ICES CIEM

A SERIES OF TWO WORKSHOPS TO DEVELOP A SUITE OF MANAGEMENT OPTIONS TO REDUCE THE IMPACTS OF BOTTOM FISHING ON SEABED HABITATS AND UNDERTAKE ANALYSIS OF THE TRADE-OFFS BETWEEN OVERALL BENEFIT TO SEABED HABITATS AND LOSS OF FISHERIES REVENUE/CONTRIBUTION MARGIN FOR THESE OPTIONS (WKTRADE3 STAKE)

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Contents

i Executive summary

ICES organised a stakeholder workshop on the evaluation of trade-offs between fisheries value and seafloor impacts of mobile bottom contact gears. The aim of the workshop was to obtain inputs from stakeholders on 1) how to quantify fisheries value and seabed impacts, 2) what management options to evaluate to reduce the impact of mobile bottom contacting Gears on seabed habitats, and 3) how to present the trade-offs. Representatives of fisheries organisations, conservation NGOs and governmental managers and advisers discussed each of these topics. No attempts to reach consensus within and among groups were made, and a wide range of opinions was shared in the meeting. All groups mentioned the importance of maintaining ecosystem services, and the protection of particularly sensitive habitats. Most fisheries representatives emphasized the importance of maintaining flexibilities and livelihoods and expressed a preference for avoiding spatial management and prefer technical gear modifications instead. Conservation organisations expressed their opinion that spatial exclusions of fishing with mobile bottom-contacting gears are priority management measures. All groups agreed that prioritising low fishing effort cells for exclusion of fishing was the best approach to minimize seabed impact while maximizing fisheries value. Freezing the trawling to a historic footprint was not a preferred management option for any of the groups. The participants generally prefer maps over figures as a means of presenting trade-offs. These inputs will feed into analyses in a technical workshop where these trade-offs will be quantified for each management option, where tools and data are available. Where this is not possible, the workshop will identify science to develop to address currently unachievable scenarios and trade-offs.

ii Expert group information

Expert group name	A series of two Workshops to develop a suite of management options to reduce the impacts of bottom fishing on seabed habitats and undertake analysis of the trade-offs between overall benefit to seabed habitats and loss of fisheries revenue/contribution margin for these options (WKTRADE3 STAKE)
Expert group cycle	Annual
Year cycle started	2021
Reporting year in cycle	1/1
Chair(s)	Josefine Egekvist, Denmark
	Jan Geert Hiddink, UK
Meeting venue(s) and dates	4-5 March 2021, online, 38 participants

1 Introduction

1.1 Background and aims of the workshop

Under ecosystem-based fisheries management, there is a need to inform managers about the interlinkages, and therefore possible trade-offs and synergies, between benthic impacts and the value (both economically and socially) of mobile bottom-contacting fisheries. Countries, the EU and Regional Sea Conventions are developing indicators of pressure and impact on benthic habitats, including from bottom-trawl fisheries, for the Marine Strategy Framework Directive (MSFD). Such indicators are developed to ensure that biodiversity, structure and function of benthic ecosystems are safeguarded, and fisheries production is sustained.

In 2016, the European Commission sent a request to ICES to deliver "advice 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 advised on a set of indicators for assessing pressure and impact on the seabed from mobile bottom-contacting fishing. These indicators were selected based on their ability to describe impacts on a continuous scale that can be used in the evaluation of trade-off between the fisheries and their impacts on the seabed. ICES provided a demonstration advice product (ICES 2017) for the Greater North Sea ecoregion to illustrate possible future approaches to annual advice on this topic.

ICES has been asked by the European Commission in a new request for "advice on a set of management options to reduce the impact of mobile bottom contacting fishing gears on seafloor habitats, and for each option provide a trade-off analysis between fisheries and the seafloor". The purpose of this advice request is to provide a neutral analysis of potential costs or benefits to fisheries of achieving different levels of seafloor protection, based on the different management options identified. It is therefore important that the range of suggested management options, and the metrics of benthic impact and fisheries used to evaluate trade-offs, span the likely range being considered.

The aim of this workshop was to solicit the opinion of stakeholders on how to quantify the trade-off between the value of mobile bottom gear fisheries and the impact of these fisheries on the seabed ecosystems in the evaluation of different management options. The workshop was seeking opinions on which management options to explore, and how to quantify and present the value of fisheries and seabed impacts in the advice. Outcomes of the workshop will feed into a subsequent technical workshop where trade-offs are quantified, when tools and data are available, for each management option in different EU (sub-)regions and subdivisions.

1.2 Terms of Reference

The Terms of Reference of the stakeholder workshop were to:

a) Present TRADE3 Working Document (see Annex 4) to the workshop participants to inform them of the progress to date and the ICES process to finalise the TRADE3 Advice response to the EC.

b) Review the management options identified to reduce the impact of Mobile Bottom Contacting Gears on seabed habitats (e.g. are there options missing) and the criteria used for their prioritisation.

c) Input from the workshop participants on whether the proposed trade-off analyses in TRADE3 are informative and produce outputs that stakeholders need.

1.3 Methods and data available

A working document prepared by a core group as preparation for the WKTRADE3 workshops is available in Annex 4. This document is based on ICES 2017 advice "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", and on further developments in the ICES Fisheries Benthic Impact and Trade-offs (FBIT) working group (ICES 2018).

The document includes a workflow that can be used to produce area specific trade-off assessment sheets with available data. The workflow includes proposals on key figures, tables and management options that can be produced in the trade-off analysis. The document provides proposals on these figures, tables and options using illustrations from the Greater North Sea. Similar output of fishing footprint and impact on benthic habitats will be produced in the WKTRADE3 technical workshop for the Baltic Sea and for subdivisions of the Greater North Sea and Baltic Sea. For the Celtic Seas and Bay of Biscay and the Iberian Coast (and their subdivisions), no assessment of benthic impact is currently available and only an assessment of the fishing footprint will be included. For all other EU regions, part of the draft assessment will be prepared with key data/knowledge gaps identified. All footprint and impact assessments on the seafloor use the seabed habitat assessments required by the GES Decision (EU) 2017/848, i.e. the MSFD broad habitat types using EUSeaMap 2019.

1.4 Structure of the workshop and report

The workshop was conducted virtually over two consecutive days (March 4-5, 2021). The work was organized around plenary sessions and three breakout groups. The workshop participants were split into one of each breakout group based on their stakeholder background. This setup ensured to get a range of opinions. Group A consisted of representatives of fisheries organisations (mostly MBCG fisheries were represented), Group B consisted of representatives of conservation NGOs and Group C consisted of representatives of environmental and fisheries managers and governmental advisers. Each breakout group discussed three different topics:

- What do we "trade-off"?
- Management options
- Understandable and useful outputs

The structure of this report follows the general structure of the workshop, where each topic is presented in a separate chapter (Chapter 3-5) that summarizes the views expressed by the different breakout groups. This is followed by a general conclusion and recommendation section that highlights which outcomes of the workshop can feed into the technical workshop and which will need to be reported for future consideration.

2 Viewpoints from stakeholders

Three participants presented in plenary their viewpoint on the fisheries benthic impact trade off question. A summary of each of these presentations is provided below.

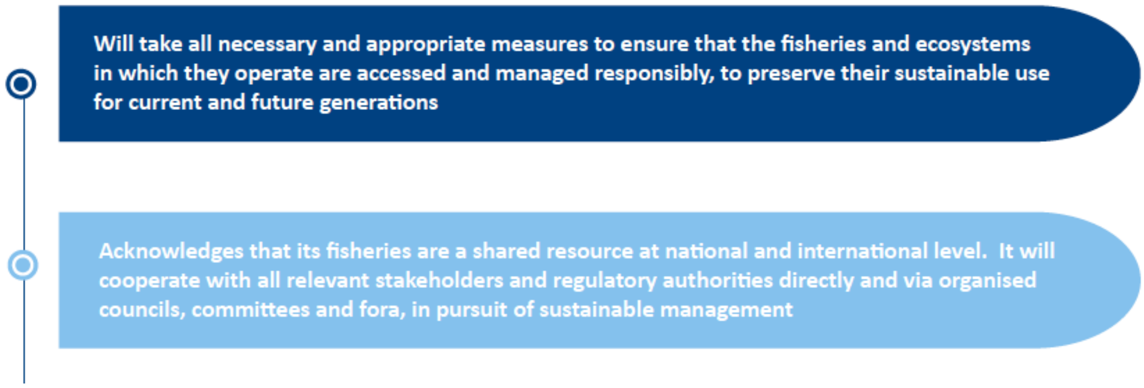
2.1 Kenny Coull – Scottish White Fish Producers Association limited

The Scottish Whitefish Producer's Association (SWFPA) represents approximately 240 vessels (each being a business in its own right) and 1400 fishermen. SWFPA is one of the constituent associations of the Scottish Fishermen's Federation which;

- Was formed in 1973
- Represents 8 associations (across 3 sectors throughout Scotland) with a total membership of approximately 400 vessels (or businesses).
- Accounts for around 90% of the total Scottish quota and 65% of the UK quota.
- Role is to preserve and promote collective interests of constituent fishermen's associations
- Represent and lobby for the fishing industry at national and international level.

Our fisheries and fishermen

The value of fish landed by Scottish vessels in 2019 amounted to £582 million, almost equally attributed to the pelagic, demersal and shellfish sectors. A total of 4860 fishermen are employed in the catching sector, including 945 who operate on a part-time or seasonal basis. Through the democratic process of the SFF, our members have developed an Environmental Policy[1] which underpins their approach to sustainable fishing. Included in this policy is the aim that in relation to fishing, their activities "will not cause or lead to undesirable changes in the biological and economic productivity, biological diversity, or structure and functioning of the ecosystem from one human generation to the next". Key sections of the SFF Environmental Policy which are relevant to the work of WKTRADE 3 include sections on Marine Protected Areas, The effect of fishing on the seabed, The long way to go on co-management, and, Our Sustainability Pledge which highlights that we;



[1] https://www.sff.co.uk/wp-content/uploads/2020/10/Environmental-Policy-Statement-Website.pdf

Use of seabed in multi-use context

Co-existence is not always easy and SFF / SWFPA highlighted several issues which highlighted the competition for space by seabed users;

Aquaculture

- Spatial overlap results in loss of inshore *Nephrops* fishing grounds
- Sites are currently in coastal waters but future plans extend to deeper waters

Renewables

- Spatial overlap- loss of inshore fishing opportunities
- Low engagement by developers to minimise impact on fishers
- Impact of developments on benthic and demersal species not fully assessed

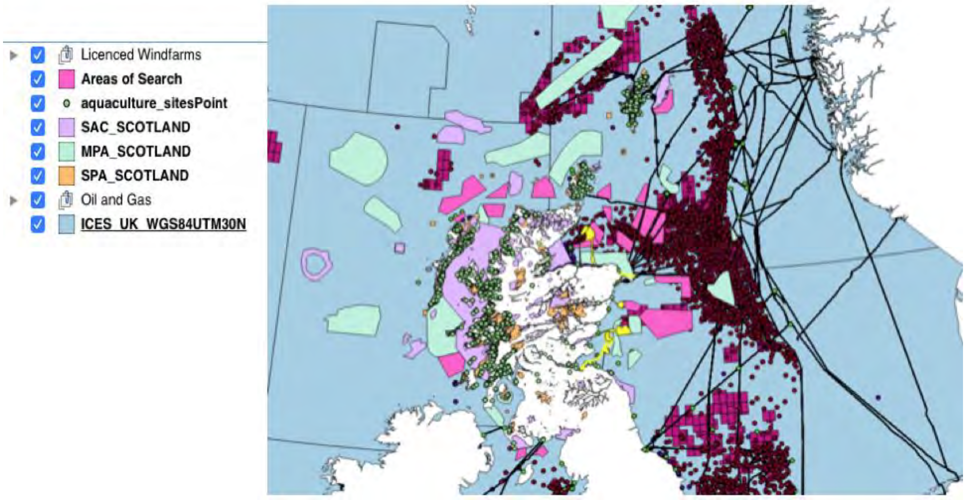
Oil & Gas

- Spatial overlap – loss of significant offshore fishing tows
- Decommissioning – return of fishing on sites unlikely to happen

Nature conservation

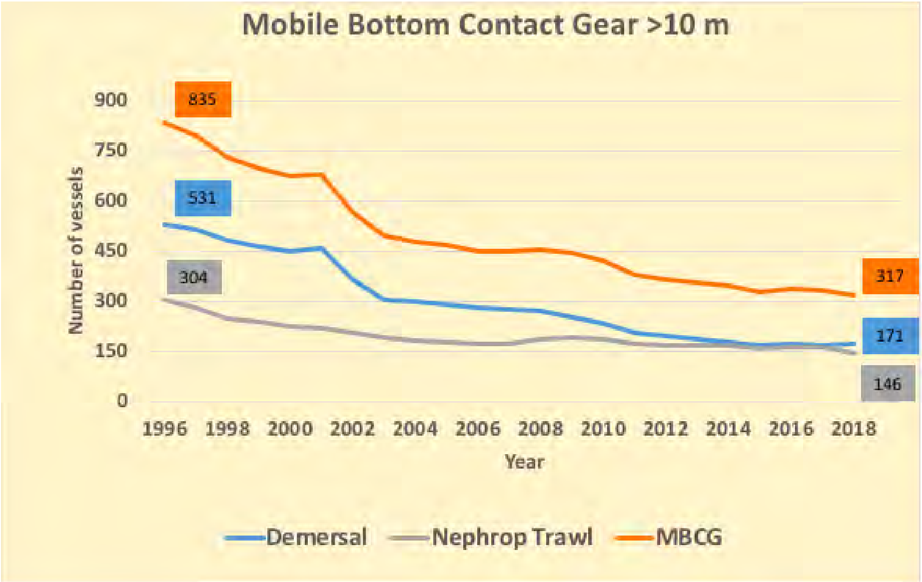
- Is resulting on restriction to activity (based on risk to specific features)

A series of layered maps were shown which highlighted areas these activities are located and a final combined layer (below) demonstrates the potential scale of cumulative loss of fishing activities.



Changing status of Scottish Fleet

The Scottish mobile fleet has undergone significant reductions in last 22 years, demonstrating a 54% reduction in vessel numbers and 32% reduction in fleet power (KWs) respectively. In relation to the period since 2102 – 2014, this reduction amounts to 9% and 6% respectively. Specifically relating to changes in Mobile Bottom Contact Gears, a reduction of 54% can be observed in the graph below. However, data relating to scallop dredge was not (readily) available from the Scottish Sea Fisheries Statistics.



Key points to bear in mind when trading away fishing opportunities;

- We already have experience of Trade-offs through stakeholder workshops in developing fisheries management measures for the Scottish MPA Network (through open and frank discussion, reached a balance between conservation and sustainable harvesting).
- Scottish seas are shared with competing sectors and this is increasingly contributing towards areas of non-fished seabed and habitat.
- The Scottish fleet continues to be reduced in capacity,
- Fishing footprint and pressure reduced significantly in recent times (-53% less MBCG) and as yet, no assessment of the benefits of this has been completed.
- Vessels within a metier may have totally different catching opportunities (TAC)
- Different species and groups targeted by vessels of similar gears

2.2 Nicolas Fournier – OCEANA

Nicolas Fournier (Campaign Director at Oceana in Europe) stressed the importance of the policy context around seabed integrity and bottom-fishing, particularly the poor delivery of the MSFD implementation on Descriptor 6 and the renewed EU climate and biodiversity imperatives. He first presented the relative higher impacts on EU seabed by bottom-trawling compared other regions of the world, highlighting that some EU seas had the highest trawling impacts in the world, like the Adriatic Sea, the Skagerrak and Kattegat or the Western Baltic Sea. On top of physical damages, he pointed out the broader impacts on benthic and associated ecosystems, with changes on habitats (nurseries) but also food availability and food webs, biochemical cycle, carbon sequestration and climate resilience. On trade-offs, he explained that in several studies, the majority of fishing pressure and catches come from a relatively small seabed area, and as a result, closing off large areas of seabed could come at small costs to the fishing sector while generating huge gains for biodiversity and beyond, including higher catches in the long term due to improved environmental conditions overall. He stressed that long-term trade-off requires structural changes to fishing models, such as adjustment in fleets and fishing gears to enable a transition to low-impact fishing. For Oceana, a critical aspect of trade-off was the actual definition of "recovery", which he described as fully regenerated ecosystems in their diversity, richness, functions and processes. This inherently introduces a time-element together with uncertainties which requires adopting precautionary approach to trade-offs. One is to permanently remove fishing pressures to allow the seabed and its communities to regenerate fully, with the objective to even gain habitats back, including complex ones that may have disappeared due to continuous bottom-trawling (biogenic reefs, VMEs). He advocated for the benefits of bottom-fishing restrictions in coastal waters, the most productive part of our oceans, building up on the experience from the Mediterranean Sea where the spatial approach also grants preferential access to low-impact fishers. This could be implemented rather directly based on the known distribution of sensitive coastal habitats in the rest of Europe, such as seagrass/seaweeds, maerl or rhodolith beds. He concluded by stressing the value of having ambitious policy targets aiming at reducing bottom-fishing footprint and impacts, to not only deliver GES but also broader climate and biodiversity commitments.

2.3 Stephen Thompson – Eastern Inshore Fisheries and Conservation

Balancing the trade-off between the fisheries and protection of the sea-floor: An IFCA perspective

Inshore Fisheries and Conservation Authorities – IFCAs – came into being as a result of the 2009 Marine and Coastal Access Act (MACAA 2009). They replace the previous Sea Fisheries Committees, and are partly funded by local authorities and partly by central UK government. The ten IFCAs between them cover English waters from the tidal limit to six nautical miles out to sea.

All IFCAs operate to a common vision to "*lead, champion and manage a sustainable marine environment and inshore fisheries, by successfully securing the right balance between social, environmental and economic benefits to ensure healthy seas, sustainable fisheries and a viable industry*". IFCAs have obligations under several pieces of legislation to manage sustainable fisheries in a fair and equitable manner, whilst at the same time ensuring compliance of fisheries with environmental legislation. It is specifically stated in MACAA 2009 that conservation objectives have primacy, and actions undertaken by the IFCAs must ensure that legislative conservation targets are not impeded by fishing activities.

The Eastern IFCA district is the inshore waters of the counties of Lincolnshire, Norfolk and Suffolk. Our sea area is predominantly shallow, with a seabed of mobile sediment. It is an area of high seabed energy due to strong tides and exposure to waves. More than 95% of the sea area is some form of Marine Protected Area (MPA), with in many cases multiple designations at the same location. In particular, The Wash – one of England's major embayments – is protected by numerous designations, each of which brings its own legislative obligations.

Fisheries include cockles and mussels (predominantly by hand gathering), shrimps (lightweight beam trawling), crabs and lobsters (potting), whelks (potting) and some finfish (predominantly static nets, with some trawling). There is a limited range of suitable target species compared with e.g. the South West of England, due to the limited range of appropriate finfish species in the district.

Eastern IFCA is tasked with assessing all commercial fisheries within our district and ensuring that they do not compromise the achievement of the legally defined conservation objectives for those features and species designated within MPAs. We have byelaw making powers to ensure that effective management can be implemented when identified as necessary. In order to do so, we need to understand the pattern and impacts of fishing activity, the location and sensitivity of specific features, and the interactions between fishing activity and designated features. In many instances, there is a lower level of information available for all of these factors than would be ideal.

The area with the highest level of environmental protection – The Wash – is also the location of some of our most important fisheries (cockle and mussel, and shrimp). Identification of the indicated management for these fisheries required a very great deal of effort to adequately understand the factors above. A lack of sufficient nuance in the official conservation advice required that we conduct detailed, rigorous assessment of the specific local conditions, by means of literature review, targeted field work, and investigation of fishing practices. It is very important that such locally specific assessment is conducted, and remains possible within both legislative framework and scientific advice.

3 What do we trade-off?

In each breakout group, participants were asked for their opinion on: What do we value? What do we want to maximise? What is important to this sub-group? Time scale? How do we quantify what we value (metrics)?

3.1 Group A – Fisheries representatives

Value is not just about the economic value of intensity. It is also about what it means to fishing communities and those linked with the community (peripheral maritime regions). These communities need incomes that are resilient to change to keep infrastructure and skills supported. Year on year fluxes in revenue caused by a closure being imposed are not helpful. Value is also seen in the number of jobs - however, this need not necessarily translate to a preservation in the number of vessels.

Value, where it has real relevance is where it exceeds, minimum added value. The most important way of ensuring this comes from the productivity of fishing grounds and the flexibility in making sure fishing opportunities are there. Fishers require flexibility in where they fish to achieve this and to avoid possible gear conflicts. Spatial management may be optimal now, but sub-optimal in the long term by limiting flexibility. Flexibility was seen as an important concept – it increases fishing opportunities, reduces gear conflict and allows catches to be brought in at the correct time (daily, often) to maximise value. Flexibility also ensures that vessels are suited to the grounds and that the opportunities match the economic requirements of running such vessels (here the fleet make-up and the shape/locality of the grounds are tightly linked). Protecting just short distance grounds (to ports) is far too simplistic.

We need to think about value widely – not just direct benefits of fishing but also tourism.

Trade-offs require pragmatism. This requires understanding of both sides when reaching a decision, not intransigence. Trade-offs should also take into account the environmental consequences of getting the "lost" protein elsewhere – this is a wider issue of food security. Do alternative food production systems have less environmental impact?

The fishing sector has undergone huge changes in the last decades and effort has reduced drastically. We should take time to understand what this means to benthic integrity. Stocks and the seabed are also subject to influences other than fishing and we need to acknowledge that.

The question of timescales relates to flexibility – bringing in fish to market at the correct time. It also relates to regulatory processes – incremental is seen as better as it reduces immediate discontinuities and allows for testing to see if measures are having their stated effect (benthic improvement is the focus but what about enhancements to the fisher and spill-over?) Timescales also relates to biomass – as this may change over time and so measures should react within this timeframe. A long-term stepwise approach is preferred where management measures are implemented together with the fishing industry and properly evaluated before next steps are made.

3.2 Group B – Conservation NGO representatives

Priority should be given to assess how to achieve GES (and thus to ensure ecosystems are healthy and productive) and not to the assessment of associated costs. The aim should be to maximise ecosystem services and resilience and associated communities, as well as the protection of VMEs, thus putting the analyses in a broader ecosystem-based context (and approach).

Accordingly, the assessment of costs should be associated with the estimate of the potential benefits (both socioeconomic and ecological) from protecting seabed habitats. Indeed, the assumption that reducing fisheries footprint would not reflect in socio-economic benefits to the fisheries sector is considered to be not realistic in many cases (e.g. in Scotland the reduction in spatial footprint in the coastal area resulted – in many cases, in the increase in catches and the value of landings or employment levels). For instance, "Economic modelling, including that commissioned by Scottish Government, has shown that spatial management of MBCG within coastal waters would result in greater job and GVA returns".

There is a need for more economists to support the analyses of trade-off on fisheries sector and beyond (e.g., towards other metiers, considering Ecosystem services, etc.): the current approach considering only direct economic cost and loss associated with a reduction in fishing footprint is considered partial and thus misleading as it neglects wider environmental cost, including non-monetary.

A distinction in the approach applied in the trade-off assessment between coastal areas and open sea should be introduced: most often in the coastal areas there is a higher occurrence of sensitive habitats and an overlap of multiple pressures, and this condition should be duly taken into account. "For NGOs, the management approach scenario of nearshore restrictions and zoning should be considered and prioritised".

In the open sea or heavily trawled fishing grounds, it would be necessary to protect the seabed, in particular on areas with high (past) biodiversity (i.e., the fact that an area has been subjected to high fishing pressure does not mean it has a –potential- high ecological value). Moreover, heavily trawled areas may have a high value for ecosystem services (e.g. regulating C resuspension, biogeochemical cycles, provisioning, climate resilience, etc.) and thus their protection should be ensured. "The permanent removal of the fishing pressure was stressed as a prerequisite and key success factor for seabed restoration and recovery".

An effort to be able to trace (take into account) the pressure exerted from small-scale fishing vessels adopting benthic impacting fishing gear should be put forward, to have a complete picture of the pressure. Many data are missing for a comprehensive analysis. Cumulative effects on seabed habitat should be considered, thus not restricting the assessment to (only) fishing pressure.

The trade-off analyses shall explore a vast range of variation in pressure and footprint (till -50% and even above) given the current exploitation/pressure level. There is also a concern in considering current (or recent) fishing pressure as a reference baseline. "Keeping the same fishing footprint would not actually be a "zero cost scenario" as stated, particularly as it neglects the environmental costs of continuous trawling".

Moreover, inaction (no change in spatial footprint, i.e. Business As Usual approach) would not prevent the progressive worsening of habitat condition and, likely fishing productivity, due to impacts on essential fish habitats, while the trade-off assumes that no reduction in footprint would not affect (i.e. worsen) GES.

When exploring trade-off, the size of the patches to be protected (and not only the total area) shall be taken into account. Indeed, the effectiveness of protection could increase by protecting larger areas protected rather than multiple very small units.

3.3 Group C – Managers

The Managers group need to find the balance between the value of landings, jobs and value for communities with the red listed habitats. For some habitats focus need to be on the seabed, while for others it can be other components, e.g. also pelagic fisheries, and the debate could be widened to the wider ecosystem. It is also important to consider impact from other sectors impact on the seabed than the fisheries when considering seabed protection.

A challenge is also that most people would care more about, e.g. cetaceans than benthic species in regards to nature protection. It is important that no species should go extinct, and the most vulnerable species are often the top predators. It is important to have a healthy state ecosystem to support all aspects of it i.e. top predators and ecosystem services and climate change resilience.

Clear targets, supporting information and a log of changes and reasons would be useful for managers, as legislation is evolving, making it difficult to follow for stakeholders. It is important when applying legislation correctly to use evidence appropriately to reach proportionate decisions, taking into account uncertainty should to reach applicable conservation objectives. A focus on communicating decisions and ensuring transparency and understanding across sectors.

Conservation objectives are three different things: conservation of seabed habitats, protection of fish stocks and protecting the fishermen and their livelihoods. In protection of the seabed, hopefully a wider protection of the wider environmental protection will follow. Managers have to each GES but also keep the effects in the economic picture in mind, not to compromise conservation objectives but allow dialogue and options in how that can be achieved.

Another aspect of the management is the completion for space between sectors, so the question is also in the wider picture or global perspective if the key fishing grounds can be protected. Fishing isn't evenly distributed, and closing the productive areas with the most fishing is counterproductive, as it will result in displacement to less productive areas, which will result in higher fishing intensity to get the same catch. If you want a coherent network of protection for all habitat types then you may have to take a small part of the heavily fished areas.

To take fishing from smaller fishing vessels into account in marine spatial management, a way to track small fishing vessels is on the wish list. In the Baltic Sea, a phone app is used in regards to protection of harbour porpoises.

There are number of different overlapping time scales in regard to seasonality of fisheries, quotas, recovery times of species, marine spatial planning activities and viability of fisheries. There is a very short term financial resilience of the inshore sector in particular. Issues in relation to time-scale are how we adjust management of fisheries in a way that changes doesn't happen overnight, but there needs to be transition, e.g. to other areas or other gears etc. Ecosystem recovery doesn't happen overnight but it's very important to track the changes to quantify what the improvements might be, as this evidence will be important in justifying the management measures and how well they work requiring monitoring.

For quantifying what is valued, any metrics or indicators should allow for flexibility to make it locally appropriate. In the long run you can look at indices (ecological gains) but initially percentages/proportion of habitats areas is good to start with. Total landing values and landing values per harbour should be calculated to ensure that areas are not being disadvantaged. Landings or value of landings for fisheries should also consider fishing opportunities or effort as this doesn't depend on the density in an area or the market value. It is easier to track the proportion of disturbance than it is to assess environmental indicators. A simple metric would be fishing effort per area per habitat.

4 Management options

The Working Document (Annex 4) has identified different management options that can be applied to the management of mobile bottom-contacting gears, following a recent publication of McConnaughey et al. (2019).

Participants in each breakout group were asked to 1) select preferred management options (e.g. 3-5 options) from Table 1, 2) come up with a few strength and weaknesses for each and 3) come up with a better alternative (for those with more weaknesses) or to provide new options.

Table 1. List of management options.

Measure/action	Objective
Technical measure	
Gear design and operations	Reduce impacts and maintain or increase catchability of target species
Gear switching	Use alternative gear with reduced impacts to catch target species
Effort control	
Reduction of effort	Reduce impacts by reducing fishing activity
Spatial control	
Prohibitions by gear type	Eliminate high-impact gears in a defined area
Freeze trawling footprint	Confine impacts to currently disturbed areas
Prohibitions by small-scale habitat type	Protect small-scale sensitive habitat
Multipurpose habitat management	Broadly protect essential, representative and vulnerable habitats
Impact quotas	
Habitat impact quotas	Habitat conservation to protect benthic biota

Participants were also asked to comment on different options that were further explored in Annex 4. These options are organised as a nested set of more and less detailed scenarios:

- The progressive removal of total MBCG fishing effort.
- The progressive removal of fishing effort of particular individual MBCG metiers.
- Progressive removal of all MBCG fishing effort for each broad-scale MSFD habitat.
- The removal of effort until the estimated impact in each benthic habitat is reduced.

These four options removed effort by either starting from the least or most fished grid cells over the period 2013 to 2018.

Lastly, participants were asked to comment on a final option that freezes the footprint:

- The freezing of MBCG fishing activity to the 2012 to 2014 fishing effort footprint or freezing it to 90% of c-squares that are most fished;

4.1 Group A – Fisheries representatives

Technical measures

Gear design and operations are viewed favourably and can be very effective in limiting damage. Industry has experimented with gear modifications that changed discards and seabed footprint. This is damage that is not in the interest of fishers. However, this positive feeling centres round the fact that catchability remains variable, the cost is taken into account, and that changes can be picked up in the trade-off decision around the seabed. The role of verification gear impacts on the seabed was noted as needed.

Gear switching could be seen as an extreme variant of gear design. Investment in switch should be made and the process needs to be controlled – but this is not a preferred option – there is a social economic cost – licence value/viability of the business model. There is a real danger that the switch is causing competitive market issues, if switching is a blanket measure across a sector, with the switching requirement to set up a barrier to market entry. The nature of the gear that the industry switches to must also be regarded as better – and this should be evidence based. In terms of modelling, scenario modelling of more actors within a sector should be considered as this may have displacement effects and cause environmental harm.

Switching negates examining advances in gear design. This is preferred. Switching gear can result in switching impact from the benthic organisms and habitats to bycatch of mammals, birds and turtles.

Effort Control measures

Minimisation measures of effort were seen to be preferable to spatial measures as there is flexibility in operation for those in the industry.

Reduction of effort: It was hoped that advice could be given as to what the acceptable minimum impact is to enable gear and effort levels be altered/adjusted to allow freer access to fishing grounds. If some areas are on effort control and others not, you force fisheries to displace to the non-effort-controlled area which may create unwanted side effects. Effort control has to be linked to the habitat that you want to protect and to the specific gear that causes a certain impact; it makes less sense as a measure "to just remove total effort". It was noted that effort control is not really effort control in the working document (Annex 4) but a spatial management measure.

Spatial control measures

Real concern expressed around spatial measures due to displacement and gear conflicts and due to the lack of flexibility in exploiting fishing opportunities. With recovering fish stocks, we could end up with a much more productive fishery and not be able to fish them sustainably.

One benefit of some spatial measures was that it was recognised that it would allow for proper monitoring of benthic state without fisheries. It was felt that such a context, relating to wider (environmental) disturbance pressures outside fisheries, is needed. If this were to happen, static gear (i.e. all anthropogenic abrasion pressures) should be prohibited as well.

Freeze trawling footprint was seen as a very blunt option, not especially linked to impact, and not desirable. It was noted that freezing active areas to historic levels means fixing to a scenario that may no longer exist. We are not matching spatial areas to current need. There is also a need to put the size of the area of such freezes within an historical context – the footprint is the smallest it has been for decades. Freezing footprint to 2012 -2014 will not take account of the reduction in effort that has happened over the past 20 years - could result in opening up areas that have in years not been fished with MBCG

Prohibitions by gear type is preferred to the above as it pays attention to the actual impact. Some management has been done through prohibition, e.g. prohibition of MBCG in Natura 2000 areas. Yet, the same issues as with gear switching apply – avoidance of blanket measures, block to sector/market entry. Additionally, prohibitions of gear may bring displacement issues if many boats are concentrated in a small area.

Prohibitions by small-scale habitat type/ multipurpose habitat management: Spatial controls are not preferred, but both these options have a more targeted feel on the benthic features. The preference was expressed for high granularity targeting benthic sensitive features, not block effects. The more targeted approach is preferred over something broader. Any measures need to be applied at a fine scale and should be site specific – that way, fragmentation due to closing or opening areas is not a problem to the industry.

Consideration could be given to defining areas where fishing could take place rather than defining closed areas. Yet, the fished/unfished dichotomy does not facilitate a shift to lower impacting gears such as from beam to seine net.

It was noted that further differentiation of impact by gear types and vessel sizes could promote appropriate measures that allow low impact fisheries in some areas. GES should be kept in mind when making these decisions rather than arbitrary closures.

Not very clear how the small-scale habitat management measure may link to the current implementation of GES/MSFD.

Impact quotas

Habitat impact quotas: The option was regarded as attractive in that it allows industry to manage their affairs. This was seen as a results-based approach. However, it was noted that governance system would be complex and would require administration and data support. Coupling this with gear design could be beneficial.

Five selected management options

None of these options were seen as desirable given the previous discussion over blanket spatial measures. The first option was seen as very blunt and could affect a sector hardest that is not a big issue. The second option was trying to spread the reduction widely – but is this in any way getting at the heart of the issues of which gear is the worst and how to improve/replace it. The third option is seen as trying to represent habitats but again impact not considered. The fourth option is seen as better as the end point is the habitat, but a spatial option like this is not preferred. What is the mechanism if a sector improves? Will we see an expansion of the area? Could option four test spatial shifts against changes in gear type? Option 5 was seen a retrograde due to the previous comments on freezing fishing.

Recommendations

The group suggested to add gear modification as an option to examine. This could be a notional % of improvement on a single metier or a suite of metiers. It looks like the modelling approaches used could handle it and it would provide impetuous to current gear modification projects.

Impact quotas – could this be included? We understand that this could be a problem for the model.

It was assumed that all 5 scenarios will be tested against the status quo – the group felt the need for this. There was a call for more data relating to the improvements in the benthos brought about by decades of effort reduction. The role of verification data was stressed on the actual benthic state of the seabed over modelling methods to predict benthic state.

Progressive removal of c – squares: low effort or high effort first? Social and economic impacts need to be considered. The selection of habitats and species in areas of low fishing activity should be preferred – this has limited economic cost and the seabed is presumably in better state (goals more likely to be achieved). Fishing is an economic activity and maximising rate of capture is of importance.

4.2 Group B – Conservation NGO representatives

Technical measures

Gear design and operations are seen as a non-effective option regarding the protection of the seabed. Indeed, if the goal were to ensure the community to recover, any disturbance (to the benthic habitat) would not guarantee a recovery of ecosystem structure and functioning, especially when sensitive habitats and vulnerable structuring species are taken into account. Also, geomorphic structures and ecosystem services (e.g. biogeochemical cycles) could be damaged even by "low benthic impacting gear". It is critical not to loose sight of the overarching ecological objective of restoring the seabed.

Gear switching from benthic impacting fishing gear to non-benthic impacting gear (e.g. static gears) is thus considered as the only viable option if seabed protection is taken into account, thus ensuring that a large proportion (to be determined) of seabed habitats will not directly be affected by benthic impacting gears. Of course, the impact of alternative (static) gear should be also assessed in terms of interaction with other species to ensure its sustainability. Gear switching in this context seems an option that could allow socio-economic negative effects to be minimised and counterbalanced. This option is also favoured to instigate a transition model to low-impact gears, phasing out most destructive permanently, and delivering long lasting benefits for the seabed.

Effort Control measures

Reduction of effort was not seen as an effective option by the group. The reason is the same as what explained about gear design and operations: the reduction in the effort would not guarantee the protection of (benthic) ecosystem structure and functioning, nor its recovery.

Spatial control measures

Spatial control measures were seen (in general) as those conveying potentially better results.

Prohibitions by gear type were considered the most suitable approach. The prohibition should be applied to all benthic impacting gear and in all habitats, allowing to protect a certain proportion from direct disturbance. The proportion may differ according to habitat and areas (coastal vs- open sea). The assessment of displacement should be considered when considering this option. For NGOs, the management approach of nearshore restrictions and zoning should be considered and prioritised.

Freeze trawling footprint was not seen as a relevant option. Indeed freezing trawling footprint would not guarantee to reach any environmental goal, and would not guarantee that current footprint (set at current or, as proposed 2012-2014 limits) will not determine in any case a progressive deterioration of environmental status.

Prohibitions by small-scale habitat type were seen as a useful approach especially if put in the context of the coastal area. However, the application of protection at the very fine spatial level would imply the need for high-resolution habitat maps (not frequently available), and spatially explicit complex measures, thus limiting the potential applicability of the measure. Also, other pressures might be present in coastal areas. In this context, the adoption of protection measures able to protect completely the coastal habitats from MBCG would be more effective. Measures as adopted in the Mediterranean Regulation (Reg. 1967/2006) banning trawling (e.g.) within 3 NM or in shallow water (above 50m) shall be considered and adapted to the specific cases in the Northern Atlantic, where similar sensitive habitats - e.g., vegetated coastal habitats - exist and their distributions are broadly available.

Multipurpose habitat management was considered as an option in particular on the open sea, where a large portion of BHT could be protected owing to their role as EFH, ad/or the presence of sensitive habitats and so on. What would be relevant would be to ensure that the extent of each habitat would be left not disturbed by MCBG. This extent shall be defined to allow reaching GES.

Impact quotas

Habitat impact quotas: the group considered that the option was not associated with enough details to comment on its potential applicability and validity to contribute to reaching MSFD goals and in particular GES for the seabed.

Five selected management options

The group reflected on the different options confirming the general preference (as described above) concerning the application that would be considered more interesting to explore in the trade-off analysis. Still, concerns about the capability to fully represent the costs and benefits for the fishery sector and the benefits in terms of ecosystem services (see previous paragraphs) were remarked. When exploring the options for a reduction in fishing pressure from the least exploited and the most exploited cells, preference was given for the first approach. Still, the group remarked the need to ensure, in any case, protection in (part of) heavily exploited fishing grounds. Also, the size of patches where trawling would be not allowed (granularity) was seen as a relevant issue, also to be considered (as larger “patches” were assumed to determine better results.

4.3 Group C - Managers

The preferred management options could be a combination of measures, and there needs to be flexibility, looking at the circumstances. In addition to the spatial management options, temporal closures could be important, e.g. seasonal closures for spawning seasons/nursery areas.

	Advantages	Disadvantages
Gear design and operations	For example removal of tickler chains in their inshore IFCA has been done. Clearly are a 'good' thing to do.	Difficult to quantify improvements.
Gear switching	Switching from trawling to pot fishing improves quality of habitat and fish stocks. Shellfish grow larger and higher market value.	Has implications to business models, different companies, different size vessels, different crew levels.
Reduction of effort		Important to take intensity into account
Prohibitions by gear type	Easier to realise and communicate. Good approach that gets you the result you want.	Needs to be spatial. Would other gears come in to fill the space? Need to understand what this means for displacement. Safer to ban groups or gears?
Freeze trawling footprint	Is it better to allow intense fishing in specific areas if we know that they are productive?	Relatively stable footprint so difficult to see what effect it would have, doesn't feel like it would be a significant affect. Protecting the core areas would be more useful. Fishers are concerned with loosing freedom of choice and flexibility. This only works if we're quite happy with the current footprint.
Habitat impact quotas		Complicated, this requires quite quick regenerating habitats.

Starting with the most or least fished c-squares?

If you close the highest fished c-squares , it would have most economic impact on the fishery and probably result in displacement, giving a lose-lose scenario. If you only remove least the fished c-squares, then you may never help out certain habitats, it doesn't give you a representative protection across habitats. Depending on the size of the removed area from the higher fished c-squares it doesn't necessarily mean displacement to a previously unfished area. Ideally, figure out how much habitat you need to protect of each type and find the areas where you find good examples of them, in combination of little fishing.

Thoughts on options 1-5:

1. **The progressive removal of total MBCG fishing effort.**
   Options 1 and 2 wouldn't ensure protection of all habitat types and might not protect characteristics of areas. They doesn't comply with the MSFD approach in that sense.
2. **The progressive removal of fishing effort of particular individual MBCG metiers.**
   Assumes no increase in other métiers. But this could be wrong, there could be "displacement" over métiers.
3. **Progressive removal of all MBCG fishing effort for each broad-scale MSFD habitat**

4. **The removal of effort until the estimated impact in each benthic habitat is reduced.** If the fishing effort is removed then the quality of the seabed in that area should recover, but if you fish in other parts of that habitat then the impact in those areas remains the same or increases, so parts are recovering and parts of worsening. So how does this scenario work? Recent advice from ICES produces an average impact per habitat type. From an MSFD perspective two values would be needed: how much is in high quality and how much is in worse.
5. **The freezing of MBCG fishing activity to the 2012-2014 fishing effort footprint or freezing it to 90% of the core area.**

Final thoughts

Another possibility is removing all fisheries (i.e. not just MBCG), as there is an effect from anchoring lines etc. that would have a bigger impact on an area so requires smaller areas to achieve the same protection (this includes static gears and midwater trawls etc).

The lack of data for small vessels needs to be looked into in the future to validate the assumptions we're making about unfished areas.

4.4 Points raised in the plenary discussion

The chairs commented on why the technical measures including gear modifications are not being tested. The challenge is lack of economic data. It was also questioned why the impact quota is note being tested, as it was done in the EU Benthis project.

It was concluded that both subgroups A and B are seeing the benefits of protecting highly sensitive habitats.

It was confirmed the fisheries representatives generally prefer an effort reduction removal from the lowest effort c-squares, though in some areas, e.g. which are important for juvenile fish and important food chains, a reduction from high effort c-squares is preferred by some fisheries representatives.

It is a remaining challenge to identify and estimate the fishing effort by small vessels deploying MBCGs – typically operating in coastal waters. ICES have looked into using AIS data, however, these data are currently not available to all relevant scientist in EU, furthermore the AIS data is not (yet) linked to logbook information, and there is no coordinated effort in the EU to solve these issues. Solving this is important for the estimates of fishing impact in coastal waters in particular.

5 What outputs communicate the trade-offs well?

Participants in each breakout group were asked to share ideas for understandable and useful outputs, reflecting what has been discussed in the group regarding trade-off and management options. How would you like to see outputs from analysis presented? Graphs, tables, maps. Do you need specific groupings of e.g. fishing gears, areas, habitats?

The examples below present the same information in a graph (Figure 1), map (Figure 2) and table (Table 2). Other examples are in the working document (Annex 4).

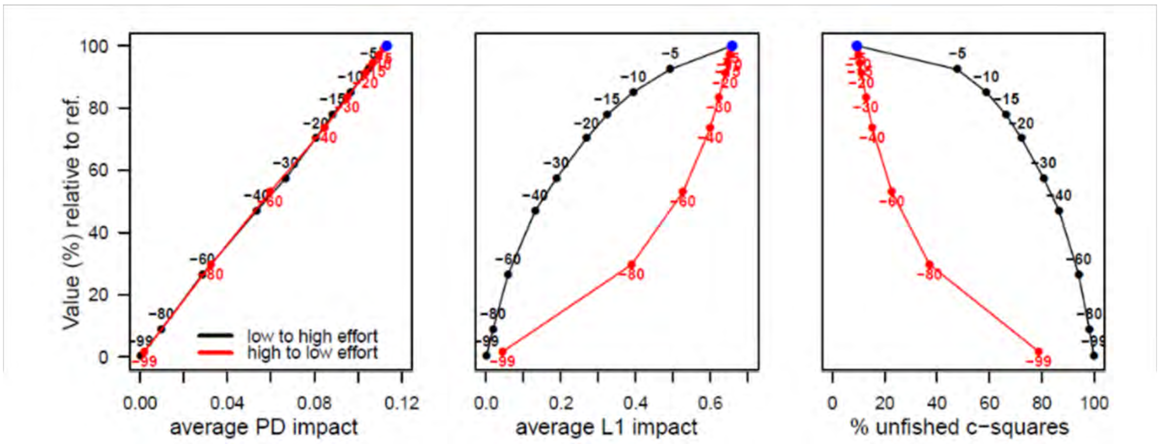


Figure 1. Progressive reduction of effort from 5% to 99% visualized in a graph.

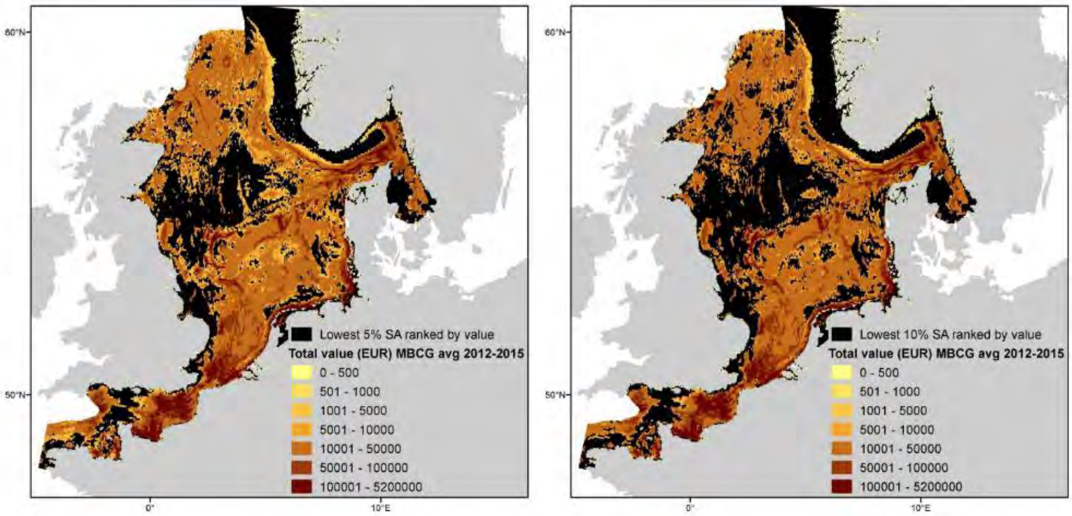


Figure 2. Progressive reduction of effort - low effort cells first – visualized in a map. Black areas are all unfished grid cells and the lowest 5% (left panel) or 10% (right panel) ranked by value.

Table 2 Progressive removal of effort (low effort cells first) shown in a table.

Effort reduction	PD impact	L1 impact	% unfish-ed c.Sq	% decline in value	% decline in weight
0	0.11	0.65	9	0	0
5	0.10	0.49	48	8	8
10	0.10	0.39	58	15	15
15	0.09	0.32	66	23	24
20	0.08	0.27	72	30	27
30	0.07	0.19	80	43	38
40	0.05	0.13	86	54	48
60	0.03	0.06	94	74	75
80	0.01	0.02	98	91	92
99	0.00	0.00	100	100	100

5.1 Group A – Fisheries representatives

Maps

These are vital to show the spatial information and are easy to understand. The problem that lies with these maps is that they show a static picture. Footprints will change with time and will be different in the future. There is need to reflect this – perhaps more interactive.

It is also missing layers that give vital context. Layers for habitat type, and SAC, MCZ, MPAs, wind farms, etc., would be useful. A breakdown using larger scale maps might also be useful.

An accompanying map would be helpful that shows ports and the metier usages of grounds (including static gears – especially in areas that are seen as unfished). A regional map and sub-region maps showing where the fishing metiers from the different ports are fishing, i.e. distant water fisheries as well as local fisheries would be helpful to show where and why the contradic-tions and displacement processes occur.

Time period – maps are too fixed in time. For example, cod fishing effort in the Kattegat is not apparent, but the hope is that it will return (similar issues for sandeel fisheries that tend to "go around" grounds in a cyclical nature). Cycles in usage will be apparent for other fisheries, also. Another issue is for those years where political access restrictions for certain nations change – will this always be locked off, regardless of an opening?

Maps also have the illusion of producing complete picture when we know data is missing, e.g. < 12m coastal areas, etc.

Important note: c – squares are large blocks and may be overstating the footprint. Is it fair that spatial measures are applied on this basis? I pass through a 36km sqr cell registers the same pressure as 30x tows. The power of these percentages is very strong when it comes to lobbying and they should be used with care. Can we at least determine the margin of error around these footprints given work elsewhere? Also, the lack of smaller vessels means that we may put spatial controls on areas that are high value, but we just do not know that they are.

Plots

They have a comparative usage, but this can come from tables that are not as difficult to interpret. They do tell the entire story at once (not in many rows) and are suited to the addition of thresh-olds. Comparative value reductions in the graph are harder to discern than from a table.

It was felt that the plots presented show a theoretic trade-off (0% - 100% options) and lack the thresholds that really tells us what will happen. The PD impact numbers were seen as somewhat esoteric. How far off are we from where we need to be in terms of GES?

It was noted that 100% activity on the plots might not be 100% in actuality, as temporary effort reduction may be taking place.

Plots lose spatial relevance/context, and this is significant.

Tables

Tables allow for accompanying metrics. Weight and Value give context – but what is the sector, locality break down? The number of vessels could also be useful, but could this be done?

Thresholds are hard to show on a table – unless in legends.

5.2 Group B – Conservation NGO representatives

The group discussed both the range of output that could better convey the results of the trade-off analyses and the scale of the assessment that would need to be reported.

It was pointed out that in the current figures and tables a reduction in impact always results in a reduction in value. This is a fundamental flaw as, for example, studies in Scotland have shown no reduction in value or even positive effects from fisheries restrictions within MPAs (Marine Scotland 2020, Williams et al. 2020).

Regarding the output, maps were considered as a valuable and easy mean for communicating the outcomes of the analysis and the preferred option.

However, maps would need, in any case, to be complemented by further documentation. In particular, tables (e.g. table 2) were seen as a better option than graphs (e.g. figure 2) when willing to represent the effect of a measure on a response variable (costs/benefits) or a relationship among them. Therefore, these means for communicating the outcomes of the analyses should be prioritized, although they could be still associated with further graphical elaborations.

The group considered the spatial scale of the assessment to be very relevant. Indeed, the assessment and its reporting are set at the regional scale, while the group felt that this should be accompanied by a national level (or better EEZ scale) assessment/reporting, allowing to represent what would be the implications of any option in the trade-off assessment also at this finer scale. This would be essential to understand the full implications of the trade-off analyses. This would also imply to generate maps with enough spatial details.

It would be relevant to test the implications of applying the management options at the whole regional level or within each EEZ since this would have clear effects on the protection of some habitats/sites. The group supported the value of sub-regional and national scenarios/targets to better understand trade-off implications at different geographical levels and to limit effort-sharing across areas or countries.

The temporal scale is also relevant, in the sense that some benefits may arise only on a medium-term scale; these seem to be underrepresented while the analyses seem to be biased towards short-term costs.

Ideally, the trade-off results should also take into account/convey information on the likelihood/probability of meeting management objectives under different management options (e.g., a certain % in the reduction of effort, or % of seabed closed to trawling) (see for instance the Kobe plot in fisheries science).

5.3 Group C - Managers

The question is who are we communicating to? The people we are communicating with will have to communicate that further. A preference for visual output such as maps and graphs but it is important to have supplementary tabular information. In IFCA experience fishermen prefer nautical charts than maps when its small scale so they can relate that to features they recognise.

The subgroup agrees that they would like to have access to shapefiles and the extracted data, and that they would like to see the maps by habitat type, a on a detailed scale, separate map or table for each habitat type. The finer the resolution of tabular data the better, so that users have the option to aggregate it and can process it for their own needs.

There is a preference to see visual representations of data and for each habitat type or characteristic by itself, but tables are more important for reporting.

The graphs are more difficult to understand than the tabular data, an advantage is seeing the complete range 0-99 in this case. It makes the balance between the trade-offs very clear.

Cumulative maps would be useful, to see the intervals that would be removed with a colour ramp, 5% intervals. There is also a need to consider the practicality of producing so many figures within the ICES advice reporting.

Having an interactive web facility/live online tool where you could go in and select your own habitat types and metiers to see percentile maps would be extremely helpful as it's difficult to pre-empt what the specific management combinations will be. It would also be useful with contours.

TG seabed would like to see the evaluation by habitats etc. nationally. It is also important to remember that more than just fisheries goes into setting the thresholds.

Uncertainty and measures of confidence is important. The example figures and tables shown in the WD are very clear and takes out the emotions/arguments from stakeholders.

Communication on MPA's: fishers may see MPAs as territory that they can never get back regardless of there being an evidence basis for the success of the MPAs or not, this may be why seasonal closures are favoured by fishers.

5.4 Points raised in the plenary discussion

The results could be presented using a KOBE matrix as is done in the Tuna fishery.

Graphs assume linear relations between footprint, effort and landings, however, when we look at historic data there has been an increase in footprint, a reduction in (some metier's) effort and (as shown in SFF presentation) roughly stable landings. This shows the relationship does not conform to the linear one posed in the example graphics.

"The results do not show benefits for the environment or economy (value in the form of price and/or weight).

The regional scale assessment for MSFD should also consider subdivisions to encompass biogeographic characteristics and differences and relate to habitat types

Also, assessment is needed at the national EEZ scale to be operational for management

6 Final remarks and future steps

The chairs highlighted some of the points (not comprehensively) that were raised by stakeholders during the meeting. These points, and any additional comments, are listed below for each topic.

The chairs mentioned that the stakeholder suggestions will feed into analyses in a technical workshop where these trade-offs will be quantified for each management option, where tools and data are available. Where this is not possible, the technical workshop will identify science to develop to address currently unachievable scenarios and trade-offs.

Topic 1: Trade-offs

- It was clear that fisheries value flexibility and continuity of fishing opportunities in a changing world, in both space and time, and value maintaining jobs in fishing communities. The point of maintaining the livelihood of fishing communities was re-emphasized.
- From a scientific perspective, changes in gear modification and changes in gear type are on a continuum.
- Different groups of stakeholders mentioned the importance of evaluating broader ecosystem services.
- Evaluations should consider the area of habitats as well as the quality within habitats.
- How far does the current MPA network take us to reach the GES objectives?
- Connectivity of MPAs is important
- There are currently different management measures being implemented, e.g. MPAs (Natura 2000 and MSFD) and windfarms. No metric is currently able to estimate the consequences of these measures on the environmental status. Most of the MPA/windfarm changes have yet to occur. In addition, there are developments of permanent / sub-permanent structures and sand and gravel extraction; these other human activities should also be mapped.

Topic 2: Management options

- All groups highlighted to prioritize the greatest gear impact on most sensitive habitats
- Habitat credit approach (or habitat impact quota) has the potential advantage to merge different approaches. Do we know which measures may work in combination, and which not?
- The fisheries representatives expressed concern around spatial measures. The group highlighted the importance of flexibility, and analyses should try to quantify the importance of flexibility for fisheries.
- Conservation representatives found spatial measures essential. They feel that complete removal of all effort in some areas is needed, because reductions in effort or technical measures are not enough.
- There was consensus across groups to start reductions in effort from the least fished cells.
- Freezing the footprint was unpopular with all groups.
- Effects of displacement is important. Every member state has obligations in relation to the MSFD. There is a risk of displacement to other member states areas, which can be spatial as well as temporal.
- Any change of MBCG effort since the mid-90s and its effect on benthic state should be documented where possible.

- Small-scale habitat protection of particularly vulnerable habitats was considered important by more than one group but may not be compatible with the MFSD approach which targets broad-scale habitats.
- Additional options that could be considered to evaluate in the technical workshop are:

    1. Non-spatial effort reductions
    2. Technical measures, gear modifications, can be done with some assumptions.
    3. Habitat impact quotas, complex to implement, but worth exploring in future work

<u>Topic 3 – Presentation of the results</u>

- Interactive maps that allow exploring the process outputs were mentioned several times as a means of allowing stakeholders to explore results for areas that suit them and overlay outcomes with other pressures.
- It was considered important to evaluate uncertainty around the pressure and impact indicators.
- Tables were considered easier to read than graphs by many stakeholders, but graphs might be more useful when evaluating thresholds

7 References

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Annex 1: Agenda

4th March 2021

10.00 – 11.00	Welcome *Eugene Nixon (ICES)* • House rules • Presentation of the process Presentation round: Name, organisation, interest in the topic Introductory presentations *David Connor and Michel Sponar (DG ENV)*: • Background for the 2021 request *Josefine Egekvist*: • 2017 ICES advice to DGENV • Working document *Jan Hiddink* • Trawl impact assessment methods • What input do we need from stakeholders?
11.00 – 11.15	*Break*
11.15 – 11.45	Introductory presentations continued
11.45 – 12.30	Presentations from stakeholders on balancing the trade-off between the fisheries and protection of the sea-floor (15 minutes each). • Fisheries representative perspective: *Kenny Coull, Scottish White Fish Producers Association Limited* • Conservation NGO perspective: *Nicolas Fournier, OCEANA* • Environmental Management perspective: *Stephen Thomson, Eastern Inshore Fisheries and Conservation*
12.30 – 13.30	*Lunch break*
	Subgroups to discuss questions. The workshop participants will be split into three groups. • Group A consists of representatives of fisheries organisations and is chaired by *Phillip Boulcot*. Click here to join the meeting • Group B consists of representatives of conservation NGOs and is chaired by *Sasa Raichevich*. Click here to join the meeting • Group C consists of representatives of environmental and fisheries managers and governmental advisers and is chaired by *Genoveva Gonzalez-Mirelis*. Click here to join the meeting Each subgroup will report back in plenary after their discussion.
13.30 – 13.40	Introduction to subgroup topic 1: **What do we "trade-off?"** – *Josefine Egekvist*
13.40 – 14.30	Subgroup topic 1 • What do we value? What do we want to maximise? What is important to this sub-group? Time scale? • How do we quantify what we value (metrics)?

14.30 – 15.00	Plenary subgroup 1: subgroup chairs or rapporteurs report back
15.00 – 15.15	*Break*
15.00 – 15.15	Introduction to subgroup topic 2: **Management options** – *Jan Geert Hiddink*
15.15 – 16.00	Subgroup topic 2 • Select preferred management options (e.g. 3-5 options). From the table, or new options. For each come up with a few strength and weaknesses. For those with more weaknesses, come up with a better alternative

5th March 2021

10.00	Start
10.00 – 10.30	Plenary subgroup 2: subgroup chairs or rapporteurs report back.
10.30 – 10.45	Introduction to subgroup topic 3: **What outputs communicate the trade-offs well?** – *Josefine Egekvist*
10.45 – 11.30	Subgroup topic 3 • How would you like to see outputs presented? Graphs, tables, maps.
11.30– 12.00	Plenary subgroup 3: subgroup chairs or rapporteurs report back
12.00 – 12.15	*Break*
12.15 – 13.00	Final discussions and conclusions. What will happen next - *Josefine Egekvist and Jan Hiddink*

Annex 2: List of participants

For each participant, the subgroup attended is indicated:

***Subgroup A:* Representatives of fisheries organisations**

***Subgroup B:* Conservation NGOs**

***Subgroup C:* Environmental and fisheries managers and governmental advisers**

Name	Institute	Country (of Institute)	Email	Subgroup
Alice Cornthwaite	JNCC	UK	Alice.Cornthwaite@jncc.gov.uk	C
Dale Rodmell	National Federation of Fishermen's Organisations	UK	Dale.Rodmell@nffo.org.uk	A
Daniel van Denderen	ICES	Denmark	daniel.vandenderen@ices.dk	
David Connor	European Commission DGENV	Belgium	david.connor@ec.europa.eu	C
Eirini Glyki	ICES	Denmark	eirini@ices.dk	
Elena Balestri	Scottish Fishermen's Federation	UK	e.balestri@sff.co.uk	A
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Annex 3: Resolutions

WKTRADE3 – A series of two Workshops to develop a suite of management options to reduce the impacts of bottom fishing on seabed habitats and undertake analysis of the trade-offs between overall benefit to seabed habitats and loss of fisheries revenue/contribution margin for these options.

WKTRADE3 responds to a special request from DG Environment. The two Workshops will be chaired by Josefine Egekvist (Denmark) and Jan Geert Hiddink (United Kingdom) and will be held 4-5 March 2021 and 6-9 April 2021 in Copenhagen, Denmark.

In preparation for the Workshops, a Core Group, consisting of the two Chairs of WKTRADE3, invited experts and members of the ACOM Leadership and the ICES Secretariat will be established. The Core Group will prepare a TRADE3 Working Document Draft 1, designed to describe the potential management options and the methodologies for undertaking the trade-off analysis. This Working Document will be built up incrementally to facilitate additions and modifications at each of the steps set out in the ToRs below.

TRADE3 Working Document Draft 1 will be based on the demonstration assessment contained in the 2017 ICES advice, *"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"* (sr.2017.13). It will receive input from WGFBIT, in particular on how the developing process described therein can be made operational. The document will be amended by the Core Group into TRADE3 Working Document Draft 2.

TRADE3 Working Document Draft 2, will be presented to the European Commission's (EC) Technical Subgroup on seabed habitats and sea-floor integrity (TGSeabed) for comment and input. Following this, TRADE3 Working Document Draft 3 will be prepared by the Core Group. The TRADE3 Working Document Draft 3 will be peer-reviewed to ensure the best available, credible science has been used and to confirm that the analysis provides a sound basis for the developing advisory product.

TRADE3 Working Document Draft 3 will be used as the input to the first of the TRADE3 Workshops, the Stakeholder Workshop scheduled for 4-5 March 2021.

ToRs for the March 2021 WKTRADE3 Stakeholder Workshop are:

a) Present TRADE3 Working Document Draft 3 to the workshop participants to inform them of the progress to date and the ICES process to finalise the TRADE3 Advice response to the EC.
b) Review the management options identified to reduce the impact of Mobile Bottom Contacting Gears on seabed habitats (e.g. are there options missing) and the criteria used for their prioritisation.
c) Input from the workshop participants on whether the proposed trade-off analyses in TRADE3 are informative and produce outputs that stakeholders need.

Participants for invitation to the Stakeholder Meeting will be selected in conjunction with DGEnv.

Following WKTRAD3 Stakeholder Workshop, the Core Group will update the working document to TRADE3 Working Document Draft 4. This will be used as input to the TRADE3 Technical Workshop, scheduled for 4 days during April 2021.

ToRs for the April 2021 WKTRADE3 Technical Workshop are:

a) Review TRADE3 Working Document Draft 4 to the workshop participants.
b) Review and evaluate for each management option identified in TRADE3 Working Document Draft 4 any potential consequences to the ecosystem, including commercial fish stocks that could arise, if greater areas of seabed are left undisturbed by bottom fishing.
c) Conduct an analysis of spatial and temporal variation in fishing intensity appropriate to assess the footprint of mobile-bottom contacting fishing gears in a six-year management cycle. The analysis should include an estimation of the proportion of 'core fishing grounds' and should determine the spatial variation in 'core fishing grounds' over time.
d) Produce an estimate, where possible, of the revenue and contribution margin associated with the fishing activity per area by integrating fisheries economics data (e.g. STECF AER) with VMS/logbook data for all mobile-bottom contacting fishing gears and per gear grouping in (sub)regions.
e) Produce regional-specific assessments of pressure and impact of bottom-contacting fishing gears on the seabed and of trade-offs in fisheries and seafloor habitats, based on available data and building on the 2017 demonstration advice *"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"* (sr.2017.13). The assessments will follow the methodology set out in the TRADE3 Working Document Draft 4. For data poor areas, only part of the assessment will be run, and key data/knowledge gaps will be identified. The assessments should include a trade-off analysis between fisheries and seafloor habitats, i.e. overall benefit to the seafloor, relative to loss in revenue/contribution margin, for prioritized management options identified in the TRADE3 Working Document Draft 4.

Experts from ICES WGs (WGSFD, WGFBIT, WGECON), as well as, other regional-specific experts will be encouraged to contribute to the Technical Workshop. Participants for invitation to the Technical Workshop will be selected by the Core Group.

In preparation for the workshop meeting, the Core Group will facilitate coordination and consolidation of work. The Core Group will also ensure that the workshop reports are finalized.

Supporting information

Priority	High, in response to a special request from DGENV on a set of management options to reduce the impact of mobile bottom contacting fishing gears on seafloor habitats, and to provide a trade-off analysis between fisheries and the seafloor. The advice will feed into ongoing efforts to provide guidance on the operational implementation of the MSFD.
Scientific justification	The demonstration assessment within the 2017 ICES advice (sr.2017.13) provided aggregate values for four types of bottom-contacting fishing gear groupings at the scale of the entire Greater North Sea region and in relation to the 2004 EUNIS habitat classification. In order to better understand the relationship between catch/value of landings and the levels of physical disturbance for MSFD purposes, this 'trade-off' analysis needs to consider the following two aspects: 1) Mobile bottom contacting fishing: at the level of fishing gear grouping, on the basis that this is likely to be a more appropriate resolution for management purposes. 2) Footprint/Impact on the seafloor: at the resolution of seabed habitat assessments required by the GES Decision (EU) 2017/848 (i.e. the MSFD broad habitat types, based on the EUNIS 2016 classification, and subdivisions of an MSFD (sub)region).

	WKTRADE3 will review a suite of options to reduce impacts of mobile bottom contacting fishing gears on seabed habitats (ToR b in Stakeholder and Technical workshop). This review should include any wider benefits/consequences to the ecosystem, including commercial fish stocks that could arise, if greater areas of seabed are left undisturbed by bottom fishing. This should include an exploration of the empirical evidence of options presented in two recent publications (Collie et al 2017; McConnaughey et al. 2020). Potential consequences (positive and negative) to the wider ecosystem should be identified to provide some ecosystem perspective to the trade-off question. Based on the review, WKTRADE3 will produce a prioritized list of management options for trade-off analysis and include the criteria used to prioritize. WKTRADE3 will develop a methodology that explains how each option is implemented in the trade-off assessment. WKTRADE3 will provide analyses of spatial and temporal variation in fishing intensity, catch and landings in a way appropriate to assess the footprint of mobile-bottom contacting fishing gears in a six-year management cycle (Technical Workshop ToR c-i). The analyses should be done for all mobile-bottom contacting fishing gears together and per métier grouping, covering different MSFD (sub)regions (Greater North Sea, Baltic Sea, Celtic Seas, Bay of Biscay and Iberian Coast) and the subdivisions of these MSFD (sub)regions. The analysis should summarize the results for the entire assessment region and per MSFD broad habitat type within the region, based on the EUNIS 2016 classification. The analysis should include an estimation of the proportion of area fished that covers 90% of value/landings (i.e. core fishing grounds) for each métier and per MSFD (sub)region/subdivision and should determine the spatial variation in 'core fishing grounds' over time. The analysis of fishing footprint and core fishing grounds will be estimated for (sub)regions and per métier grouping where VMS and logbook data is available. WKTRADE3 will review available data that can be used to estimate the revenue and contribution margin associated with the fishing activity per area (Technical Workshop ToR c-ii). Revenue and contribution margin associated with fishing activity will be estimated for one region by integrating fisheries economics data (e.g. STECF AER) with VMS/logbook data for all mobile-bottom contacting fishing gears and per gear grouping. This analysis will also be done, where possible, for other (sub)-regions. Results will be incorporated in the trade-off assessment sheets, with recommendations on how to improve the dataflow. WKTRADE3 will produce a prioritized list of management options, and for each option provide a trade-off analysis between fisheries and seafloor habitats, i.e. overall benefit to the seafloor, relative to loss in revenue and contribution margin (Technical Workshop ToR c-iii).
Resource requirements	ICES secretariat and advice process.
Participants	Stakeholder Meeting with relevant stakeholders from DG-Environment, DG-Mare, NGO's, National Fisher Organizations and representatives from national agencies. Technical 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 WGFBIT, WGSFD, WGECON CSGMSFD and SCICOM.
Linkages to other organizations	Links to OSPAR and HELCOM.

Annex 4: Technical working document

Draft working document describing a workflow to be used by WKTRADE3 to produce (sub-)regional-specific trade-off assessment sheets with available data, building on from the 2017 demonstration advice (ICES 2017).

Background

In 2016, the European Commission sent a request to ICES to deliver "advice 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 advised on a set of indicators for assessing pressure and impact on the seabed from mobile bottom-contacting fishing. These indicators were selected based on their ability to describe impacts on a continuous scale that can be used in the evaluation of trade-off between the fisheries and their impacts on the seabed. ICES provided a demonstration advice product (ICES 2017) for the Greater North Sea ecoregion to illustrate possible future approaches to annual advice on this topic.

The document set out below has been prepared by ICES in response to a new request of the European Commission to deliver "**advice on a set of management options to reduce the impact of mobile bottom contacting fishing gears on seafloor habitats, and for each option provide a trade-off analysis between fisheries and the seafloor**". The document includes a workflow that can be used to produce area specific trade-off assessment sheets with available data, building on from the 2017 demonstration advice (ICES 2017). The workflow includes proposals on key figures, tables and management options that will be produced in the trade-off analysis.

The document provides proposals on these figures, tables and options using illustrations from the Greater North Sea. Similar output of fishing footprint and benthic impact will be produced after review of the document for the Baltic Sea and for subdivisions of the Greater North Sea and Baltic Sea. For the Celtic Seas and Bay of Biscay and the Iberian Coast (and their subdivisions), no assessment of benthic impact is currently available and only an assessment of the fishing footprint will be included. For all other EU regions, part of the draft assessment will be prepared with key data/knowledge gaps identified. All footprint and impact assessments on the seafloor use the seabed habitat assessments required by the GES Decision (EU) 2017/848, i.e. the MSFD broad habitat types using EUSeaMap 2019.

Overview of document

This document provides information on a generic workflow to develop (sub-)regional specific trade-off assessment sheets with available data. The workflow document and subsequent trade-off assessment sheets should inform on the following:

a) Provide analyses of spatial and temporal variation in fishing intensity appropriate to assess the footprint of mobile bottom-contacting fishing gears in a six-year MSFD management cycle. The analysis should include an estimation of the proportion of 'core fishing grounds' and should determine the spatial variation in 'core fishing grounds' over time.
b) Develop and review a suite of options to reduce impacts of mobile bottom-contacting fishing gears on seabed habitats. This review should include any potential consequences to the ecosystem, including commercial fish stocks, that could arise if greater areas of seabed are left undisturbed by bottom fishing.
c) Produce a prioritized list of management options for trade-off analysis and the criteria used to prioritize.
d) Estimate, where possible, the contribution margin associated with the fishing activity per area by integrating fisheries economics data (e.g. STECF AER) with VMS/logbook data for all mobile bottom-contacting fishing gears and per gear grouping in (sub)regions.
e) For prioritized management options, provide a trade-off analysis between fisheries and seafloor habitats, i.e. overall benefit to the seafloor, relative to loss in revenue and contribution margin.

Chapter 1 of this document provides definitions and elaborations that will be used throughout the document and in the development of the region-specific assessment sheets.

Chapter 2 provides an overview of potential management options to reduce the impact of mobile bottom-contacting fishing gears on seafloor habitats. For each management option, we explain whether we aim to use it in the trade-off analysis and how (we aim) to implement the management measure.

Chapter 3 describes a methodology to estimate, where possible, the contribution margin associated with the fishing activity per area by integrating fisheries economics data (e.g. STECF AER) with VMS/logbook data for all mobile bottom-contacting fishing gears and per gear grouping in (sub-) regions.

Chapter 4 illustrates a draft assessment sheet for the Greater North Sea with key figures and tables to produce a region-specific trade-off assessment, appropriate to assess the footprint of mobile bottom-contacting fishing gears (and per gear grouping) in a six-year management cycle.

Most chapters include illustrations of current work as well as future actions (provided in a text box) that will be done after the review of this document.

Chapter 1: Definitions and elaborations

How to develop an assessment appropriate for a six-year management cycle?
We will develop an assessment of fishing footprint and impact that is appropriate for a six-year management cycle of MSFD assessments. The assessment maps and indicator values produced will be based on an average fishing intensity of the latest six-year (2013-2018). The use of an average stabilizes the fishing footprint and supports the calculation of impact indicators (which are based on equilibrium conditions). The 6-year average further corresponds to the recovery time of a high proportion of benthic organisms that are impacted by the trawl.

The assessment product will further show year-to-year variations in the pressure. This follows previous ICES advice highlighting that impact assessments for all physical disturbance pressures would benefit from taking variations in the pressure between years into account to get the most accurate estimate of impact (ICES 2019a). It may further allow managers to evaluate management options that were introduced part-way the six-year cycle. Lastly, year-to-year variation in the pressure will be used to evaluate changes in core-fishing grounds over time (as requested).

The assessment period is linked to the latest available fishing data, rather than to the MSFD Art 8 assessment periods (which might run from 2011-2016 for reporting in 2018, 2017-2022 for reporting in 2024, although there is debate about which 6-year period should be used as it depends on data flows per descriptor).

Which seabed habitat assessment units will we use?
All footprint and impact assessments on the seafloor will use the seabed habitat assessments required by the GES Decision (EU) 2017/848, i.e. the MSFD broad habitat types, based on the EUNIS 2016 classification (Evans *et al.*, 2016) and provided by the EUSeaMap 2019.

What is the spatial scale of the assessment?
ICES has currently adopted a 0.05° × 0.05° grid, hereafter termed c-square.

What is the temporal length of the assessment?
Temporal patterns in fishing activity are available from 2009 for vessels over 15m and from 2012 for vessels over 12m. Temporal variation in fishing activity will hence represent vessels over 15m (2009-2011) and vessels over 12m (2012-2018).

How are changes in the fishing footprint analyzed?
The coupling of VMS (vessel monitoring systems) data with logbook data is currently the most practical and cost-effective method for describing the spatial dynamics of fishing activities. To describe the fishing footprint, we will express fishing intensity as swept-area ratios (SAR). The swept area is calculated as hours fished x average fishing speed x gear width. The gear width is estimated based on relationships between average gear widths and average vessel length or engine power (kW), as stated in Eigaard *et al.* (2016) and using ICES expert input. The swept-area ratio is the sum of the swept area divided by the area of each grid cell (c-square). Therefore, the C-square SAR value indicates the theoretical number of times the entire grid cell has been swept if effort was evenly distributed within the cell. For example, a SAR of 2 means that each location within the c-

square is fished 2 times over the year, a SAR of 0.5 means that each location within the c-square is fished once in two years. Due to data availability, all analyses of the fishing footprint do not account for sub-grid variation of fishing events within the c-square. We will verify our results of the fishing footprint using fishing intensity as expressed in kW fishing hours.

How is benthic impact evaluated?

The evaluation of trade-off between the fisheries and their impacts requires an assessment method to estimate mobile bottom-contacting fishing gears impact to the seabed. To assess impact of these gears, WKTRADE3 will use two indicators of impact. Fishing impacts for these two indicators are determined for each c-square and summarized per MSFD habitat and gear grouping at the (sub-)regional scale.

The evaluation of trade-offs in this work is done for both impact indicators, as well as, one pressure indicator (unfished versus fished c-squares). During the stakeholder workshop, WKTRADE3 will discuss the different metrics used and evaluate their appropriateness.

The first indicator of impact estimates the amount of benthic biomass (relative to carrying capacity) which will not exist in the ecosystem if the current trawling intensity continues for a long time. This indicator is estimated using a population dynamic (PD) method (Pitcher *et al.*, 2017, ICES 2018, Hiddink *et al.*, 2019). The PD method uses explicit estimates of the removal of benthos by a single trawl event, and explicitly relates longevity to recovery rates. These parameters were estimated from all globally available trawl impact studies for infauna and epifauna (Hiddink et al. 2017, 2018). The PD method combines information on total benthic biomass (which is linked to the overall functioning of the ecosystem, see WGFBIT report 2018 section 3.2.1 on page 57) with the relative abundance of different longevity classes that in turn relates to the structure and biodiversity.

The PD method does not account for declines of rare and vulnerable species that managers may want to protect (e.g. within Descriptor 1: diversity). Rare and sensitive species are potentially heavily affected by trawling even though the structure and function of a community is largely unaffected. To account for rare and sensitive species, WKTRADE3 includes a second benthic impact indicator which is more precautionary. This indicator assumes that a population is affected by trawling if animals are disturbed by trawls during their life span. Only species in the community with a longevity less than the average interval between two successive trawling events, based on the swept area ratio, will not be affected (Rijnsdorp et al. 2016, 2020).

For both indicators, sensitivity of the benthic community is estimated from the longevity of benthic fauna in the community, i.e. the more long-living organisms the higher the vulnerability. Predictions of longevity, and hence impact, are available for the North and Baltic Sea, based on the present unfished reference condition of infauna and small epifauna, as collected by boxcore and grab samples. The unfished reference condition does not take into account what could have been present in the past. It thus prioritizes areas that are at present sensitive to bottom trawl disturbance and directly benefit from protection.

WKTRADE3 does not consider the LL-method as used in the demonstration product (ICES, 2017). The LL method is a statistical model that describes how the fraction of long-lived fauna changes with bottom trawling intensity and environmental variables. In effect, it is a multiple-regression model that interpolates between known data points. The method is therefore not mechanistic and more difficult to standardize across marine regions with varying data availability. Previous work has shown that the impact scores of the LL-indicator are correlated in the North Sea with the indicators used in WKTRADE3 (Rijnsdorp et al, 2020; see all grid cells in Figure 3, metier-specific impact estimates in Figure 8). Nonetheless, the LL-method does predict that impact is less strong in the southern parts of the North Sea due to interactive effects between trawling and natural disturbance. WKTRADE3 highlights that the development of methods to assess benthic impact are ongoing. The evaluation of trade-offs in this document is generic and can be done with other impact assessment methods, where available, when these methods describe impact on a continuous scale.

The trade-off analysis will focus on the MSFD broad habitat types as the units for assessment and assess footprint and impacts at this resolution. It does not intend to assess other, more finely defined habitat types, although the same methods could be applied.

What are revenue and contribution margin?

Revenue is the value of landings. Contribution margin is the value of landings minus variable costs (see chapter 3).

What gear groupings will we use?

In order to better understand the relationship between catch/value of landings and the levels of physical disturbance for MSFD purposes, this trade-off analysis will consider mobile bottom-contacting fishing gears at a finer resolution than used in the demonstration advice product (ICES 2017), on the basis that this is likely to be a more appropriate resolution for management purposes. To this end, 10 gear groupings (hereafter termed métiers) will be examined together with the total intensity of all gears. The gear groupings follow Rijnsdorp et al. (2020) and the groupings available in the ICES VMS database (Table 1.1). For the calculation of PD-impact, the depletion of benthos by a single trawl event will differ between the different métiers based on the penetration depth of the métiers (Hiddink et al. 2017, Rijnsdorp et al. 2020).

Table 1.1. Gear groupings used in the trade-off analysis. Some gear groupings are combined (note that regional-specific variation of important gear groupings may exist and may result in disaggregation of the combined groupings in specific areas). Depletion rates depend on the gear penetration depth of the different métiers (Rijnsdorp et al. 2020).

Métier	Main gear type	Target species	Depletion rate
DRB_MOL	Dredge	Scallops	0.200
OT_CRU[1]	Otter trawl	Nephrops, Pandalus, mixed fish	0.100
OT_DMF	Otter trawl	Cod or plaice	0.026
OT_MIX[2]	Otter trawl	Mixed fish	0.074
OT_SPF	Otter trawl	Sprat or sandeel	0.009
SDN_DMF	Seine	Plaice, cod	0.009
SSC_DMF	Seine	Cod, haddock, flatfish	0.016
TBB_CRU	Beam trawl	Brown shrimp	0.060
TBB_DMF	Beam trawl	Flatfish	0.140
TBB_MOL	Beam trawl	Whelk, snails and scallops	0.060

1 including OT_MIX_CRU and OT_MIX_CRU_DMF

2 including OT_MIX_DMF_BEN, OT_MIX_DMF_PEL

Chapter 2: Management options

A list of potential management options to reduce the impact of mobile bottom-contacting fishing gears have been reviewed recently in McConnaughey *et al*. (2020). Table 2.1 describes each option (note that we have added gear switching as a management measure, which was not included in the McConnaughey *et al*. paper). Below we discuss for each management option whether it will be used in the trade-off analysis and how it will be operationalized.

Table 2.1 Management options to reduce the impact of mobile bottom-contacting fishing gears and whether they will be used in the trade-off analysis

Measure/action	Objective	Priority in WKTRADE3
Technical measure		
Gear design and operations	Reduce impacts and maintain or increase catchability of target species	No
Gear switching	Use alternative gear with reduced impacts to catch target species	No
Effort control		
Reduction of effort	Reduce impacts by reducing fishing activity	Yes
Spatial control		
Prohibitions by gear type	Eliminate high-impact gears in a defined area	Yes
Freeze trawling footprint	Confine impacts to currently disturbed areas	Yes
Nearshore restriction and zoning	Reduce trawling in shallow sensitive habitats and minimize gear conflicts.	No
Prohibitions by small-scale habitat type	Protect small-scale sensitive habitat	No
Multipurpose habitat management	Broadly protect essential, representative and vulnerable habitats	Yes
Impact quotas		
Invertebrate bycatch quotas	Reduce bycatch of benthic invertebrates	No
Habitat impact quotas	Habitat conservation to protect benthic biota	No

Gear design and operations
Not prioritized. Reducing benthic impacts through gear modifications is possible through, for example, less gear penetration into the seabed (Hiddink et al. 2017). Yet, no information is readily available to estimate how a gear penetration reduction, or any other technical measure that lowers benthic impact, affects catchability of the target species. This change in catchability is likely gear- and target-species specific. These measures do not directly comprise a trade-off and are difficult to implement at the (sub-)regional scale. If a participant brings the information that are needed to the technical workshop, it could be tested.

Gear switching
Not prioritized. Gear switching behavior may lower benthic impact when fisheries shift from high- to low-impact gears, e.g. *Nephrops* fishing with bottom trawl to pots. Such behavior is difficult to implement in a regional assessment, as we need information on the possibilities of gear switching and on the benthic impact and fisheries revenue/contribution margin associated with the new gear. If a participant brings the information that are needed to the technical workshop, it could be tested.

Reduction of effort
Prioritized. The objective is to reduce fishing impact by reducing fishing activity irrespective of métier and MSFD habitat type. The measures we decide to take are 1) to close c-squares to all bottom-contacting fisheries, starting at the lowest/highest effort c-squares, until 5 - 99% of effort has been removed, 2) Identical to 1, but starting at the highest effort c-squares, until 5 - 99% of effort has been removed and 3) identical to 1, but where effort in each EEZ, rather than total effort, is reduced by 5 – 99%.

Prohibitions by gear type
Prioritized. The objective is to examine how reductions in low/high-impact fishing gears change benthic impact at the (sub-)regional scale and for each MSFD habitat type. The measures we decide to take are 1) a reduction of 5 – 99% in fishing effort (SAR) of each métier, starting at the lowest effort c-squares, until 5 – 99% of effort has been removed, and 2) the total removal of one métier fleet segment.

Freeze trawling footprint
Prioritized. The objective is to confine impacts to previously disturbed areas. The measure we decide to take is 1) to freeze the trawling footprint to all fished c-squares (SAR > 0) per (sub-)region based on the reference period 2012-2014, and 2) to freeze the footprint to the core fishing grounds, i.e. the c-squares with 90% highest average SAR values in the 2012-2014 period.

Nearshore restriction and zoning
Not prioritized. We acknowledge there is a desire to protect nearshore areas. The current approach is designed to evaluate the MSFD broad-scale habitat types and does not represent nearshore areas very well. The nearshore zone (definition?) has a more complex/fine scale mosaic of habitat types and data for fishing activity, especially from smaller vessels <12m, is generally lacking. However, some nearshore habitats are subject to fishing and so the need to perform similar analyses will

remain. A finer grid size would need to be applied also as the current c-squares are too coarse in relation to the complexity of habitat types.

Prohibitions by (small-scale sensitive) habitat type (not MSFD habitat types)
Not prioritized. The finer resolution of such habitats (i.e. at EUNIS levels 4-6) would need better habitat maps and finer resolution of the fishing data (c-squares are too coarse). Protection of MSFD broad habitat types will offer some protection of the finer types, but there will still be a need to evaluate whether more specific measures are needed for those habitats that have been most affected by pressures.

Multipurpose habitat management
Prioritized. The objective is to broadly protect essential, representative and vulnerable habitats, i.e. MSFD habitats. The measures we decide to take are 1) to close c-squares in each MSFD habitat type to all bottom-contacting fisheries, starting at the lowest effort c-squares, until 5 - 99% of effort has been removed, and 2) to protect each MSFD habitat per (sub-)region by closing c-squares to fisheries, starting at the lowest effort c-squares, until average benthic impact for each MSFD habitat has reached a certain impact threshold (e.g. < 0.3, 0.2, 0.15, 0.1, 0.05).

Invertebrate bycatch quotas
Not prioritized. Bycatch is not part of the current impact assessment and we have no options to analyze trade-offs.

Habitat impact quotas
Not prioritized. Requires dynamic fisheries models which are not readily available across marine regions for regional assessments.

Future actions chapter 2

- During a stakeholder dissemination meeting (4-5 March 2021), review management options with stakeholders. Are there options missing? Are the measures proposed informative?

- During a technical meeting (6-9 April 2021), review for each management option the wider benefits/consequences to the ecosystem, including commercial fish stocks, that could arise, if greater areas of seabed are left undisturbed by bottom fishing (following Collie *et al.*, 2017, McConnaughey *et al.*, 2020).

- Investigate if simple displacement assumptions can be used, e.g. simple assumption of steaming time relative to the distance to coast/nearest harbour.

Chapter 3: Fisheries revenue and contribution margin

WKTRADE3 applies a methodology to estimate, where possible, the contribution margin associated with the fishing activity per area by integrating fisheries economics data (STECF AER) with VMS/logbook data for all mobile-bottom contacting fishing gears and per gear grouping in (sub)regions.

In the ICES VMS data information about the landings value from the fisheries are available, but according to the WKTRADE2 workshop (ICES 2019b), the variable costs should be subtracted from the landings value. In 2020, STECF FDI data (Fisheries Dependent Information) were published in a new format, including the DCF level 6 metier codes. This can potentially make it possible to link the VMS data with FDI data, and the FDI data can potentially be linked with AER data where the costs are reported by country on EU level. If the costs can be distributed out on the métiers and further out on the VMS data, the costs can be subtracted from the value of landings from the fisheries. This analysis is testing the above ideas.

A disaggregation method is used that combines three data sources (Figure 3.1):

- AER: Data from EU STECF Annual Economic Reporting (AER) have been downloaded from https://stecf.jrc.ec.europa.eu/dd/fleet. Data are available for the years 2008-2018 and includes the variables in figure 3.1 below. WKTRADE2 (ICES 2019b) suggested to use the contribution margin to assess and compare the profitability of different fisheries. The variable costs for energy (fuel), personnel, repair and maintenance and other variable costs are included in the analysis.

- FDI: Data from EU STECF FDI data call has been downloaded from https://stecf.jrc.ec.europa.eu/dd/fdi. Data are publicly available, but on country level, member states can mark weight/value of landings and effort as confidential, typically if there are less than 3 vessels within the aggregation. The other fields are still available. In addition, there is a dataset aggregated over all countries that includes the confidential data. Data are available for the years 2015-2019.

- ICES VMS/Logbook data, ICES Member States fishing in the North Atlantic.

The fishing technique available in the AER and FDI data is a dominant gear group used by a vessel throughout a year. That means that the fishing technique DTS (Demersal trawlers and seiners) can include fishing by gillnet, and the fishing technique PMP (Vessels using active and passive gears) can include fishing by both active and passive gears. In the AER, if there are too few vessels within a fleet segment (fishing technique + vessel length category), it can be clustered together with another fleet segment. In this analysis the national clustering of fleet segments have been extracted from the data and applied to both the AER and FDI data.

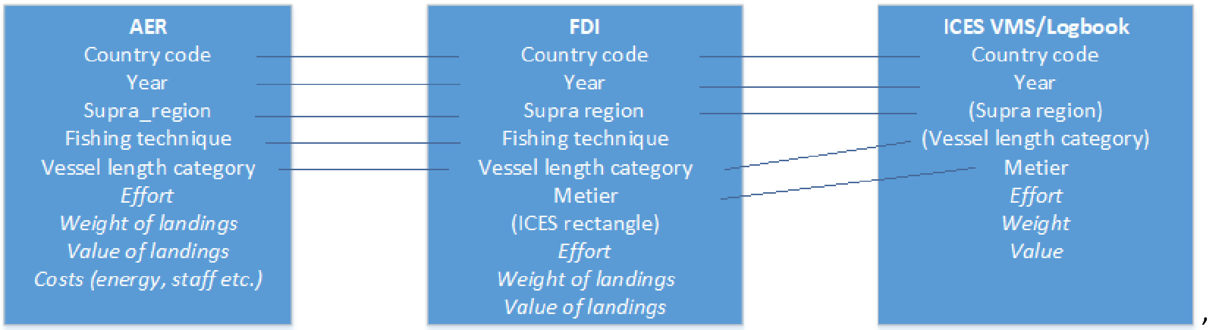


Figure 3.1 Disaggregation method to combine different data sources

In WKTRADE3 the costs reported in the AER, are disaggregated via the FDI data call to metiers, to the ICES VMS data, so that they can be deducted from the value of landings. When combining the data from the different data sources, there are data issues, depending on member states, which will be documented.

Future actions chapter 3:

1. Run the disaggregation method with available data
2. Document data issues

Fisheries contribution margin example in Danish waters

An explorative example has been produced for Danish 2017 data since the full ICES VMS data is not yet available for the WKTRADE3 work.

Economic data (AER)
Supra regions: NAO, MBS, OFR

As concluded in WKTRADE2 (ICES 2019b), only variable costs should be subtracted from the value of landings (= contribution margin) to characterize the profitability of the fishing activity. Expenditure variables in the AER data are (table 3.1):

- Personnel costs
- Value of unpaid labour
- Energy (fuel) costs
- Repair & maintenance costs
- Other variable costs
- Other non-variable costs
- Lease/rental payments for quota
- Consumption of fixed capital

In this explorative example, only energy costs are included, but "Personnel costs", "Other variable costs" and "Repair & maintenance costs" will be included in the coming analysis.

Table 3.1 Example of AER data for Danish fisheries 2017

country_code	year	supra_reg	fishing_tech	vessel_length class	Aer kWFishingDays	Expenditure (EUR)	Energy_costs (EUR)
DNK	2017	NAO	DRB	VL1012	24,670	1,093,274	59,358
DNK	2017	NAO	DRB	VL1218	314,457	6,500,362	266,779
DNK	2017	NAO	DTS	VL0010	63,295	731,325	55,784
DNK	2017	NAO	DTS	VL1012	218,929	2,366,070	245,132
DNK	2017	NAO	DTS	VL1218	2,589,565	36,145,305	3,841,900
DNK	2017	NAO	DTS	VL1824	2,544,131	43,717,757	4,509,133
DNK	2017	NAO	DTS	VL2440	4,686,454	70,255,361	10,965,165
DNK	2017	NAO	DTS	VL40XX	3,766,329	61,517,099	8,755,989
DNK	2017	NAO	PGP	VL0010	902,759	15,223,966	429,101
DNK	2017	NAO	PGP	VL1012	427,261	5,184,070	230,113
DNK	2017	NAO	PGP	VL1218	439,427	8,367,321	390,276
DNK	2017	NAO	PMP	VL0010	391,253	4,976,243	325,603
DNK	2017	NAO	PMP	VL1012	277,168	3,800,022	347,857
DNK	2017	NAO	PMP	VL1218	606,336	8,631,010	933,803
DNK	2017	NAO	PMP	VL1824	763,624	16,540,881	1,380,092
DNK	2017	NAO	TBB	VL1218	288,190	4,261,155	599,614
DNK	2017	NAO	TBB	VL1824	450,642	7,942,245	1,143,595
DNK	2017	NAO	TM	VL1218	149,568	5,012,569	453,411
DNK	2017	NAO	TM	VL40XX	3,151,726	75,245,004	9,216,637

Fisheries dependent data
The FDI data call provides information on kW fishing days (the vessel's engine power times the number of days that the vessel is fishing, meaning that the fishing effort is adjusted by the engine power) by country, year and metier. There is an option for member states to mark data values as

confidential. In the data that has been published, total values summed across all countries are available, but in the data at country level the values that have been marked as confidential, have a "C" instead of the actual value (Table 3.2).

Table 3.2 Example of FDI data for Danish fisheries 2017

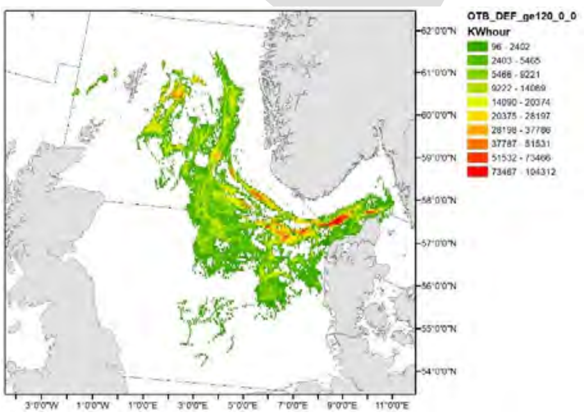
country.code	year	quarter	vessel.length.category	fishing.technique	metier	FDI kW.fishing.days
DNK	2017	1	VL1218	DRB	DRB_MOL_>=0_0_0	36,682
DNK	2017	1	VL1218	DTS	OTB_DEF_100-119_0_0	C
DNK	2017	1	VL1218	DTS	OTB_DEF_>=120_0_0	8,652
DNK	2017	1	VL1218	DTS	OTB_CRU_32-69_0_0	C
DNK	2017	1	VL1218	DTS	OTB_DEF_32-69_0_0	C
DNK	2017	1	VL1218	PMP	OTB_DEF_>=120_0_0	C
DNK	2017	1	VL1218	TBB	TBB_CRU_16-31_0_0	C
DNK	2017	1	VL1218	TBB	TBB_CRU_16-31_0_0	67,836

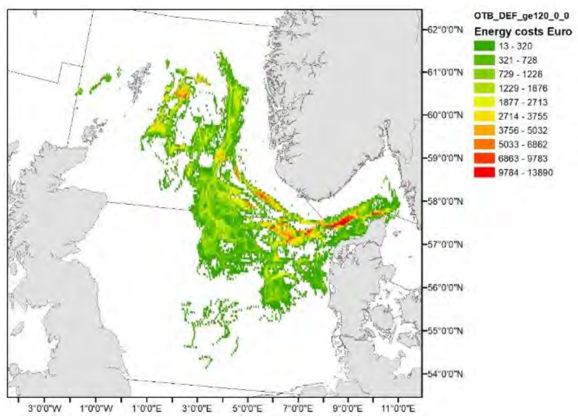
To estimate the kW fishing days in the FDI data where it is marked with C (because there are less than 3 vessels within the aggregation), the total kW fishing days are found from the AER data by fishing technique and vessel length category. The kW fishing days found in the FDI data are also summed by fishing technique and length category and the kW fishing days missing in the FDI data call (AER kW fishing days – FDI kW fishing days) are distributed evenly across the metiers where the kW fishing days have been marked with "C". It would of course be more correct if the actual values were used.

Integrating different data sources

The energy costs are then distributed across the metiers in the FDI data within the same country, year, supra region, fishing technique and vessel-length category relative to the kW fishing days. The energy costs are further distributed across the c-squares in the VMS data call by country, year and metier relative to the kW fishing hours. This means that the distribution of the energy costs will vary relative to the fishing effort.

Maps below are showing the kW*fishing hours, energy costs in euro, the value of landings in euro and the value of landings minus the energy costs for the metier OTB_DEF_>=120_0_0 for the Danish fisheries in 2017 per 0.05x0.05 degrees c-square (Fig. 3.2).





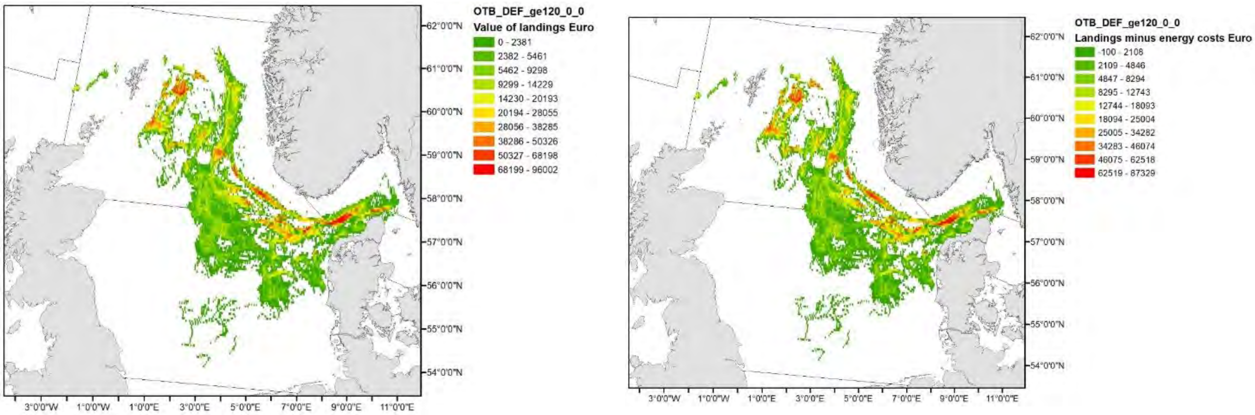


Figure 3.2. Maps of the kW*fishing hours, energy costs in euro, the value of landings in euro and the value of landings minus the energy costs for the metier OTB_DEF_>=120_0_0 for the Danish fisheries in 2017 per C-square.

Chapter 4: Draft assessment sheet Greater North Sea

Contents

Summary of pressure and impact

The physical disturbance pressures from mobile bottom-contacting fishing gears varies spatially in the North Sea ecoregion with 91% of the grid cells (I-2), and 62% of the surface area (I-3), in the depth zone 0-200m, being fished on average per year for the period 2013-2018 (Table 1). Fishing is aggregated with 90% of the pressure occurring in 41% of grid cells (I-4).

The PD method shows an average decline in community biomass of 11% relative to carrying capacity across c-squares (I-6). Most c-squares, 82% (I-7), have an impact score less than 20%.

The L1 method, estimating the proportion of the community with a life span exceeding the time interval between trawling events, shows an average impact of 0.66 across c-squares (I-6). Only 21% (I-7) of the c-squares have impact scores less than 20% (I-7).

Maps of spatial distribution of intensity, sensitivity and economic value and weight of fisheries landings are shown in Figure 1.

Table 1. Pressure and impact indicators for 2013-2018 in the depth zone 0-200m in the Greater North Sea.

	Description	Value	
Pressure indicators			
Intensity (I-1)	Average number of times the North Sea is swept per year by MBCG. Estimated as the sum of swept area for all MBCG (averaged for 2013-2018), divided by the total area.	2.09	
Proportion of grid cells fished (I-2)	The number of c-squares fished at least once in the six years (irrespective of the swept area within the cell), divided by the total number of c-squares.	0.91	
Proportion of area fished (I-3)	The sum of swept area across all c-squares in the North Sea, where swept area in a specific grid cell cannot be greater than the area of that grid cell, divided by the summed area of all c-squares.	0.62	
Aggregation of fishing pressure (I-4)	The smallest proportion of c-squares in the North Sea where 90% of the total swept area occurs.	0.41	
Persistently unfished areas (I-5)	The number of c-squares persistently unfished in 2013-2018 (irrespective of the swept area within the cell), divided by the total number of c-squares.	0.09	
Impact indicators		**PD**	**L1**
Impact (I-6)	Average fishing impact across c-squares (averaged for 2013-2018).	0.11	0.66
Proportion area with impact <0.2 (I-7)	The proportion of c-squares with an average impact below 0.2 for 2013-2018	0.82	0.21

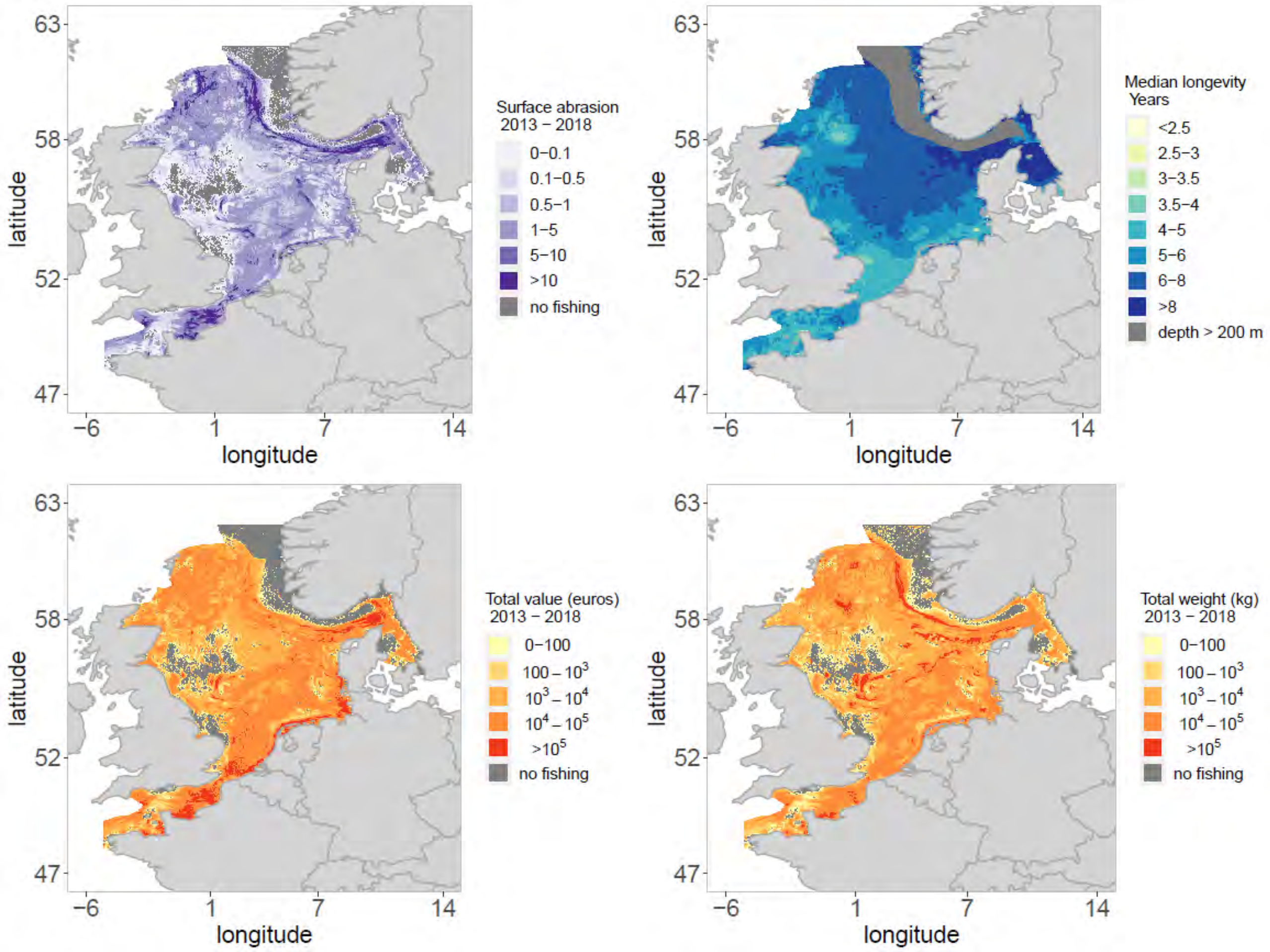


Figure 1. Geographic distribution of surface abrasion, seabed sensitivity (community longevity) and total value and weight from mobile bottom-contacting gear in the Greater North Sea. The maps of surface abrasion, value and weight show the average per year for 2013-2018.

Fishing pressure

Intensity, landings and value mobile bottom-contacting gears

Fishing pressure in this context is defined as the fishing activities of all mobile bottom-contacting gears, including otter trawl, seines, beam trawls and dredges. Fishing intensity (Swept Area Ratio) is the average number of times the area is swept (total swept area divided by total area). A swept area ratio of 1 means that in average, the area of the c-square is swept once per year, but within the c-squares, there can be an aggregation of the fisheries.

The distribution of fishing intensity in the Greater North Sea has a strong spatial variation (Figure 2). Areas of higher intensity occur in the northern North Sea along the edge of the Norwegian Trench and in the eastern English Channel. Areas with lower intensity occur in the western part of the North Sea, and in the deeper parts of the Norwegian trench.

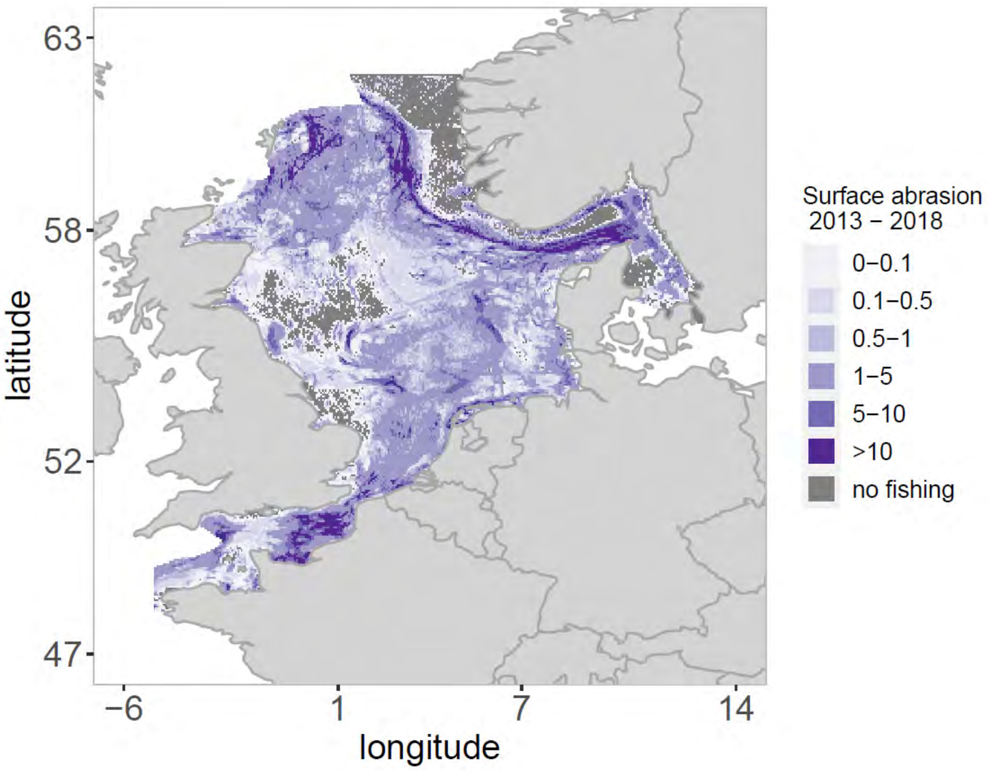


Figure 2. Fishing intensity, Swept Area Ratio, by mobile bottom-contacting gears ($year^{-1}$), averaged for the 2013-2018 six-year cycle.

In the North Sea most of the mobile bottom-contacting fishery operates in waters less than 200 m with 62% of the seafloor fished (Table 1). The proportion of area subject to fishing pressure differs between broad-scale habitats and is highest in offshore circalittoral mud (99% of grid cells fished) and circalittoral sand (97% of grid cells fished) (Table 2). Fishing intensity is highest in upper bathyal sediment (average intensity = 5.61 $year^{-1}$) and offshore circalittoral mud (average intensity = 3.24 $year^{-1}$).

Total fishing intensity has increased since 2016 (Figure 3). There was a large peak in intensity in offshore circalittoral mud in 2016. Fishing intensity is relatively stable over time in circalittoral sand and offshore circalittoral coarse sediment. The area within which fishing occurred (footprint) showed less variations in time (except for a decline in 2017). This shows that the overall increase in intensity has not affected the spatial distribution of the footprint much (Figure 3, middle panel).

Fishing pressure is aggregated in a relatively small part of the total footprint, both at the regional level as well as at the level of the habitat (Figure 3, right panel). 90% of the effort occurred in between about a third and half of the area. The intensively fished areas represent the 'core fishing grounds'. These grounds contribute most of the landings and value (Figure 4). Almost 70% of the fishing effort (swept area) and 60% of the landings and value, occur in only 20% of the surface area of the Greater North Sea (Figure 4, red dot).

Table 2. Overview of pressure indicators of all mobile bottom-contacting gears per broad-scale habitat in the Greater North Sea averaged for 2013-2018 (0-200m). "I" refers to the indicators in Table 1.

MSFD broad habitat type	Extent of habitat (1000 km^2)	Num. of grid cells	Landings 1000 tonnes	Value 10^6 euro	Swept area 1000 km^2	Average fishing intensity (I-1)	Prop. of grid cells fished (I-2)	Prop. of area fished (I-3)	Prop. of habitat fished with 90% of effort (I-4)
Offshore circalittoral sand	241.39	14140	283.11	255.58	435.46	1.86	0.92	0.58	0.4
Offshore circalittoral mud	108.69	6475	148.37	163.19	347.45	3.24	0.99	0.86	0.58
Offshore circalittoral coarse sediment	77.13	4184	78.2	142.33	211.83	2.65	0.95	0.6	0.36
Circalittoral sand	68.43	3794	160.33	151.29	125.38	1.82	0.97	0.72	0.53
Circalittoral coarse sediment	30	1598	25.59	40.36	43.38	1.41	0.84	0.42	0.28
Unknown	27.64	1583	10.71	36.41	22.21	0.78	0.5	0.26	0.17
Infralittoral sand	12.75	713	19.86	36.83	18.43	1.4	0.72	0.52	0.38
Offshore circalittoral mixed sediment	7.27	411	4.4	9.37	16.16	2.23	0.95	0.63	0.42
Circalittoral mud	5.59	310	6.93	13.59	11.07	1.92	0.89	0.62	0.43
Circalittoral mixed sediment	4.7	267	3.54	3.42	3.85	0.84	0.87	0.41	0.38
Offshore circalittoral rock and biogenic reef	3.45	217	0.34	0.97	2.97	0.83	0.52	0.31	0.22
Infralittoral coarse sediment	3.08	161	5.82	7.98	4.36	1.41	0.89	0.59	0.46
Circalittoral rock and biogenic reef	2.57	144	0.55	1.08	0.98	0.38	0.72	0.19	0.21
Infralittoral rock and biogenic reef	1.41	81	0.27	0.62	0.39	0.29	0.53	0.1	0.09
Infralittoral mixed sediment	1.39	81	0.01	0.01	0.02	0.02	0.42	0.02	0.2
Infralittoral mud	1.37	77	0.62	1.71	1.31	0.85	0.3	0.24	0.16
Upper bathyal rock and biogenic reef	0.39	25	0.01	0	0.29	0.72	0.36	0.22	0.16
Upper bathyal sediment or Upper bathyal rock and biogenic reef	0.33	22	0	0	0.02	0.05	0.09	0.05	0.05
Upper bathyal sediment	0.14	9	0.53	0.05	0.81	5.61	0.89	0.78	NA

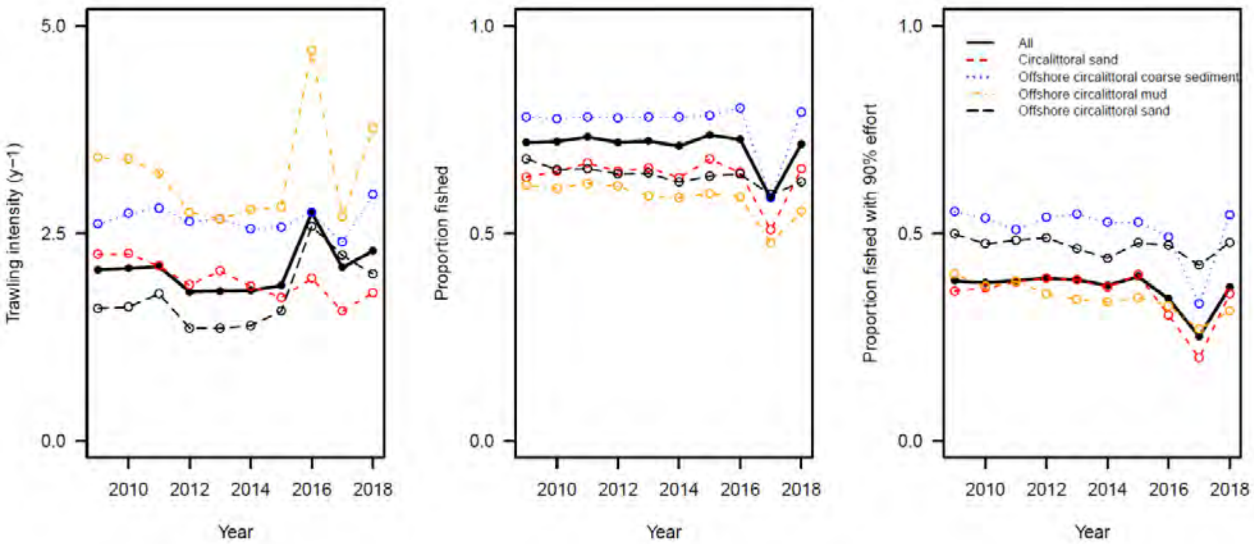


Figure 3. Time series of (a) mean fishing intensity (surface abrasion), (b) proportion of the surface area of the seafloor fished, (c) aggregation of fishing (proportion of the surface area with 90% of the fishing effort) by habitat for the depth zone 0-200m in the Greater North Sea. Results represent vessels over 15m (2009-2011) and vessels over 12m (2012-2018).

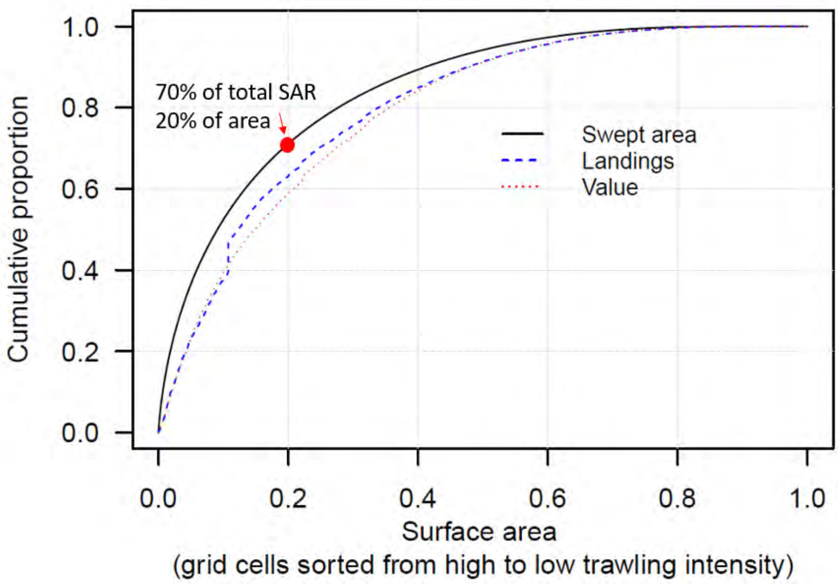


Figure 4. Cumulative proportion of the swept area, landings and value. Grid cells were sorted from highest to lowest fishing intensity and include non-fished cells. The results are for all mobile bottom-contacting gears in the Greater North Sea based on averaged fishing data per c-square from 2013-2018.

Changes in core fishing grounds over time

In this analysis, core fishing grounds are defined as the c-squares with the 90% highest value of landings in the VMS data. Figure 5 below show the percent distribution of the number of years c-squares are within the 90% highest value by metier. If fishing in a metier occurs in the same c-square every year with high value of landings, the bar at the right will be high, meaning that the c-square is within the 90% highest value of landings every year during the period 2013-2018. If a c-square is only within the 90% highest value in one year, it will end up in the bar at the left. The fisheries for small pelagic fish generally have a high variation in space.

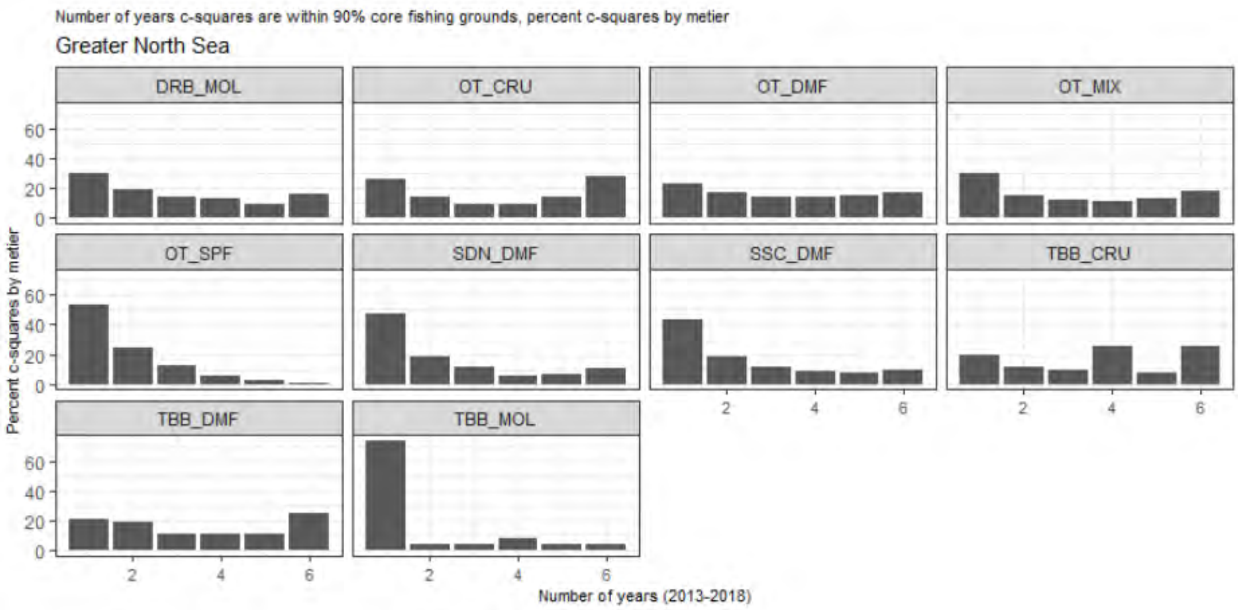


Figure 5: Number of years c-squares are within the 90% core fishing grounds as percent c-squares by metier during the period 2013-2018 for the Greater North Sea.

The plots below illustrate the relationship between area fished in percent and the cumulated value of landings, sorted from the c-squares with highest value fisheries. The curves are generally starting steeply, illustrating the concentration of the fisheries at fishing grounds and the curves are ending horizontally, illustrating the peripheral fisheries going on outside the main fishing grounds.

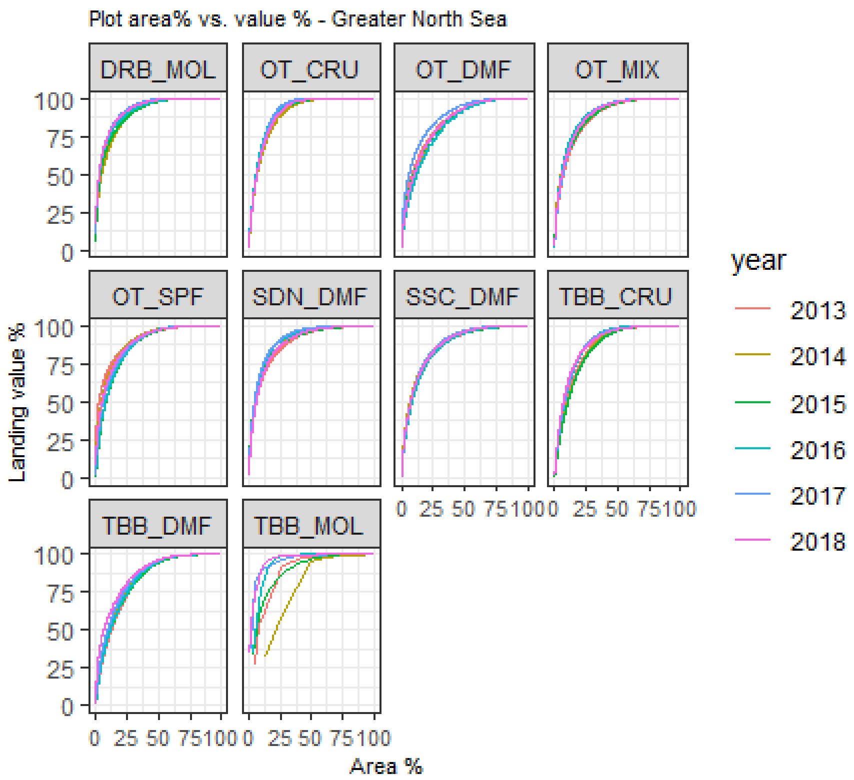


Figure 6: Plot of percent area fished vs. landings value (euro) by métier, coloured by year for the Greater North Sea

Future action: 1. Check which VMS based outputs that can be published, respecting the ICES VMS data policy.

Intensity, landings and value of métiers

Intensity, weight and value of landings were estimated for the grid cells that were fished by one MBCG métier, ignoring cells fished by other métiers (Table 3). The métier with the highest landings and value per area fished is the beam trawl fishery for whelks, snails and scallop (TBB_MOL) but note that only a very small area has been fished by this métier. The seines (SDN_DMF and SSC_DMF) have the lowest landings and value per area fished. This is followed by otter trawls that target crustaceans (OT_CRU).

Table 3. Overview of area fished (sum of swept area), landings and value for the different métiers. Area fished in 1000 km², weight of landings in 1000 tonnes, value of landings in 10⁶ euro.

	DRB_ MOL	OT_ CRU	OT_ DMF	OT_ MIX	OT_ SPF	SDN_ DMF	SSC_ DMF	TBB_ CRU	TBB_ DMF	TBB_ MOL
Area fished	9.71	142.95	521.69	31.57	12.99	146.33	216.68	55.04	109.38	0.02
Weight	44.87	16.39	482.47	12.99	69	8.8	22.26	26.09	64.55	1.8
Value	104.18	73.5	245.18	32.01	16.38	17.14	44.35	94.54	235.03	2.47
Landings / Area fished	4.62	0.11	0.92	0.41	5.31	0.06	0.1	0.47	0.59	87.42
Value / Area fished	10.73	0.51	0.47	1.01	1.26	0.12	0.2	1.72	2.15	119.84

Future action:
Develop an overview figure/table per métier and MSFD habitat type.

Impact

The impact of mobile bottom-contacting fishing from the PD method shows the areas of highest fishing impact along the slopes of the Norwegian trench in the Skagerrak and western Norway and in the eastern English Channel (note the 200m depth limit in this assessment) (Figure 7, left). High impact areas are also seen along the continental coast of the North Sea, in the southern North Sea and Kattegat.

High impact from the L1 method covers a much larger area (Figure 7, right) that largely mimics the map of fishing intensity (Figure 2).

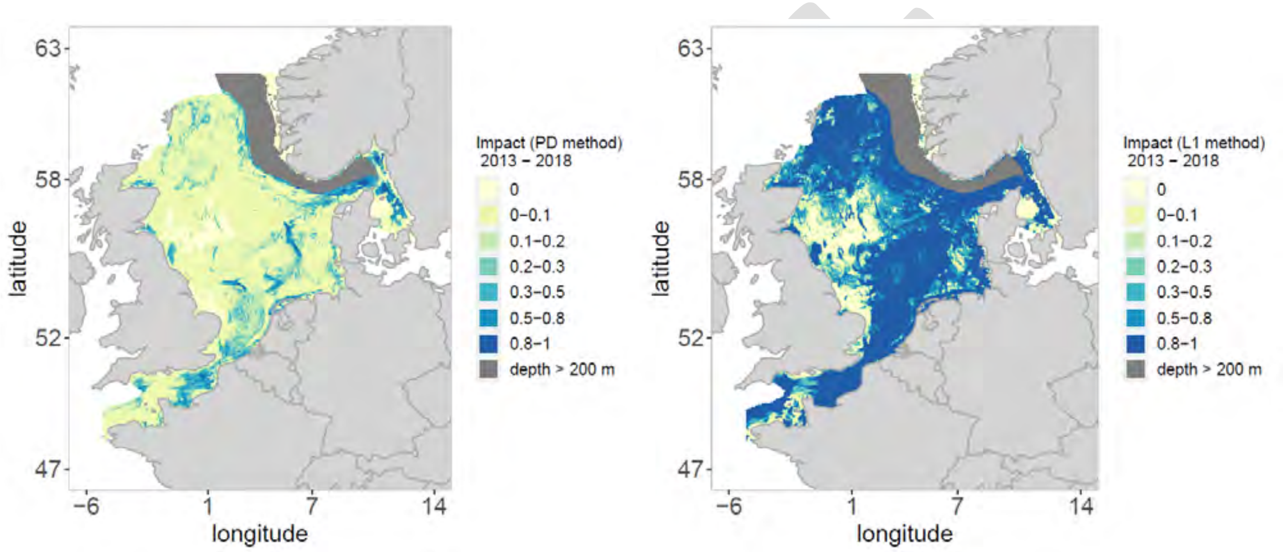


Figure 7. Impact of mobile bottom-contacting gears averaged for the 2013-2018 six-year cycle for the PD and L1 method.

The impact scores of the PD and L1 method are largely constant over time (Figure 8, left panel). Impact varies between habitats (Figure 8 shows the four most extensive habitat types). Of these four habitat types, impact is highest in offshore circalittoral mud and lowest in offshore circalittoral sand. Between 50-80% of each habitat type has a PD impact score <0.2, whereas only 10-40% of each habitat type has an L1 impact score <0.2.

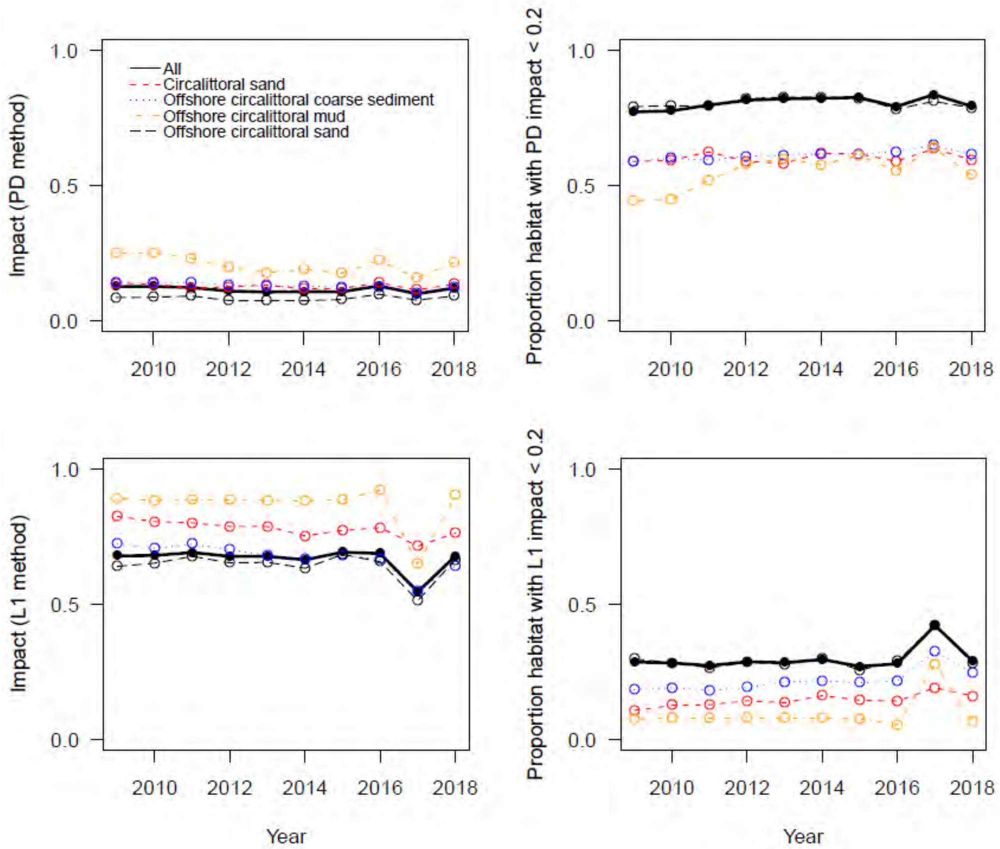


Figure 8. The mean impact of mobile bottom-contacting gears in all combined MSFD habitats and the four most extensive habitat types in water less than 200m depth in the Greater North Sea between 2009 and 2018 (left). The proportion of the fished area with an impact of less than 0.2 (right)

Impact of selected métiers

The different métiers were assessed for the grid cells that were fished by one MBCG métier, ignoring cells fished by other métiers (Table 4). As such this estimates the maximum impact compared to the untrawled situation and the impact estimated assuming all other métiers to have impacted the habitat will be less than this. The métier with the highest impact (PD and L1) relative to the value and landings is the otter trawl fishery for crustaceans (OT_CRU). The beam trawl fishery for whelks, snails and scallop (TBB_MOL) has the lowest impact per value and landings but note that only a very small area has been fished by this métier (Table 3).

Table 4. Overview of impact per metier relative to weight and value of landings estimated for the grid cells fished (SAR >0) with these métiers only. Weight of landings in 1000 tonnes, value of landings in 10^6 euro.

	DRB_ MOL	OT_ CRU	OT_ DMF	OT_ MIX	OT_ SPF	SDN_ DMF	SSC_ DMF	TBB_ CRU	TBB_ DMF	TBB_ MOL
Weigth / PD impact	0.33	0.02	0.41	0.08	3.31	0.07	0.08	0.14	0.06	8.28
Value / PD impact	0.77	0.07	0.21	0.2	0.8	0.14	0.16	0.49	0.23	11.35
Weigth / L1 impact	0.06	<0.01	0.03	0.01	0.08	<0.01	<0.01	0.02	0.01	1.41
Value / L1 impact	0.13	0.02	0.02	0.03	0.02	0.01	0.01	0.08	0.04	1.94

Métiers differ in their habitat association and impact on each habitat type (Figure 9). Fishing impact on mud is dominated by the otter trawl fishery (OT_CRU and OT_DMF). Beam trawl impact mostly occurs in circalittoral sand. For the three most dominant metiers (OT_CRU, OT_DMF and

TBB_DMF), changes in impact over time are limited; there is some decline in impact scores by the otter trawl fishery on crustaceans (OT_CRU) in mud since 2010 (not shown). The two impact indicators are showing similar qualitative patterns but qualitatively differ in predicted impact of OT_CRU and OT_DMF. These differences arise as the PD method uses a four times larger depletion rate for OT_CRU compared with OT_DMF due to a larger gear penetration depth, whereas the L1 method assumes that all fauna are sensitive to bottom trawl disturbance (independent of the gear penetration depth).

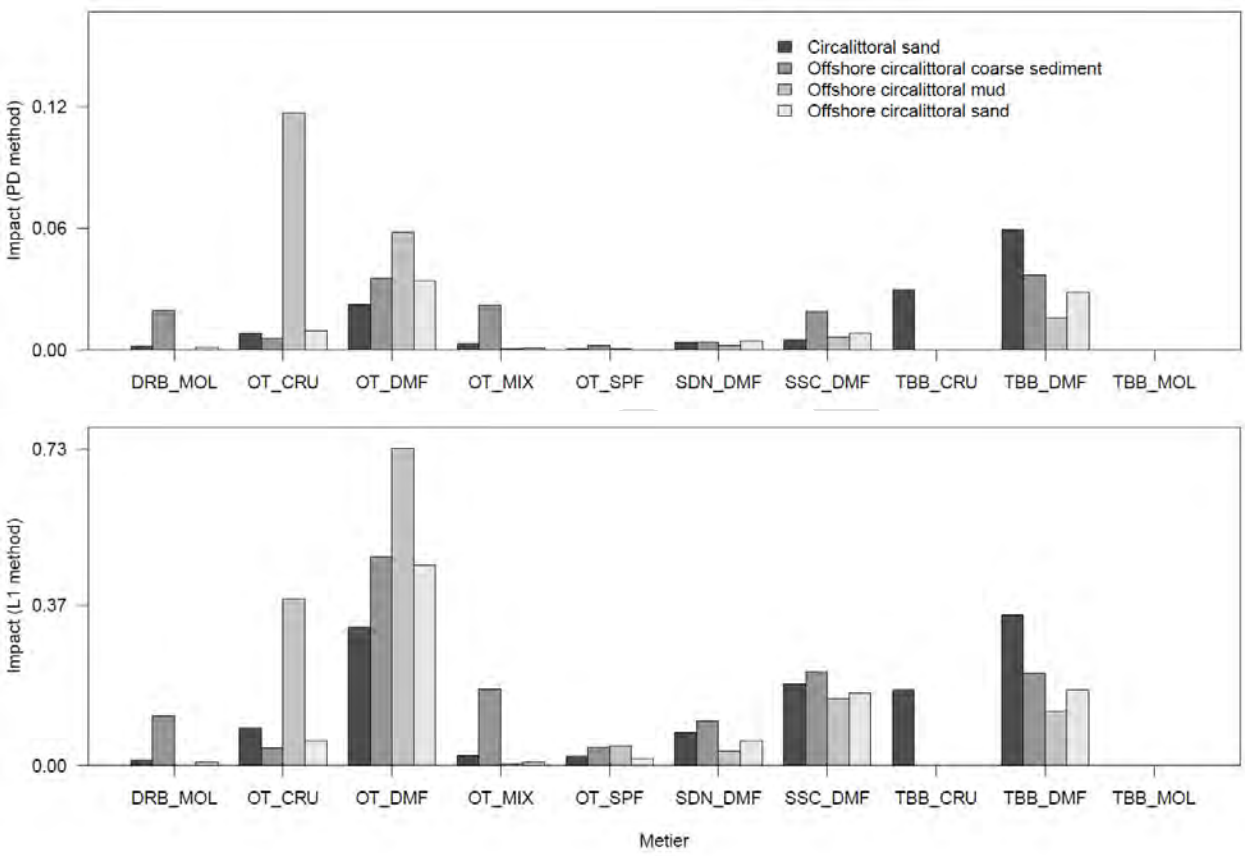


Figure 9. PD impact (upper panel) and L1 impact (lower panel) of selected gear groupings on the most extensive MSFD habitat types in the Greater North Sea. Impact is estimated in isolation of the other gear groupings. Note the different scales on the Y-axis.

Trade-off assessment of management options

Future action:

- We will use fisheries contribution margin based on the economic analysis (Chapter 3), if available. Otherwise we will use value of landings, weights and/or fishing intensity (kw/hours) to reflect areas of high benefit. This differs from the demonstration advice product (ICES 2017) where only value of landings was used.

Reduction of effort

An illustration of the trade-off analysis through reduction of effort is shown in Figure 10 for two measures: 1) to close c-squares to fisheries, starting at the lowest effort c-squares, until 5 to 99% of effort has been removed (black lines), and 2) identical to 1, but where effort is removed starting from the highest effort c-squares (red lines). The analysis shows that reduction of effort starting at the lowest effort c-squares leads to more unfished c-squares, a lower average impact but also a larger decline of fisheries weight and value of catches. Importantly, a 5% decline in effort, starting at the lowest effort c-squares, results in a similar change in average impact and value/weight as a 20% decline of effort starting at the highest effort c-squares, whereas the first option leaves 40% of the North Sea c-squares persistently unfished.

The reduction of effort is done irrespective of MSFD habitat type and métier and will affect these in different ways. For example, measure 2 has a large effect on otter trawl fisheries on crustaceans (OT_CRU), which can reach high SAR intensity levels in c-squares (not shown). A more detailed analysis of MSFD habitat types and métiers is explored below.

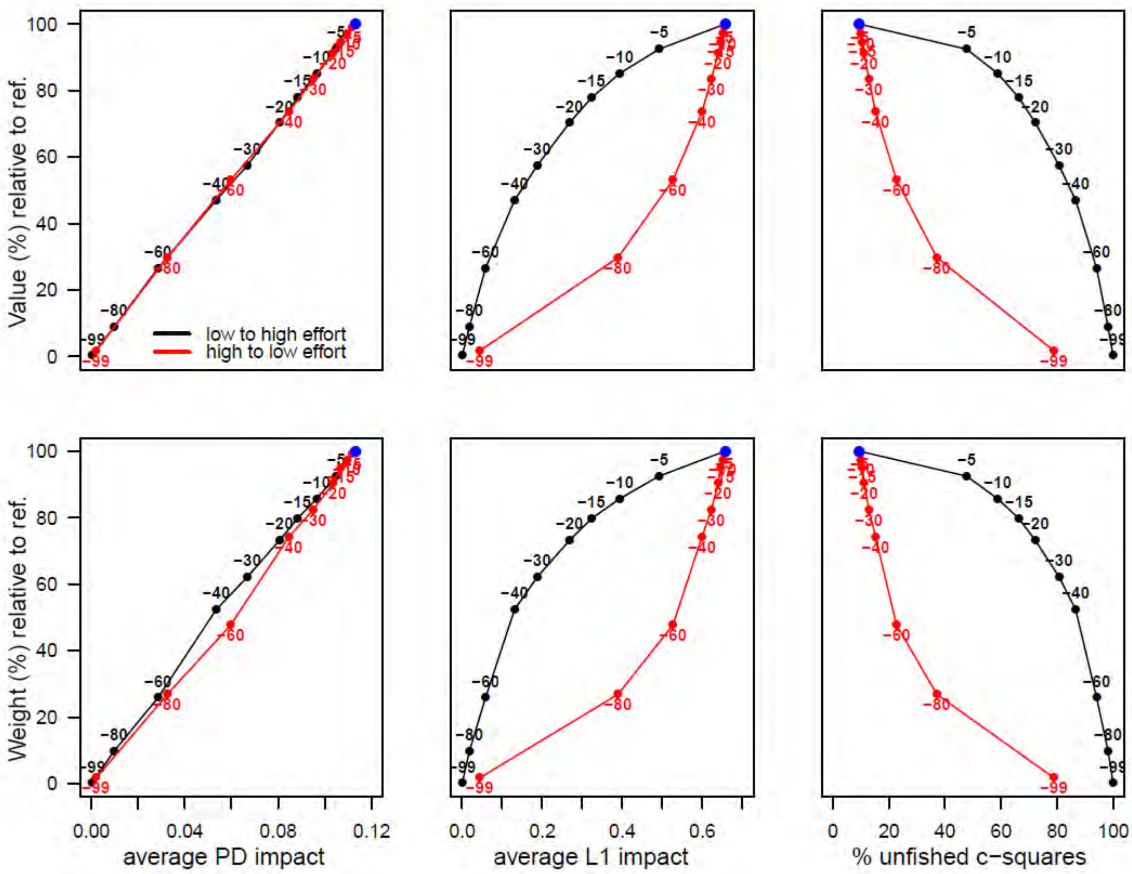


Figure 10. Example output of the reduction in effort management option showing the trade-off between average impact (PD, L1) or unfished C-squares and fisheries values/weight of landings in water less than 200m depth. The analysis is based on the progressive removal of 5 to 99% of all MBCG fishing effort, starting from the least (black) or most (red) fished c-squares. Blue dots show the current situation and are used as reference.

Prohibitions by gear type

An illustration of the trade-off analysis by gear type is shown in Figure 11. The figure shows how the total removal of one métier fleet segment changes benthic impact and the percentage of unfished c-squares in water less than 200m depth.

The results show that the removal of most gear types has a limited effect on total fisheries weight, except for the removal of OT_DMF (Figure 11, lower panel). The removal of métiers provides limited gains in the percentage of unfished C-squares, highlighting that most C-squares are fished by multiple métiers.

The removal of OT_CRU results in a relatively large improvement in average PD impact at a low decline in total fisheries weight and value. This is because OT_CRU has the highest impact relative to value and weight of landings (Table 4) and is associated with a high depletion rate (Chapter 1, Table 1.1).

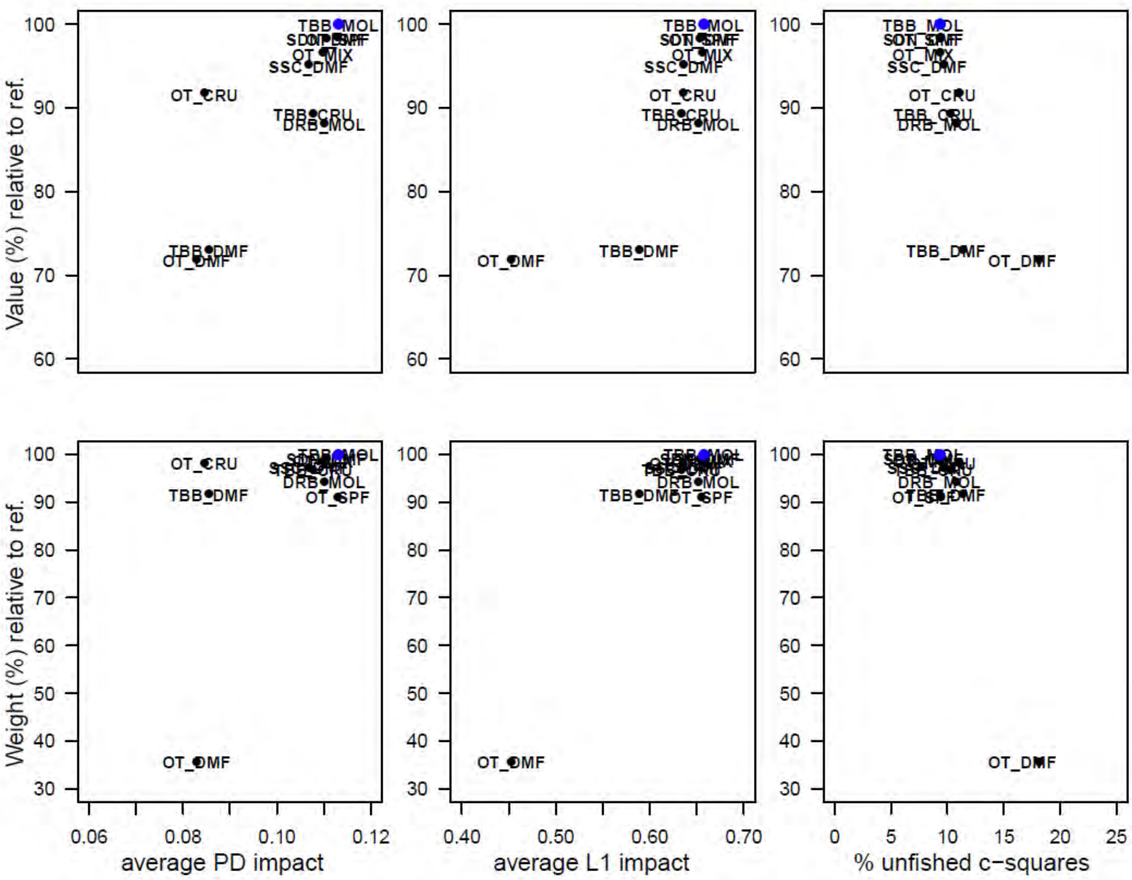


Figure 11. Example output of the trade-off between average impact/unfished C-squares and fisheries values/weight of catches in water less than 200m depth after total removal of one metier (noted next to the dot). Blue dots show the current situation and are used as reference.

Freeze trawling footprint

An illustration of the trade-off analysis through the freezing of the trawling footprint is shown in Figure 12 for two measures: 1) to freeze the trawling footprint to all fished c-squares (SAR > 0) per (sub-)region based on the reference period 2012-2014, and 2) to freeze the footprint to the core fishing grounds based on the reference period 2012-2014 (i.e. the c-squares with 90% highest average SAR values in water less than 200m depth).

The results show that freezing the trawling footprint has a limited effect on average impact and value/weight of fisheries landings, whereas the number of c-squares that are now persistently unfished is increased. Freezing the footprint to the core fishing grounds results in more unfished c-squares, lower impact and a larger decline of weight and value of catches. The changes are small compared to the "Reduction of Effort" scenario (Figure 10).

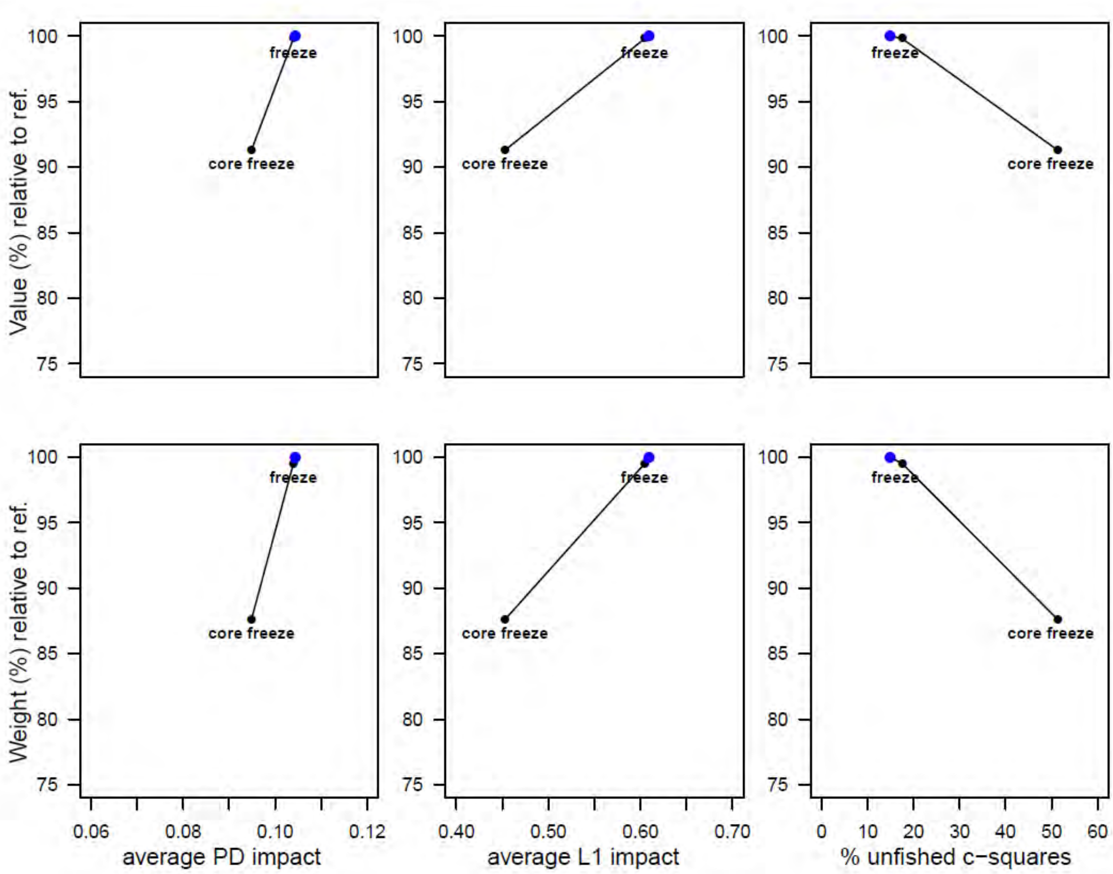


Figure 12. Example output of the trade-off between average impact/unfished c-squares and fisheries values/weight of catches in water less than 200m depth under two different measures (explained in the text). Blue dots show the current situation and are used as reference.

Multipurpose habitat management

An illustration of the trade-off analysis to protect MSFD habitat types is shown in Figure 13 for the five most extensive MSFD habitat types that together cover 88% of the North Sea. In all MSFD habitat types, a small reduction in effort leads to a large increase in unfished c-squares. This reduction is largest in circalittoral coarse sediment and offshore circalittoral coarse sediment where a 5% reduction in effort results in >50% unfished c-squares.

Offshore circalittoral mud is the habitat that has the least unfished c-squares and the highest average impact in both impact indicators.

The reduction of effort is done irrespective of métier. Table 5 illustrates, by setting a 10% effort reduction per MSFD habitat type starting from the least fished c-squares, how this may affect métiers in different ways. The table shows the percentage decline of value of landings per métier relative to the total value of landings of that métier across all MSFD habitats. OT_SPF is most affected in both offshore circalittoral sand and mud by the 10% effort reduction of total effort. This impact on OT_SPF may be disproportional given that OT_SPF is one of the more efficient and low impact gears (Table 3 and 4).

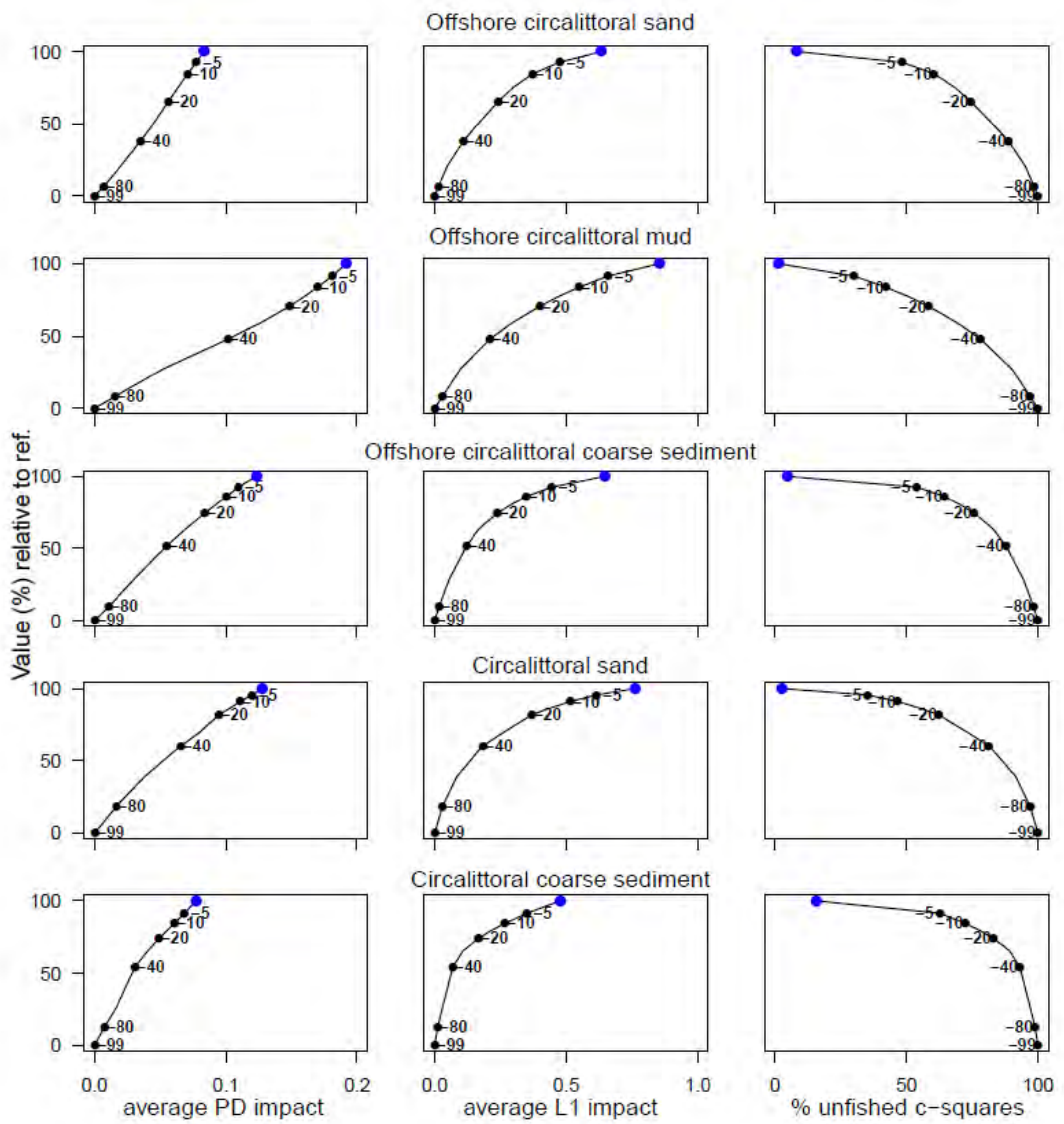


Figure 13. Example output of multi-purpose habitat management with reductions in effort for the five most extensive MSFD habitat types. Figures show the trade-off between average impact (PD, L1) or unfished C-squares and fisheries values of landings in water less than 200m depth. The analysis is based on the progressive removal of 5 to 99% of all MBCG fishing effort, starting from the least fished c-squares. Blue dots show the current situation and are used as reference.

Table 5. Consequences of effort reductions on each métier based on a 10% effort reduction per MSFD habitat type starting from the least fished c-squares. The table shows the percentage decline of value of landings per métier relative to the total value of landings of that métier across all MSFD habitats.

	Offshore circalittoral sand	Offshore circalittoral mud	Offshore circalittoral coarse sediment	Circalittoral sand	Circalittoral coarse sediment
DRB_MOL	1.37	0.08	5.05	0.49	2.65
OT_CRU	0.77	3.35	0.19	0.11	0.01
OT_DMF	6.53	4.8	2.47	0.72	0.41
OT_MIX	0.14	0.1	2.39	0.13	0.53
OT_SPF	13.23	14.13	1.4	2.17	0.15
SDN_DMF	0.74	0.19	0.64	0.31	0.04
SSC_DMF	2.87	2.1	0.96	0.71	0.18
TBB_CRU	0.13	0.05	0	2.6	0.32
TBB_DMF	7.34	3.74	2.92	3.27	0.82
TBB_MOL	0	0	0.1	7.16	0

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