tested in advance of the 2019 meeting by WGEXT and in the context of the aggregate extraction database that has now been set up at the ICES Data Centre for these data. It should be noted that ICES does not cover the Mediterranean and the Black Sea, and a different approach may thus be required for these regions.

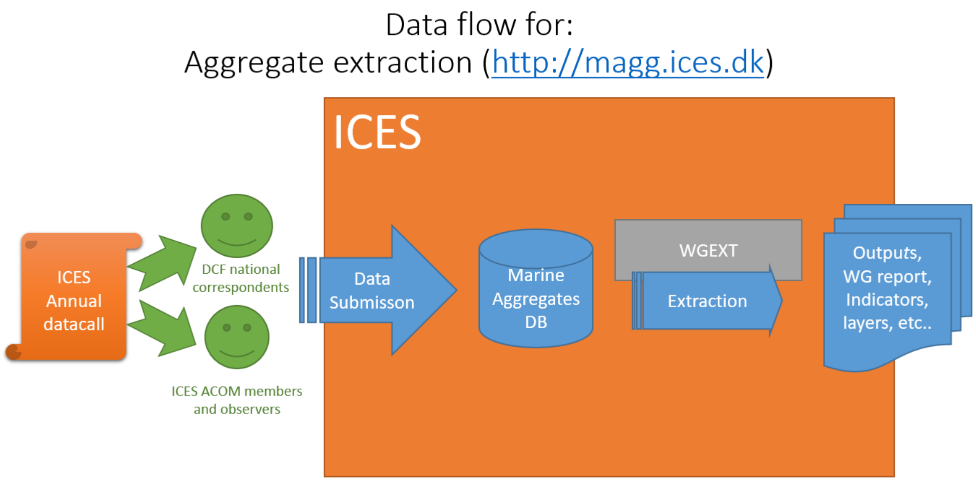

Figure 4.3.1. Data flow for aggregate extraction

Aggregate extraction data is collected during the annual WGEXT meeting and stored in Excel (not a database); although a standardized annual data call is being drafted for 2019. To ensure long-term stability and traceability, it is proposed that the ICES aggregate extraction database is developed further to hold this information.

Standardized reporting formats need to be developed, the most important parameters that need to be standardized for assessment purposes are volume extracted (m^3) and area (km^2). A standardized reporting format for the shapefiles for the licenced and extracted areas, with a standardised attribute table, is also needed. The reporting formats could be developed by the database host in cooperation with the national agencies carrying out reporting. The national reporting agencies would be responsible for ensuring that reported data is provided in the agreed format.

If the full data set is used, a grid size of 50 x 50 m is possible, but if a longer time resolution is used, larger grid cells are required in order to capture gradients in the intensity. For data provided at time intervals of five minutes, a cell size of 100 x 100 m is suggested, but a coarser resolution may be required. Considering that extracted areas have the potential to vary from 0.1 to 20 km^2, there could be difficulties in using the ICES 0.05° x 0.05° c-square system, as values expressed at this resolution may not be representative for the impact on the seafloor. It would be proposed to develop a dataset at a higher spatial resolution.

Operational for 2019 timeline: The next meeting of ICES WGEXT is in April 2019. There is time to prepare a data call before this and to develop a dataset to be used at the WKBEDPRES2 meeting.

Details of a data call and the establishment of workflow

Additional to the above, there is a functioning network of countries represented in WGEXT. This network could be used together with organisations like EMODNet-Human Activities and national MSPPortals to get in contact with responsible licensing authorities and national agencies in the Mediterranean/Black Sea region with the aim of initiating ICES Data Calls.

The data formats discussed and the listed responsible national agencies involved in collating data for aggregates are also relevant to future mineral extraction activities. However, mining does not exist, to our knowledge, within the 4 EU regions considered at this present time.

4.4 Collection of dredging and depositing pressure data

Data on dredging and depositing is called for and collated by OSPAR (North East Atlantic) and HELCOM (Baltic Sea). This report presents example dataflows from these RSCs. The data produced could be used by WKBEDPRES2, scheduled for Sep/Oct 2019.

Contracting parties to OSPAR report in accordance with *Guidance*[1] (OSPAR Agreement 2018-02) using the *Reporting Format*[2] which is available on-line[3]. However, there have been issues with the completeness and accuracy of reporting. Data layers for 2014-2016 are on OSPAR's Data and Information Management System (ODIMS[4]) under "OSPAR Dumping and Placement of Wastes and Other Matter at Sea". An

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[1] https://www.ospar.org/documents?d=39004

[2]https://www.ospar.org/site/assets/files/37439/dredged_material_reporting_format_2018.xlsx

[3] https://www.ospar.org/work-areas/eiha/other/reporting-formats

[4] https://odims.ospar.org/

assessment product was developed for the OSPAR Intermediate Assessment 2017[5]. Data are submitted each year with the intention of preparing assessments biennially. The data-flow, as it currently exists, is described in the data-flow diagram below (Fig. 4.4.1). However, it should be noted that the relevancy of the overall tonnage of deposits is currently unclear, and therefore drawing conclusions from these numbers is not yet possible.

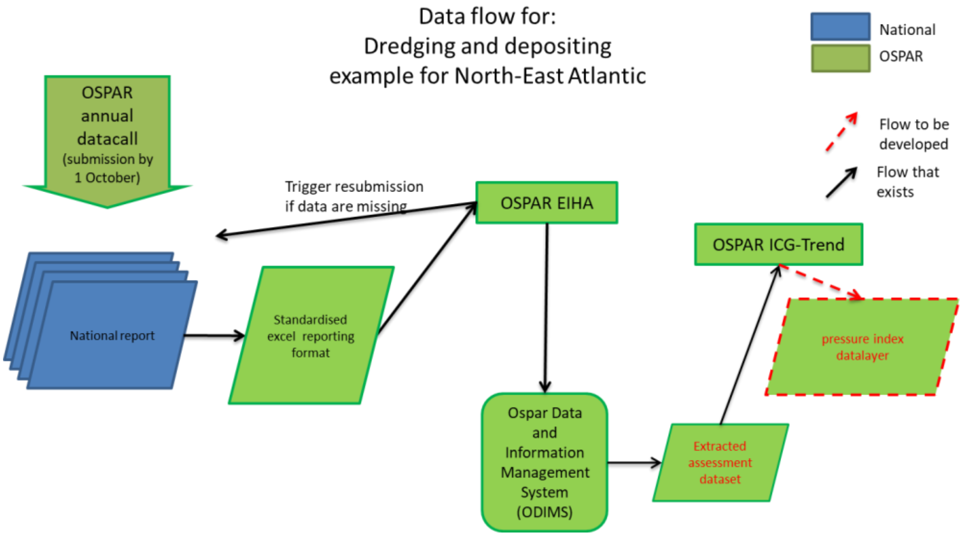

Figure 4.4.1. Data flow example for dredging and depositing.

Contracting parties of HELCOM report on dredging and depositing. The HELCOM Guidelines for management of dredged material at sea states that data on deposition activities, and partly the dredging activities, are to be submitted to HELCOM Secretariat by 1 October of the year following the deposition activity. The most recent data were reported by the HELCOM member states in accordance with the requirements of the Guidelines, including data on chemical analysis of reallocated dredged material and spatial data on the activities. Dredging points and areas have also been collated separately for 2011-2016. These different data layers have been utilised by HELCOM in their 2018 assessment of cumulative impacts.

For the Mediterranean Sea and Black Sea areas some dredging and deposition data has been compiled by EMODnet Human Activities. Similar data-flows developed for HELCOM and OSPAR countries could be expanded to for Mediterranean and Black Sea countries with a targeted data call (e.g. jointly by ICES, EEA, JRC – MSFD CIS group could identify the relevant recipients).

4.5 Collection of Shipping and Anchoring pressure data

Shipping pressure

Shipping results in increased sediment re-suspension rates in areas with relatively finer sediment at shallower depths. For estimating or quantifying the effect of shipping on benthic habitats in shallow waters, an estimation of the shipping intensity may be required. This pressure may be relevant at a regional scale only in shallow non-tidal seas such as the Baltic Sea, but it could also be applicable in other shallow

[5] (https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/pressures-human-activities/dumping-and-placement-dredged-material/

and sheltered areas. For the maritime transport sector, including activities such as anchoring and shipping, the main most comprehensive data source is the Automatic Identification System (AIS). Shipping related AIS data is collected through the coastal station network supported by National Maritime Transport Agencies. All of the national maritime agencies in Europe send the AIS signal data to European Maritime Safety Agency (EMSA). However, access to the data is problematic. Currently, the data needs to be acquired or purchased through companies or third party resellers, with data use depending on the contract between the distributor and owner of the data. To address these shortcomings EMODnet-Human Activities is working on producing a European wide shipping density data product. However, this product may only cover one specific year, which might bring in some issues of representativeness. The timeline to finish the product is by the end of 2018.

In addition to the derivation of shipping density information, AIS data can also be used to derive an estimate of Pan-European fishing activity for all fishing vessels larger than 15 m that deploy mobile bottom contacting or pelagic gear and carry AIS. JRC[6] (has worked on the Pan-European AIS data for estimating fishing activity per bottom contacting and pelagic towed gears, or for identifying anchoring sites (see Baltic Sea example further down).

To operationalize AIS data, a procedure with responsible parties should be established (Fig. 4.5.1). To get access to the AIS data from EMSA, a data call issued by DG ENV may be required. No lead institute working on the data processing and mapping of AIS data has yet been established – but JRC or EMODnet-Human Activities can be considered due to their expertise on AIS data handling.

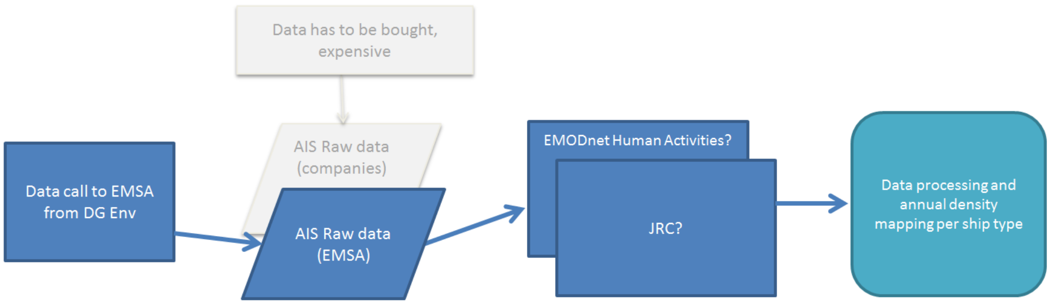

Figure 4.5.1 Proposed data collection procedure for AIS data.

Data flow example for AIS data:

Examples of AIS shipping density data, its processing, and established data products already exist for the Baltic Sea region (Fig. 4.5.2). Processed datasets for annual aggregated shipping density per ship type during 2006-2016, *including fishing vessels* (ship crossings / 1 x 1 km grid cell), are available for the Baltic Sea through the HELCOM Map and Data Service[7] (MADS). R-code[8] used for processing AIS raw signal data is also provided. If Pan-European AIS data is made available, shipping density (e.g. line crossings per e.g. 0.05 degree c-square) can be processed by modifying the processing code made available by the HELCOM Secretariat.

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[6] https://bluehub.jrc.ec.europa.eu/
[7] http://maps.helcom.fi/website/mapservice/
[8] https://github.com/helcomsecretariat

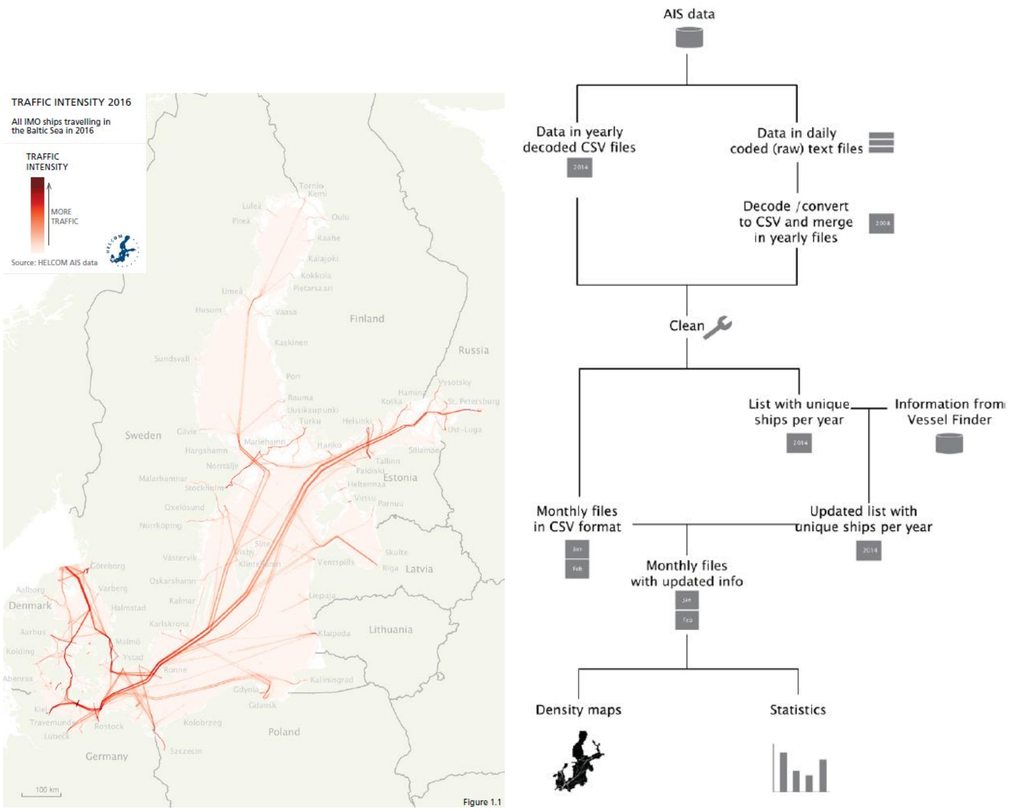

Figure 4.5.2. Shipping intensity in the Baltic Sea in 2016, the flowchart describes the steps that are necessary to process AIS data in the Baltic Sea. Source: HELCOM Maritime Assessment 2018.

Anchoring Pressure

Processed AIS data can be used to derive anchoring points by identifying areas outside harbours where ship speed is very slow or stagnant. Additionally, commercial anchoring sites are nationally designated areas and are drawn on nautical maps. The collation of these sites at a Pan-European scale would most likely be better served through national data calls, as probably no open and freely accessible data sources exist at this scale. For recreational vessels, no data on anchoring exists at the Pan-European scale. Anchoring sites could, nonetheless, be identified from aerial photos or satellite images and collated by national agencies: this requires the aerial photos and satellite images to be taken at times when the vessels are anchored. However, in common with the analysis of AIS data to determine anchoring sites, the interpretation of these data is not unambiguous and is potentially very resource hungry.

Taking into account the challenges with the availability of the AIS data and the requirement for extensive data processing, practical first steps to collate data for anchoring sites are needed. It is possible that a national data call for designated areas could be established. This data call could be issued at the EU level (through, perhaps, the EEA or DG ENV) to national maritime authorities holding the spatial data on the activity.

4.6 Physical restructuring (e.g. coastal constructions)

Concerning physical restructuring, WKBEDPRES1 had only a limited overview about the availability of relevant pressure data. It was also unclear how long physical disturbance pressures resulting from coastal defence (rather than pressures associated with loss, D6C1) would persist beyond the comparatively short construction phase, or how consistently member states apply the definitions of hydromorphology under WFD. However, some data, might be available from international and national bodies and could be identified from the European MSP platform[9]: e.g. , EMODnet Human Activities[10], projects like MEDTRENDS[11] or specific reports compiling information about other potential data sources (e.g., Med Maritime Integrated Projects[12]; or the EEAs Changing faces of Europe's coastal seas[13]). Although compiled some time ago now, potential sources of data may be available via national level reporting for the Water Framework Directive and/or via national MSFD reports.

4.7 Data management best practices

The quality of guidance relating to physical disturbance pressures depends on the quality of data provided and how it is collated, as well as the routines to process and analyse them. Due to the complexity of the data, the different setups between individual countries, and differences between the data aggregating units used for holding and extracting the data, trying to standardize workflows and/or final products can be a challenging task. One way to address this issue could be the development of 'best practices guides' and the preparation of predefined workflows and routines. Some useful overarching principles are:

- Use existing standards and formats to describe data wherever possible, making adaptations only where necessary (i.e. avoid making new standards/formats).
- Create documentation (ideally ISO meta-data) on the origin of the data you are using in the process.
- Ensure data are delivered to an agreed data policy (ideally an open one, such as the ICES Data policy).
- Have a clear understanding of the level of temporal/spatial resolution at which data are delivered/used in a data product (they do not need to be the same).
- If data are aggregated, where possible provide guidance on how this aggregation should be done – and document that this has happened.
- Make a data call, where timings of delivery are very clear, to ensure that everyone has the same instruction.
- Where possible, use QC scripts/programmes to check data are following expected formats/value ranges etc.
- Plan in time for all of these steps.
- Expect that this process will have an iterative feedback for improvement over a number of reporting cycles (of data).
- Verification/double checking by a second expert should be carried out where possible, the "*four-eyes principle*".

Some of the above principles can be implemented in coding routines of widely used software languages (e.g. R) and this can help ensure streamlining of data extraction,

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[9] https://www.msp-platform.eu/key-words/web-portal
[10] http://www.emodnet.eu/human-activities
[11] http://www.medtrends.org/medtrends.php
[12] http://www.medmaritimeprojects.eu/download/MyTemplate/Pdf/20141024_JAP_Upgraded_Paper_annex3.pdf
[13] https://www.eea.europa.eu/publications/eea_report_2006_6

cleaning, aggregating and submission processes. Within the work flow, code could be developed to collect information that will be used to check the quality of the data and provide a summary of the pre- and post-cleaning process, indicating potential errors in the data. This should lead to a more efficient assessment of data quality. The aim of both the best practice guide and the workflows is to standardize and enhance quality assurance for all data submitters.

Potential issues and potentially erroneous results in the submitted and aggregated data should be identified as early as possible. Once these problems are identified, a deeper analysis of the data can show whether these deviations reflect real changes or are due to errors in the original data or the subsequent aggregation process. To ensure that data submissions and aggregated data do have the best quality possible, a multi-step approach, following a *'four-eyes principle'* wherever possible, could be implemented. The four eyes principle – meaning verification by a second individual - is a cornerstone of any quality system (e.g., Good Manufacturing Practice (GMP), Good Laboratory Practice (GLP) or International Organization for Standardization (ISO) 17025). In its simplest form, this principle would mean that if a first person performs a task, then a second person checks it[14]. A thorough quality-check process increases both the reliability of the data used in the analysis as well as the confidence by the final recipient in the advice given. Quality control is vital in order to ensure the reliability of the data going in to the indicator development as well as to ensure the credibility of the resulting advice.

4.8 References

ICES. 2016. Interim Report of the Working Group on Spatial Fisheries Data (WGSFD), 17–20 May 2016, Brest, France. ICES CM 2016/SSGEPI:18. 244 pp.

ICES. 2017. Interim Report of the Working Group on Spatial Fisheries Data (WGSFD), 29 May–2 June 2017, Hamburg, Germany. ICES CM 2017/SSGEPI:16. 42 pp. ICES.

HELCOM, Brief about dredging, (2015) available at http://www.helcom.fi/action-areas/industrial-municipal-releases/dredging

HELCOM, Dredging points 2011–2016 available at:

http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/bb6622b7-e5df-4637-8ebe-c2736e705a70

http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/2a0fbdfd-9aef-4d2e-9129-2d1cc3b4943b

[14] FDA GMP update (2008): out through the indoor and back in again: changes to verification of performance of operations by a second individual. The Free Library, https://www.thefreelibrary.com/FDA GMP update: out through the in door and back in again: changes to ...-a0191392441 (accessed November 08 2018)

5 Appropriate units to assess the spatial extent and distribution of physical disturbance

5.1 Habitat types and assessment units

The habitat types to be assessed under the MSFD are defined in Decision (EU) 2017/848 Table 2 ('GES Decision', Commission Decision (EU) 2017/848) and termed 'MSFD broad habitat types'. They directly equate to Level 2 habitat types in the revised EUNIS habitat classification (Evans *et al*, 2016), either one-to-one or by aggregations of Level 2 types in the littoral and bathyal/abyssal zones. EUNIS habitats have been predictively mapped at 0.002dd (roughly 250 m) and are now available for all European regional seas, including their representation as MSFD broad habitat types (see EMODnet's EUSeaMap: https://www.emodnet-seabedhabitats.eu/access-data/launch-map-viewer/). The quality and confidence of the mapping is dependent on the underlying data, e.g. seabed sediment distribution maps, but is improving gradually with time as further high quality seabed mapping (using multi-beam sonar) is carried out. Furthermore, at EUNIS Level 4, specific 'functional' habitat types, which may comprise biogenic features/reefs such as seagrass beds, horse mussel beds, deep-sea sponge grounds, *Sabellaria* reef, etc., are recognised. Other habitat types (such as more finely resolved biotopes and sub-biotopes at EUNIS level 5 or 6, or selected from Habitats Directive and Regional Sea Convention lists of protected habitats) can be added by Member States for MSFD assessments if deemed important or necessary for national and/or regional assessment and management purposes..

In the 2016 EUNIS classification, Level 3 introduces biogeographic regions, recognising broad-scale divisions of Europe's seas (Arctic, Baltic, Atlantic, Mediterranean, Black Sea) determined by strong gradients in certain physical oceanographic parameters (e.g. temperature, salinity, bathymetry). For MSFD assessments, the GES Decision requires further subdivision of the MSFD regions and sub-regions to reflect finer-scale ecological/biogeographic differences in habitat types. Suitable subdivisions are not yet fully agreed, but preliminary subdivisions were used for the North Sea and Celtic Seas in OSPAR's Intermediate Assessment 2017 (Figure 5.1.1, OSPAR Intermediate Assessment 2017). For the Baltic Sea, HELCOM's existing assessment unit divisions, based on biogeochemical gradients, are applicable (e.g. 17 sub-basins), however aggregations of these units may also be appropriate. In the Mediterranean Sea, preliminary discussions have been had on possible subdivisions; Spain has distinguished two subdivisions. For the purpose of this ICES request, assessment areas will need to be defined for illustrative purposes, pending further work to adequately delineate suitable subdivisions in each region, based mainly on temperature and salinity characteristics.

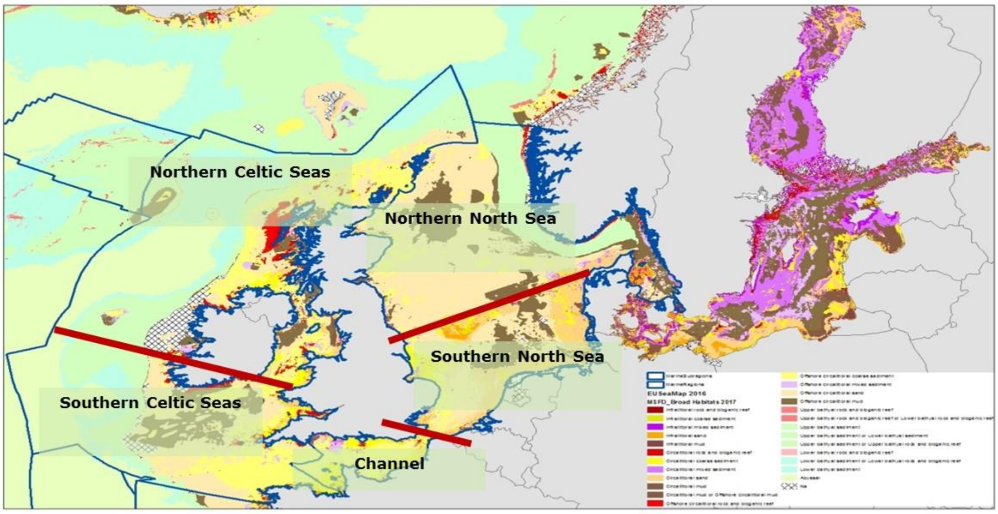

Figure 5.1.1 An overlay of the OSPAR IA2017 and EMODnet EUNIS habitat, prepared for demonstrational purposes to show subdivisions.

The MSFD habitat assessments at the broad scale of subdivisions of regions and sub-regions would therefore utilise habitat data (such as from EMODnet which is resolved at 0.002° x 0.002°and presented as MSFD broad habitat types, or even as EUNIS level 4 types) which is overlaid by physical disturbance pressure data (and other pressures) at c-square grid scale (0.05°x 0.05°). This will allow the determination of what proportion of each MSFD habitat (or other selected habitats, e.g. at Level 4) is potentially impacted by different human activities and pressures.

5.2 Caveats and improvement potentials

There are some recognised issues in adopting this approach:

1. The spatial scale of pressures resolved by c-square grid may not be sufficient to spatially separate different human activities operating within the same grid cell or to allocate them to specific habitats within the c-square.
2. Areas of increased habitat heterogeneity (particularly towards the coast) may not be sufficiently resolved by use of a c-square grid and a finer grid resolution may be needed.

However, it is felt that, given the broad spatial scale required for the habitat assessments (i.e. the scale of subdivisions of regional and sub-regional units), and the broad nature of the MSFD broad habitat types (EUNIS Level 2), such small-scale differences are expected to have limited effect on the assessment outcome. Nevertheless, 'hot-spots' where the above issues may occur could lead to the need for mapping habitats/pressures/activities at a finer scale than c-square grid. It would be useful to demonstrate with a worked example the use of coarse (c-square) and finer scale approaches, say in a coastal and offshore area, to illustrate these issues.

5.3 References

Evans, D. *et al*. (2016). Revising the marine section of the EUNIS Habitat classification - Report of a workshop held at the European Topic Centre on Biological Diversity, 12 & 13 May 2016. ETC/BD Working Paper N° A/2016.

Commission Decision (EU) 2017/848 of 17 May 2017 laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment, and repealing Decision 2010/477/EU.

OSPAR Intermediate Assessment 2017, available at: https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/

6 Conclusion and recommendations

ICES has been requested to investigate the main physical disturbance pressure(s) causing benthic impact on habitats per EU ecoregion. The aim of this scoping exercise was to establish criteria that guide the collection of pressure data, decide on practical steps to collate the data, and suggest appropriate assessment units by broad benthic habitat types used to assess the spatial extent and distribution of physical disturbance. Within WKBEDPRES1 suitable data streams relating to activities thought to be the main causes of physical disturbance were identified. These data streams are suited to the assessment framework put forward by ICES (2016) and thus facilitate the adoption of a quantitative methodology (ICES, 2017). The implementation of such a methodology presents the possibility of further activities being included into the assessment framework in a cumulative manner. These considerations address the need to be able to express the intensity of physical disturbance pressure in a way appropriate to derive the cumulative of all disturbance pressures, and to express the intensity of the pressure in a way 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 WKBEDPRES1 were:

6.1 Human activities and pressures on the seabed

- Key activities resulting in physical disturbance were similar for all of the regional seas addressed.
- These result in two main types of pressure: abrasion of the seabed and smothering of the seabed following re-suspension of sediment or dumping.
- Splitting the physical disturbance pressure (MSFD, Com. Dec. 2017/848/EU) to report on the abrasion and smothering pressures (MSFD prior to 2017 revision) was deemed necessary in order to account for lethal and sub-lethal effects on benthos as you move through pressure mechanisms to progressive state changes. This is further explained in section 3.2.
- Fishing was found to be the most extensive cause of physical abrasion over the regional seas.

6.2 Criteria to guide the collection of pressure data

- An assessment of physical disturbance performed at regional and subdivision scales is possible.
- Existing assessment techniques can process abrasion pressures from several activities and is not just limited to fishing activity.
- Data flows and methodologies for processing physical disturbance exist for fishing and are appropriate for this assessment.
- At the regional scale, data requirements for fishing and extraction are close to being met for the North East Atlantic and Baltic Sea. Established ICES data calls/workflows are good starting points for remaining regions and other abrasive pressures.
- Scope remains to include smothering effects of human activities in the process of parameterization.
- Activity data for coastal areas in all areas (e.g. anchoring and fishing by small (< 12 m) vessels) is not yet available.

6.3 Data management best practices

- Use existing standards and formats to describe data wherever possible, making adaptations only where necessary (i.e. avoid making new standards/formats).
- Create documentation (ideally ISO meta-data) on the origin of the data you are using in the process.
- Ensure data are delivered to an agreed data policy (ideally an open one, such as the ICES Data policy).
- Have a clear understanding of the level of temporal/spatial resolution at which data are delivered/used in a data product (they do not need to be the same).
- If data are aggregated, where possible provide guidance on how this aggregation should be done – and document that this has happened.
- Make a data call, where timings of delivery are very clear, to ensure that everyone has the same instruction.
- Where possible, use QC scripts/programmes to check data are following expected formats/value ranges etc.
- Plan in time for all of these steps.
- Expect that this process will have an iterative feedback for improvement over a number of reporting cycles (of data).
- Verification/double checking by a second expert should be carried out where possible, the "*four-eyes principle*".

6.4 Appropriate assessment units

- Impacted areas of concern can be highlighted by the regional scale assessment framework described within WKBEDPRES1.
- The spatial resolution for this assessment may not be suited to coastal habitats, where variables are highly heterogeneous over short distances (e.g. substrate, salinity).
- Relevant pressures can be identified using the WKBEDPRES1 methodology. However, the assessment approach is not suited to the management of local, specific habitats (e.g. *Zostera* and *Posidonia* seagrass beds).

6.5 References:

ICES (2016) EU request for guidance on how pressure maps of fishing intensity contribute to an assessment of the state of seabed habitats. ICES Special Request Advice 2016 Book 1, ICES, Copenhagen, 5pp, Copenhagen.

ICES (2017a) 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. ICES Special Request Advice 2017.13, ICES, Copenhagen, 27pp.

7 Future actions

Prior to August 2019, WKBEDPRES will collate benthic physical disturbance pressure layer data in collaboration, using sources and targeted data calls identified in section 4.2–4.6. Main actions (but not limited to) include:

- Data relating to fishing activity, identified as being the most extensive cause of seabed abrasion, should be collected via the established ICES VMS and log book data call (across the ICES area of the Baltic Sea and NE Atlantic) in the first instance. This ICES data call should be adapted to also cover the Mediterranean and Black Sea to ensure similar data flows are established. This will also take into account other sources of data to fishing activity causing seabed abrasion to allow for better coverage (e.g. AIS)
- Explore the use of available HELCOM, OSPAR and EMODnet human activities data for WKBEDPRES2.
- Fishing pressure layers (as described above), once obtained and quality assured by WGSFD, will be made available to WKBEDPRES advice process for testing within a benthic impact assessment context and will be further quality assured by two ICES working groups (WGFBIT and WGECO).
- An ICES data call for aggregate extraction activity data should be drawn up prior to the next ICES WGEXT meeting in April, 2019. The developed dataset arising from this call is to be used at the WKBEDPRES2 meeting.

8 Recommendations

Recommendation	Adressed to
1. WKBEDPRES1 recommends WGSFD chairs and ICES Secretariat to initiate and/or facilitate the addition of Mediterranean and Black Sea EU countries (through DCF) in to the established annual ICES data calls.	WGSFD chairs and ICES Secretariat
2. WKBEDPRES1 recommends the development of a database for aggregate extraction data.	ICES Data Centre, WGEXT.
3. WKBEDPRES1 recommends a standardized annual ICES aggregate extraction data call.	ICES Data Centre, WGEXT.
4. WKBEDPRES1 recommends the development of standardized reporting formats, most importantly volume extracted (m3) and area (km2)..	ICES Data Centre, WGEXT.
5. WKBEDPRES1 recommends the development of a standardized reporting format for the shapefiles for the licensed and extracted areas, with a standardized attribute table for aggregate extraction data	ICES Data Centre, WGEXT
6. WKBEDPRES1 recommends the development of a dataset at a higher spatial resolution for aggregate extraction data.	ICES Data Centre, WGEXT
7. WKBEDPRES1 recommends identify recipients for Med and Black Seas data call on aggregate extraction through an EU organization (JRC, MSFD CIS)	ICES Data Centre, WGEXT
8. WKBEDPRES1 recommends that ACOM leadership with the ICES data explore possibilities for DGENV to issue a data call to EMSA to operationalize AIS data.	ACOM leadership with the ICES data centre.
9. WKBEDPRES1 recommends the development of a "best practices guide" and the preparation of predefined workflows and routines to standardize workflows and enhance quality assurance.	ICES Secretariat, ICES Data centre, WGSFD
10. WKBEDPRES1 recommends that where only qualitative activity data is available, the assessment of such activities should be run in parallel to the quantitative assessment	WKBEDPRES2, WGFBIT
11. WKBEDPRES1 recommends that BEWG review what the effects of smothering are for the benthos, and suggest a mechanistic relationship between increased pressure and benthic response (e.g. biomass relative to carrying capacity).	BEWG
12. WKBEDPRES1 recommends that WGFBIT (and WKBEDPRES2) explore ways in which identified pressures (other than abrasion by bottom trawls) relate to sensitivity of the seafloor (e.g. PD model), and thus the resulting "cumulative" impact on the seafloor in the context of the WGFBIT assessment framework for D1/D6	WKBEDPRES2, WGFBIT

Annex 1: Terms of reference

WKBEDPRES1 - Scoping of benthic pressure layers D6C2 - methods to operational data products 2018/2/ACOM59

The **Workshop on scoping for benthic pressure layers D6C2 - from methods to operational data product** (WKBEDPRES1), chaired by Phillip Boulcott, UK (Scotland) will meet in Copenhagen, Denmark, 24 October – 26 October 2018 to:

a) Scope the main pressure(s) on benthic impact per EU ecoregion. The workshop will evaluate the relative significance of each pressure per ecoregion, the characteristics (e.g. frequency/extent) of these pressure(s), and what human activities the pressure is linked to.
b) Establish criteria to guide the collecting of pressure data. The workshop will determine criteria to guide collation of pressure data, to ensure the practical use of the data in assessing benthic impact.
c) Decide on practical steps to collate the required data, while applying data management best practices (pressure data will be sourced and data flows mapped). The practical steps include identifying what steps need to be taken and by whom to ensure identified data is collated by June 2019 (data calls, working groups, projects, organizations).
d) Suggest appropriate assessment units by broad benthic habitat types to assess spatial extent and distribution of physical disturbance. With the support of Commission Decision 2017/848/EU Table 2 and EUNIS habitat classification the workshop will suggest how to aggregate from habitat to overall spatial extent and distribution of physical disturbance. Specific characteristics of all European ecoregions should be considered.

Prior to the workshop, the Chair, together with two ACOM approved invited attendees (tbc) will prepare material to address the TORs. This group will also ensure the completion of the workshop report.

WKBEDPRES1 will report to the attention of ACOM by 12 November 2018.

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 D6C2 to assess the spatial extent and distribution of physical disturbance pressures on the seabed (including the intertidal area) for each MSFD broad habitat type within each ecoregion and subdivisions within. Physical disturbance by all relevant human activities should be considered (e.g. physical restructuring of the coast and seabed including dredging and depositing of materials, placement of infrastructure, extraction of minerals including gravel and sand, and use of bottom-contacting fishing gear). Central to this is to identify methods to express 1) the intensity of the pressure in a way appropriate to derive the cumulative of all disturbance pressures,

and, to express 2) the intensity of the pressure in a way appropriate to assess adverse effects under D6C3 and D6C5, both for the single pressure and the cumulative of all pressures. In doing this, recovery time will also be considered.

The workshop will prepare a guidance document to illustrate for each pressure the data flow from "owner" to product. General guidelines will be required that define how 1) pressure data should be (re)processed and how 2) the pressure data should be interpolated and/or extrapolated when data is missing.

The following supporting material is provided to guide the interpretation of TORs a-d:

a) What are the main pressure(s) causing benthic impact per EU ecoregion? This TOR will ensure the scoping of pressures most relevant to impact the seabed. For each EU ecoregion the top pressures impacting the seabed should be identified, with relative significance weighted in percentage. In addition, for each pressure a description estimating the frequency of activity, area of the seabed affected along with other relevant parameters (e.g temporal frequency, intensity, acute, chronic, spatial extent, direct or indirect effect, homogenising effect or heterogenizing effect) should be provided. Combined, such an approach will allow a comparison of ecoregions. When evaluating pressures, consideration will also be given to which habitat-pressure impacts are most important (and how this should be accounted for when aggregating results). For each pressure a description of the link to the main drivers and/or sectors-activities will be included (i.e. manageable human activity).

b) What criteria should be applied when collecting these pressure data? The workshop should agree upon criteria for drafting a guidance document for the collection of pressure data (see TOR C). The criteria can include the following:

- Grain and resolution (c-square) of data.
- Issues related to data security / data policy
- Encompass the main activities contributing to disturbance pressures on the seabed (including dredging and depositing of materials, extraction of minerals, and use of bottom-contacting fishing gear per metier);
- Be applicable to all EU waters (noting subregional variations where necessary due, for example, to data availability);
- Be suitable for assessment of the pressure over a 6-year MSFD reporting;
- Express the intensity of the pressure in a way appropriate to derive the cumulative of all disturbance pressures on the seabed;
- Express the intensity of the pressure in a way appropriate to assess adverse effects under D6C3 and D6C5, both for the single pressure and the cumulative of all pressures;
- Be sufficiently operational that a demonstration product can be made in Workshop 2, 2019, with available data.

c) What practical steps are needed to collect data? Using agreed criteria (see TOR B), a draft guidance document for the collation of pressure data will be produced to ensure best practice and correct standardization when assessing spatial extent and distribution of pressure and habitat data. The document will take into account work done in Regional Sea Conventions (e.g. HELCOM's SPICE), RMFOs and available data (e.g. habitat data in EMODnet). The document, for each pressure and each ecoregion, will include:

	- data sources, data flow and data management best practices - definitions of how pressure data should be (re)processed, interpolated/extrapolated when data is missing - practical steps/tasks to collect data by June 2019 (data calls, working groups, projects, organizations) d) What are the relevant assessment units and broad benthic habitat types to be used? This TOR will determine what broad benthic habitat types should be used as assessment units for each ecoregion using the Commission Decision 2017/848/EU Table 2 and EUNIS habitat classification. The TOR should include suggestions as to how to aggregate up from individual habitats to the overall spatial extent and distribution of physical disturbance. Ecoregions specific characteristics should be considered.
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, WGMPCZM, WGMHM, WGECON, CSGMSFD and SCICOM.
Linkages to other organizations	Links to OSPAR, HELCOM, Barcelona Convention, Bucharest Convention

Annex 2: List of participants

Participant	Dept/Institute	Email	Country
Andrew Kenny	Cefas	andrew.kenny@cefas.co.uk	UK
Carlos Pinto	International Council for the Exploration of the Sea	carlos@ices.dk	Denmark
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Valeria Abaza (Invited Expert)	National Institute for Marine Research	vabaza@alpha.rmri.ro	Romania

Annex 3: Agenda

<table>
<tr><th colspan="2">Wednesday 24 October</th></tr>
<tr><td>10.00 -start</td><td rowspan="2">Aims and conceptual presentations for workshop process. Brief plenary discussion and consensuses on ways of working to address workshop TORs.
1. Aims of workshop and ICES process - operational benthic pressure layers data products (D6C2, TORs)
2. Cataloguing activities relating to benthic pressures by MSFD ecoregion (e.g. Dailianis et al. 2018 link)
3. Translating different activities to a common measure of seafloor pressure (e.g. Eigaard et al., 2017 link)
4. Benthic impact on a continuous scale, need to benchmarking pressures against each other? (e.g. Hiddink et al. 2018 link)</td></tr>
<tr><td></td></tr>
<tr><td>11.30 – coffee</td><td rowspan="7">Initial sub-group work to address TORs of workshop, reporting in plenary, sub-group continued (till ice breaker), expected outcomes:
• cataloguing physical disturbance pressure(s) per ecoregion
• pressure characteristics (e.g. frequency/extent), and link to human activities
• first draft for 2-3 pressures: data flows mapped with associated meta-data</td></tr>
<tr><td></td></tr>
<tr><td>13.00-14.00 - lunch</td></tr>
<tr><td></td></tr>
<tr><td>15:30 – coffee</td></tr>
<tr><td></td></tr>
<tr><td>18.00 – ice-breaker</td></tr>
<tr><th colspan="2">Thursday 25 October</th></tr>
<tr><td>9.00 -start</td><td rowspan="10">Sub-group work to address TORs of workshop, reporting in plenary, sub-group continued, main themes:
• Assessment units by broad benthic habitat types to assess spatial extent and distribution of physical disturbance
• Criteria to translate activities to benthic pressures. Benchmarking pressures against each other, using a continuous scale of benthic impact.
• Criteria for: 1) collecting of pressure data, and 2) practical use in assessing benthos
• The main pressure(s), relative significance, characteristics (e.g. frequency/extent), and links to human activities
• Pressure data sourcing and data flow, with meta-data including characteristics (e.g. frequency/extent) of these pressure(s), and what human activities the pressure is linked to.
• Potential steps that can be taken and by whom to ensure identified data is collated by June 2019 (data calls, working groups, projects, organizations).</td></tr>
<tr><td></td></tr>
<tr><td>11.30 –coffee</td></tr>
<tr><td></td></tr>
<tr><td>13.00-14.00 - lunch</td></tr>
<tr><td></td></tr>
<tr><td>15:30 – coffee</td></tr>
<tr><td></td></tr>
<tr><td>18.00 – end</td></tr>
<tr><td></td></tr>
<tr><th colspan="2">Friday 26 October</th></tr>
<tr><td>9.00 -start</td><td rowspan="10">Reporting in plenary in progress from Thursday’s sub-groups, subgroup work continued till 12.00
• Sub-group continued from Thursday - remaining tasks/report writing/future directions
• Report writing, division of tasks, and future direction prior to WKBEDPRES2.
• Conclusions and recommendations

Note: a work plan and sub-groups will be presented at the start of the workshop</td></tr>
<tr><td></td></tr>
<tr><td>11.30 –coffee</td></tr>
<tr><td></td></tr>
<tr><td>13.00-14.00 - lunch</td></tr>
<tr><td></td></tr>
<tr><td>15:30 – coffee</td></tr>
<tr><td></td></tr>
<tr><td>16.00 – end</td></tr>
<tr><td></td></tr>
</table>

Annex 4: Availabilities and sources of data for different activities and datastreams

Table Annex 4. Availabilities and sources of data for different activities and datastreams. (BaS: Baltic Sea; GNS: Greater North Sea; CeS: Celtic Sea; BoBIC: Bay of Biscay and the Iberian Coast; Mac: Macaronesia; Med: Mediterranean Sea; BlaS: Black Sea.)

Activity / Datastream	Region	Quantitative data available	Datatype	Data originator	Data aggregater	Relevant ICES/EU group	Data Remit
Fish and shellfish harvesting (professional, recreational)							
Mobile towed gear (vessels over logbook size)	BaS; GNS; CeS; BoBIC; Mac	Yes	Logbook	National Fisheries Control Agencies	ICES Data Center (via Data Calls)	WGSFD; ICES Secretariat	EU fleet + others?
Mobile towed gear (vessels over logbook size)	Med; BlaS	Yes	Logbook	National Fisheries Control Agencies		WGSFD?	EU fleet + others?
Static gear (vessels over logbooksize)	BaS; GNS; CeS; BoBIC; Mac	Yes	Logbook	National Fisheries Control Agencies	ICES Data Center (via Data Calls)	WGSFD?; ICES Secretariat	EU fleet + others?
Static gear (vessels over logbooksize)	Med; BlaS	Yes	Logbook	National Fisheries Control Agencies	Global Fishing Watch?	WGSFD	EU fleet + others?
Mobile towed gear (vessels over VMS size)	BaS; GNS; CeS; BoBIC; Mac	Yes	VMS	National Fisheries Control Agencies	ICES Data Center (via Data Calls); Global Fishing Watch?	WGSFD; ICES Secretariat	EU fleet + others?
Mobile towed gear (vessels over VMS size)	Med; BlaS	Yes	VMS	National Fisheries Control Agencies	Global Fishing Watch?	WGSFD	EU fleet + others?
Static gear ((vessels over VMS size)	BaS; GNS; CeS; BoBIC; Mac	Yes	VMS	National Fisheries Control Agencies	ICES Data Center (via Data Calls); Global Fishing Watch?	WGSFD; ICES Secretariat	EU fleet + others?

Activity / Datastream	Region	Quantitative data available	Datatype	Data originator	Data aggregater	Relevant ICES/EU group	Data Remit
Static gear ((vessels over VMS size)	Med; BlaS	Yes	VMS	National Fisheries Control Agencies	Global Fishing Watch?	WGSFD?	EU fleet + others?
Mobile towed gear ((vessels over AIS size)	BaS; GNS; CeS; BoBIC; Mac	Yes	AIS	Maritime Safety Agencies; private companies	EMSA; Norwegian Coastal Administration (AIS network; Baltic, North Sea, Norwegian Sea/Barents Sea)	WGSFD; JRC; EMODNET-Human Activities	EU fleet + others?
Mobile towed gear ((vessels over AIS size)	Med; BlaS	Yes	AIS	Maritime Safety Agencies; private companies	EMSA	WGSFD; JRC; EMODNET-Human Activities	EU fleet + others?
Static gear ((vessels over AIS size)	BaS; GNS; CeS; BoBIC; Mac	Yes	AIS	Maritime Safety Agencies; private companies	EMSA; Norwegian Coastal Administration (AIS network; Baltic, North Sea, Norwegian Sea/Barents Sea)	WGSFD; JRC; EMODNET-Human Activities	EU fleet + others?
Static gear ((vessels over AIS size)	Med; BlaS	Yes	AIS	Maritime Safety Agencies; private companies	EMSA	WGSFD; JRC; EMODNET-Human Activities	EU fleet + others?
Small boats (towed+static) (vessels under logbook size)	BaS; GNS; CeS; BoBIC; Mac; Med; BlaS	Partly	AIS	Maritime Safety Agencies; private companies	EMSA; Norwegian Coastal Administration (AIS network; Baltic, North Sea, Norwegian Sea/Barents Sea)	WGSFD; JRC; EMODNET (human activities)	
Recreational	BaS; GNS; CeS; BoBIC; Mac; Med; BlaS	ask WGRFS	Community logbooks/ licensing/AIS	National DCF programs (in all EU MS?); for some species (cod, sea bass)	DCF	WGRFS; HELCOM Fish Group; GFCM recreational fisheries group	

Activity / Datastream	Region	Quantitative data available	Datatype	Data originator	Data aggregater	Relevant ICES/EU group	Data Remit
			Extraction of minerals (rock, metal ores, gravel, sand, shell)				
Aggregate extraction	BaS; GNS; CeS; BoBIC; Mac; Med; BlaS	Yes for ICES regions possibly for Med/Black	Licencing/EIA/ activity reports/ AIS/"black box"	National Licencing Agencies	WGEXT (ask for Med/BlaS)	WGEXT; EMOD-NET-Human Activities	
Mining	BaS; GNS; CeS; BoBIC; Mac; Med; BlaS	No	Licencing/none			WGEXT?/ ATLAS	Deep sea - international waters
			Restructuring of seabed morphology, including dredging and depositing of materials				
Dredging	BaS; GNS; CeS; BoBIC; Mac; Med; BlaS	Yes	licencing/permit/EIA or AIS?	(Sub-) National permitting and transport Agencies	OSPAR-EIHA (partly)	OSPAR EIHA	
Depositing	BaS; GNS; CeS; BoBIC; Mac; Med; BlaS	Yes	Licencing/AIS?	(Sub-) National permitting and transport Agencies	OSPAR-EIHA (partly)	OSPAR EIHA	
			Transport infrastructure, incl anchoring				
Anchoring	BaS; GNS; CeS; BoBIC; Mac; Med; BlaS	Yes	AIS/ Licencing/Charts/EMSA/Satellite+airial Imagery				Commercial and recreational

Activity / Datastream	Region	Quantitative data available	Datatype	Data originator	Data aggregater	Relevant ICES/EU group	Data Remit
Shipping	Baltic (GNS; CeS; BoBIC; Mac; Med; BlaS)	Yes	AIS	National Transport Agencies	Norwegian Coastal Administration (HELCOM)		especially in shallow areas
Physical restructuring of rivers, coastline or seabed (water management)							
Coastal Defence	BaS; GNS; CeS; BoBIC; Mac; Med; BlaS	No (unknown)		Italian Coast Construction Mapping (footprint)?, Other countries?	Google Maps Digitisation? EIA/licencing	WGMPCZM?	long term; construction phase not seen as long term loss; linked to D7C2

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

Request	Information available
	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 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).

Request	Information available
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. 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.

Request	Information available
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 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 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

Request	Information available
	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: 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 varia-

Request	Information available
	tion 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. 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. <u>Specific comments:</u> 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 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

Request	Information available
	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 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.

Request	Information available
	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. Specific comments: 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.