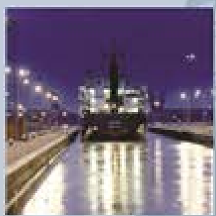
Supporting Risk-Based Assessments of Fisheries in MPAs

Final Report

National Federation of Fishermen's Organisations

December 2015

Creating sustainable solutions for the marine environment





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S.F. Walmsley	N.J. Frost	S.C. Hull

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Contributing Authors

Walmsley, S.F., Blyth-Skyrme, R., Weller, P.S., Dewey, N.K., Lambkin, D.O. Williamson, D.L., O'Neill, F.G., Revill, A., Szostek, C. and Teal, L..

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Notice

ABP Marine Environmental Research Ltd
Quayside Suite, Medina Chambers, Town Quay, Southampton SO14 2AQ
T: +44 (0) 2380 711844 W: http://www.abpmer.co.uk/

Executive Summary

The project 'Supporting Risk-Based Assessments of Fisheries in MPAs' has developed and trialled methodologies which maximise the potential for evidence-based approaches to the assessment of fisheries in European Marine Sites. The project was undertaken by ABP Marine Environmental Research Ltd and Ichthys Marine Ecological Consulting Ltd on behalf of the National Federation of Fishermen's Organisations and funded by the Sea Fish Industry Authority and the European Fisheries Fund.

This Final Report provides an overview of the project, its approach and findings, together with key lessons learned and policy recommendations. A series of appendices provide the detailed methodologies used. It is accompanied by three case study reports, which provide the full assessments for the sites and gears that were selected for study:

- Beam trawling activity on sandbank feature in the North Norfolk Sandbanks and Saturn Reef SCI. This site lies beyond 12 nautical miles (nm) and therefore includes both UK and non-UK fishing activity.
- Shrimp beam trawling activity on sandbank, intertidal mudflats and sandflats, and large shallow inlets and bays features in The Wash and North Norfolk Coast SAC. This site lies within 6 nm and therefore only UK fishing activity is present within the site. A large proportion of the fishing effort is from under-15m vessels, for which vessel monitoring system (VMS) data were not available.
- Otter trawling activity on sandbank feature in Margate and Long Sands SCI. This site lies within 12 nm and includes both UK and non-UK fishing activity. A large proportion of the UK activity is by under-10m vessels and therefore not covered by VMS.

An initial shadow assessment was undertaken for each site, using currently-available information and data. This enabled key data gaps and uncertainties to be identified, and a series of data collection and analysis activities were conducted to address the identified uncertainties and further develop the evidence base. The assessments were updated to reflect the improved evidence base.

Interviews with the fishing industry in each site provided key information on gear details and configurations, fishing patterns and areas, particularly for under-15m vessels. Modelling of the physical impacts of the gears was carried out for sediment resuspension and depth of penetration of the different gear components. This allowed the assessments to consider the impacts of fishing gears based on the individual gear components, the pressures caused and area impacted by each specific component.

Exposure to fishing was assessed for individual habitats or biotopes, and was assessed separately for VMS (over-15m[1]) and non-VMS (under-15m) vessels, using a range of different approaches:

- VMS swept area, calculated from VMS ping data (over-15m vessels, 2009–2013), on individual habitats or biotopes, based on the average towing speed, time fishing, and swept width of the gear;
- VMS 'footprint polygons' from VMS ping data (over-15m vessels, 2009–2013), based on the creation of tracks between consecutive fishing pings which were buffered to reflect the width of individual gear components;

[1] The term 'over-15m vessels' is used to refer to 15 m and over vessels.

- VMS frequency of exposure, based on the number of tracks between consecutive 'fishing' pings (2009–2013), that cross each cell of a 250m x 250m grid;
- Swept area for under-15m vessels, based on fishing areas mapped during interviews, the number of days fishing in each area, the duration of individual tows, the number of tows per day and the average tow speed.

Exposure was calculated for individual gear components. This allowed a clear distinction to be drawn between the different pressures caused by individual gear components (e.g. deep penetration by beam trawl shoes or otter trawl doors, shallow disturbance by otter trawl skids, and surface abrasion from otter trawl ground ropes), and their spatial extent.

Natural disturbance modelling was carried out to consider the proportion of time, and the number of days in a year, that sediments are mobile, and that mobile ripple bedforms of 2.5 cm height are present in the site. This allowed fishing disturbance to be considered in the context of levels of natural disturbance. Subtidal sandbanks are typically subject to high levels of natural disturbance by tidal flows and/or waves. These natural processes are important to the maintenance of subtidal sandbank features and the benthic invertebrates living in these environments are adapted to high levels of natural physical disturbance.

The sensitivity of the habitats or biotopes to pressures caused by fishing was assessed based on existing evidence, biological traits and expert opinion. Sensitivity was assessed using defined scales of tolerance and recoverability, and took into account both the habitat and its characterising species. Vulnerability was assessed based on sensitivity to individual pressures and exposure to those pressures from fishing.

Key findings and recommendations include:

- The data and methods developed through this project help address a number of key data gaps for assessments of fisheries in MPAs in relation to the extent, intensity and frequency of impact for both under- and over-15m vessels. This has improved the evidence base on which the assessments are based, reducing the level of uncertainty and the need for precaution to be used in managing fishing activities.
- Assessments of fishing in MPAs should be based on impacts and exposure at the level of individual gear components. The methods developed under this project provide an approach for implementing this, and are repeatable for other sites. There is potential for further development of the methods to assess exposure, to obtain a more accurate picture of the actual footprint of fishing activity on the seabed.
- The method for linking VMS pings to logbook information should be based on the start and end date of each fishing trip. When fishing vessels are employed in guard ship duty, there should be a way of the vessel reporting this so that VMS pings can be identified as such. The speed rule used to identify 'fishing' activity for VMS pings should be based on the actual range of speeds used for fishing for different vessel sizes and gear types.
- Assessments of the significance of trawling pressure should take account of the levels of natural disturbance, because this is the most important factor governing the structure and function of benthic communities associated with subtidal sandbank habitats.
- The significance of any effects from fishing should be considered in relation to the conservation objective of the site and there is a need for clarity of the baseline against which achievement of the conservation objectives is assessed.
- The scale and frequency of benthic disturbance from fishing that would still maintain (and/or restore) the condition of the site and its features and be acceptable should be discussed and agreed with SNCBs. This is likely to vary on a case-by-case basis and be dependent on the vulnerability of features (as well as the agreed baseline).

- The key limiting factors in being able to determine impacts from fisheries within sites in a consistent manner are: knowledge of habitat and biotope distribution and natural variability over time; the desire to drill down into greater detail where data are available; knowledge of the spatial distribution and intensity of fishing activity by vessels not covered by VMS; and the absence of detailed descriptions of gears and/or habitats in scientific studies of fishing impacts.
- Approaches to assessing fisheries in MPAs need to be further developed and agreed, including the development of guidance on determining significance of impacts, and whether baselines include fishing. A Working Group could be set up to address these issues and move the process forward. This should include consideration of how such assessments and judgements on integrity are made in other industry sectors, and how this can be applied to fisheries.

Contents

Appendices

Tables

Figures

1 Background to the Project

The Habitats Regulations[2] implement the EC Habitats and Birds Directives in UK waters and require that an Appropriate Assessment (AA) should be undertaken by a competent authority where a plan or project is not directly connected with or necessary for the management of European site (Special Area of Conservation – SAC, or Special Protection Area – SPA) and where the possibility of a likely significant effect (LSE) on the site cannot be excluded, either alone or in combination with other plans or projects.

In 2012, the Department for Environment, Food and Rural Affairs (Defra) announced a revised approach to the management of commercial fisheries in European Marine Sites (EMS). The objective of this revised approach is to ensure that all existing and potential commercial fishing activities are managed in accordance with Article 6 of the Habitats Directive. The revised approach is being implemented using an evidence-based, risk-prioritised, and phased basis. Risk prioritisation is informed by a matrix of the generic sensitivity of EMS sub-features to a suite of fishing activities, regardless of exposure. These sub-feature–activity combinations are categorised according to specific definitions, as red, amber, green or blue. Site-level assessments are required to determine whether management of an activity is required to conserve site features for 'amber' rated interactions and for 'green' interactions if there are in combination effects with other plans or projects.

The study has developed and trialled methodologies which maximise the potential for evidence-based approaches to the assessment of fisheries in European Marine Sites (EMSs). The project was undertaken by ABP Marine Environmental Research Ltd (ABPmer) and Ichthys Marine Ecological Consulting Ltd (Ichthys Marine) on behalf of the National Federation of Fishermen's Organisations (NFFO) and funded by the Sea Fish Industry Authority (SeaFish) and the European Fisheries Fund (EFF).

This Final Report provides an overview of the project, its approach and findings, together with key lessons learned and policy recommendations. A series of appendices provide the detailed methodologies used, including a series of reports by gear and ecology experts. It is accompanied by three case study assessments of fishing in EMSs:

- ABPmer & Ichthys Marine, 2015a. Supporting Risk-Based Assessment of Fisheries in MPAs: Assessment of beam trawling activity in North Norfolk Sandbanks and Saturn Reef Site of Community Importance (SCI)[3]. ABPmer Report No R.2551A;
- ABPmer & Ichthys Marine, 2015b, 2015. Assessment of shrimp trawling activity in The Wash and North Norfolk Coast SAC. ABPmer Report No R.2551B;
- ABPmer & Ichthys Marine, 2015c, 2015. Assessment of otter trawling activity in Margate and Long Sands SCI. ABPmer Report No R.2551C.

[2] Conservation of Habitats and Species Regulations, 2010; The Offshore Marine Conservation (Natural Habitats, & c.) Regulations 2007 (as amended); The Conservation (Natural Habitats, & c.) Regulations (GB: 1994 as amended in 2007).

[3] A Site of Community Importance (SCI) is a site that has been adopted by the European Commission but not yet formally designated by the government of the relevant Member State.

2 Approach

The project ran from January to December 2015, during the same period as formal assessments were being undertaken by the regulators (Inshore Fisheries and Conservation Authorities (IFCAs) and the Marine Management Organisation (MMO). We therefore sought to ensure that the assessments carried out by the project used the same baseline information as the formal assessments as far as possible, and worked to ensure that the project provided helpful contributions to the formal process. This was achieved through involving policy makers, regulators and statutory nature conservation bodies in project workshops and consultations.

We selected three site-gear combinations to study through the project (see section 2.1), on the basis of the designated features of the sites and the gears used, industry support for the study objectives, and whether the site-gear combinations would serve as useful case studies for the ongoing assessment process. We considered both EMS and Marine Conservation Zones (MCZs) for the study, and consulted with Inshore Fisheries and Conservation Authorities and the fishing industry to discuss potential sites and gears before deciding which to pursue.

2.1 Sites

The sites and gears that we selected were:

- Beam trawling activity on sandbank feature in the North Norfolk Sandbanks and Saturn Reef SCI. This site lies beyond 12 nautical miles (nm) and therefore includes both UK and non-UK fishing activity.
- Shrimp beam trawling activity on sandbank, intertidal mudflats and sandflats, and large shallow inlets and bays features in The Wash and North Norfolk Coast SAC. This site lies within 6 nm and therefore only UK fishing activity is present within the site. A large proportion of the fishing effort is from under-15m vessels, for which vessel monitoring system (VMS) data are not currently available.
- Otter trawling activity on sandbank feature in Margate and Long Sands SCI. This site lies within 12 nm and includes both UK and non-UK fishing activity. A large proportion of the UK activity is by under-10m vessels and therefore not covered by VMS.

The reports for each site are provided separately (ABPmer & Ichthys Marine, 2015a; 2015b; 2015c).

2.2 Habitat Data

Habitat data for the sites were sought from statutory nature conservation bodies in order to base the assessments on the most up-to-date information available:

- Biotope data for Margate and Long Sands SCI were provided by Natural England, based on the most recent surveys. This represented the most up-to-date reflection of understanding of the relevant biotopes in the site and their extents.
- Habitat and biotope data for The Wash and North Norfolk Coast SAC were provided by Natural England.
- UKSeaMap habitat data (at EUNIS Level 4) were used for the North Norfolk Sandbanks and Saturn Reef SCI. JNCC indicated that more up-to-date survey information was being collated but was not yet available.

2.3 Methods

We first undertook an initial shadow assessment for each site, based on currently-available information and data. This enabled key data gaps and uncertainties to be identified. We then undertook a series of data collection and analysis activities to further develop the evidence base on fishing activities for each site to address these gaps and uncertainties (see sections 0–5), and then updated the assessments to reflect the improved evidence base. This is summarised in Figure 2.1 and further described in the sections that follow.

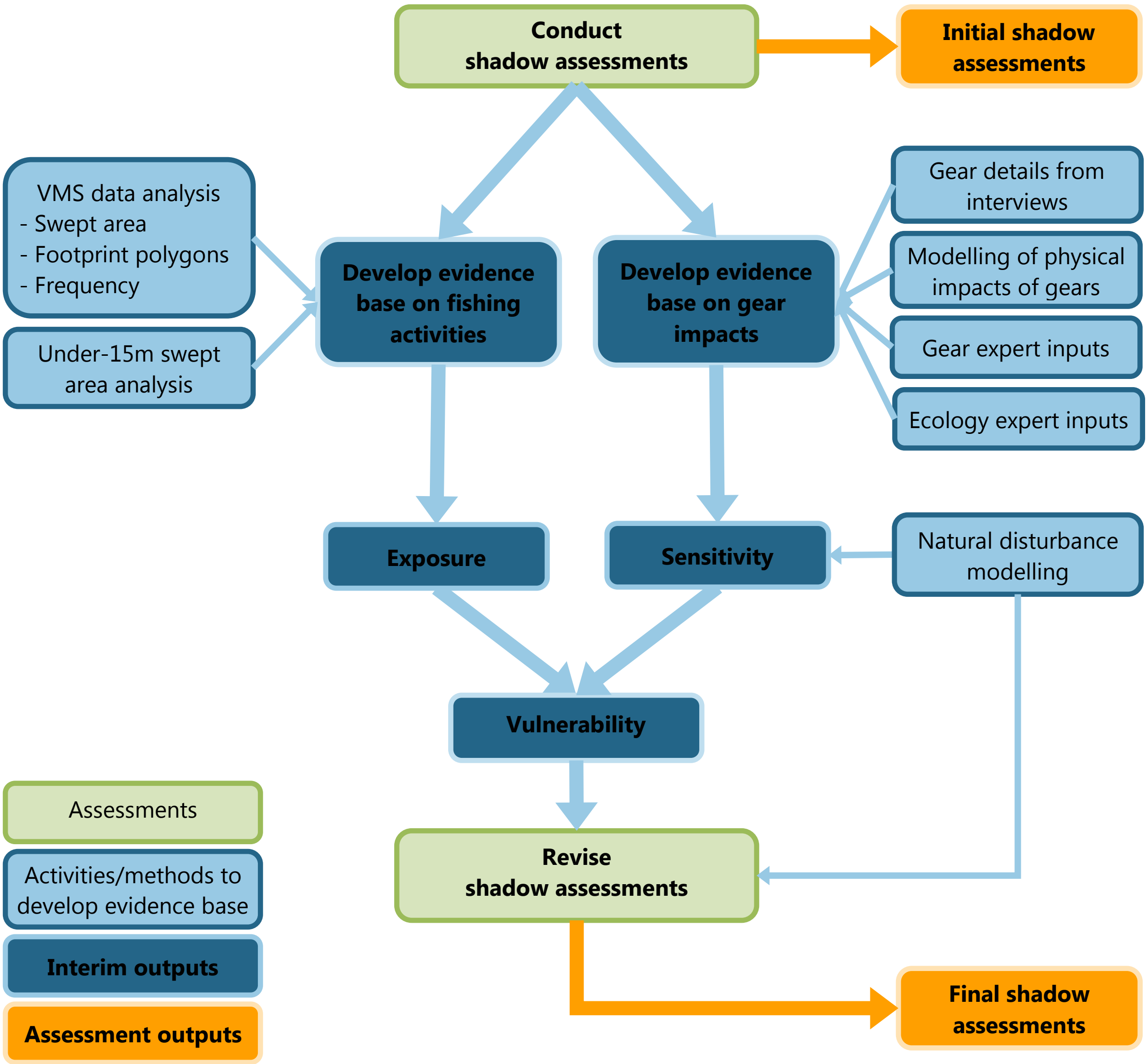


Figure 2.1 Overview of project approach

3 Assessing Impacts of Fishing Gears

3.1 Interviews with the Fishing Industry

A key part of developing the evidence base for the sites was based on interviews with the fishing industry in each site. A copy of the interview proforma is provided in Appendix A. The interviews covered a number of aspects and fed into several project components (Table 1).

Table 1 Interview topics and links to project components

Interview Topic	Relevant Project Component
Gear details and configurations (e.g. number, weight and size of gear components)	Modelling of gear physical impacts VMS swept area analysis VMS footprint polygons Under-15m swept area analysis
Fishing patterns (e.g. number of tows per day, tow speed, tow duration)	VMS swept area analysis Under-15m swept area analysis
Mapping of fishing areas for under-15m vessels and level of effort (e.g. number of days fishing) in each area	Under-15m swept area analysis

3.2 Gear Details

Details of gear dimensions and configurations were obtained from interviews with industry. We then considered the impacts of fishing gears at the level of the individual gear components and the pressures they cause. This builds on previous work by Lart (2012) and further developed by Eigaard *et al.* (2013). As such, the pressures caused by individual gear components (e.g. deep penetration into the seabed sediments by the trawl doors of otter trawl gear, surface abrasion by the ground gear of a trawl) are considered in relation to the area of impact of those individual gear components.

A similar approach of considering individual gear components has been proposed by Rijnsdorp *et al.* (2015) in relation to the physical effects of trawl gears on the seabed, on marine taxa, and on the functioning of the benthic ecosystem, in developing a framework for the quantitative assessment of trawling impact on the seabed and benthic ecosystem.

3.3 Modelling of Physical Impacts of Gears

Modelling of the physical impacts of the gears was carried out for sediment resuspension and depth of penetration of the different gear components. Full details are provided in Appendix B. Sediment resuspension is a function of the hydrodynamic drag of the gear, which is a function of the speed at which the gear is towed. The magnitude of gear penetration on any given sediment type is dependent on the pressure force, which in turn is a function of both the weight and the surface area of the gear (Ivanović & O'Neill, 2015). A smaller gear component will affect a smaller area of seabed, but may penetrate to a greater depth than a heavier component with a larger surface area.

The numerical models used have been compared with experimentally measured values, and the results of the modelling are consistent with other experimental results from sea trials and numerical results from simulation modelling (Ivanović *et al.*, 2011; Esmaeili and Ivanović, 2014; Depestele *et al.*, 2015; Ivanović & O'Neill, 2015).

For this study, the models were based on typical gear weights and dimensions as derived from the interviews with fishermen, and on sandy sediment types representative of those found within the study sites, with a silt proportion ranging from 5–20%.

Figure 3.1 summarises the penetration depth and sediment mobilisation results for the single and triple rig trawls used by under-10m vessels on sand in the Margate and Long Sands SCI. The following is noted:

- The greatest physical impact is associated with the penetration of the trawl doors into the sediment, with penetration up to 4 cm depth on sand, however, this occurs over a small proportion of the overall swept area of the gear (approximately 1.5–2 m of a 22.5 m gear spread).
- The penetration depths of the ground gear, skids and sweeps, are typically less than 1 cm on sand.
- For a sandy sediments with a 20% silt fraction, the amount of sediment mobilised through hydrodynamic drag equates to a sediment depth of 1.0 mm (average across the gear), and a maximum not greater than 6 mm for any individual component.

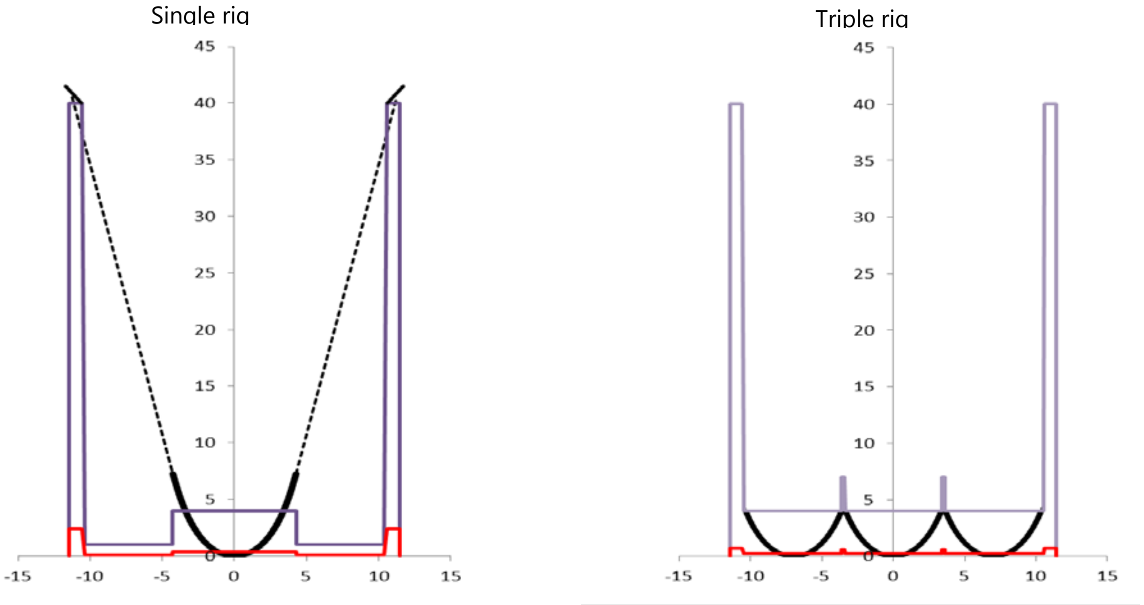


Figure 3.1 Sediment mobilised into the water column (red lines) (measured in terms of the equivalent sediment depth in mm) and penetration depth in sand in mm (grey lines) of under-10m single rig and triple rig trawls across their swept path (in metres) for the Margate and Long Sands SCI

3.4 Expert Inputs

3.4.1 Gear experts

A Fishing Gear Impacts Workshop was held on 16–17 September 2015 to discuss the impacts of the gears in use in each of the sites. In addition to the modelling of physical impacts of the gears, independent gear experts prepared reviews of the latest and relevant research into gear impacts. Their reports are provided in Appendix C (Review of impacts of the brown shrimp fishery in The Wash, by Andy Revill) and Appendix D (Physical and biological impacts of beam and pulse trawling — Summary of BENTHIS field trial results, by Lorna Teal). A further review of the literature was carried out for each assessment to ensure that relevant studies and research were included in the assessments.

3.4.2 Biological traits

A review of studies into the impacts of the gears under consideration was also carried out by an ecology expert. Information was compiled on the biological traits of the characterising species of the habitats and biotopes under consideration in the sites, which may affect their susceptibility to trawling. This was based on an adaptation of the methodology in Bolam *et al.* (2014). A review of the literature was also undertaken to determine the extent to which published research had been undertaken on the types of gears and habitats studied for this project. The full report is provided in Appendix E (Biological and ecological impacts).

4 Assessing Exposure to Fishing

Exposure to fishing was assessed for individual habitats or biotopes in each site (according to the level of detail for which the habitat data were available).

Exposure to fishing was assessed separately for VMS (over-15m[4]) and non-VMS (under-15m) vessels, using a range of different approaches, in order to build up a picture of the extent, distribution and intensity of fishing activity:

- VMS swept area, calculated from VMS ping data (over-15m vessels[5], 2009–2013), on individual habitats or biotopes;
- VMS 'footprint polygons' from VMS ping data (over-15m vessels, 2009–2013);
- VMS frequency of exposure, from tracks created between consecutive 'fishing' pings (2009–2013), on a 250m grid;
- Swept area for under-15m vessels, based on interview data.

Each method is described below, and in greater detail in Appendix F.

4.1 VMS Swept Area Analysis

The swept area of fishing on each habitat or biotope was calculated by intersecting the VMS 'fishing' pings with the habitats or biotopes in ArcGIS, and using the following formula (Gerritsen *et al.*, 2013):

$$\textit{Swept area (km}^2\textit{) = Time fishing (in hours) x Tow speed (in km/hr) x Gear width (in km)}$$

The input data were obtained as follows:

- The time fishing was either taken from the time associated with each ping from the VMS data (where available), or assumed to be two hours. The time associated with the pings was summed to obtain the time fishing on each habitat/biotope.
- The average towing speed was calculated from relevant 'fishing' pings[6] within the site, and corroborated by interview data.
- The gear width was obtained from interviews with the fishing industry (see Appendix A) and consultations with individual skippers.

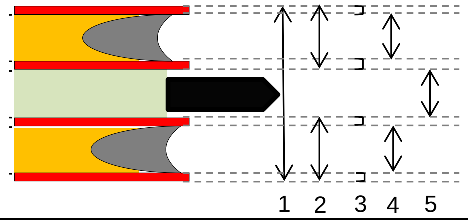
The swept area calculated for each habitat/biotope was then pro-rated to the area affected by each gear component, according to the width of the individual components (based on information of gear configurations from interviews) to obtain the area of habitat impacted by each component. Figure 4.1 shows the gear widths used for individual gear components.

4 The term 'over-15m vessels' is used to refer to 15 m and over vessels.

5 The VMS data provided by the MMO for the project cover over-15m vessels. Since 2012, VMS has been a requirement for over-12m vessels and is being progressively rolled out across the 12–15m fleet, but these data were not available for the project.

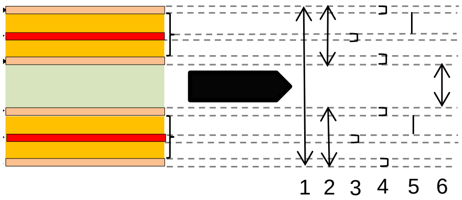
6 'Fishing' pings were taken as those identified by MMO using the speed rule of >0–6 knots.

North Norfolk Sandbanks and Saturn Reef SCI – Conventional beam trawl



1. Full gear width to outer edges of beams = 32.5m
2. Full width of each beam = 12m
3. Beam shoes on inner and outer edges of gear = 0.7m
4. Tickler chains and ground rope = 10.6m
5. No impact (vessel width to inner edges of beams) = 8.5m

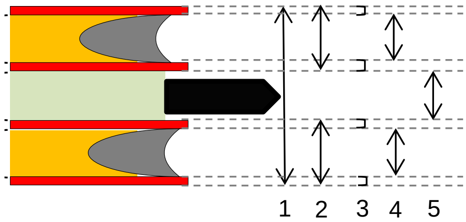
North Norfolk Sandbanks and Saturn Reef SCI – Pulse wing trawl



1. Full gear width to outer edges of beams = 32.5m
2. Full width of each beam = 12m
3. Nose shoe in middle of each beam = 0.25m
4. Wing ends (inner and outer edges of gear) = 0.1m
5. Electrodes (pulse gear) = 5.58 m

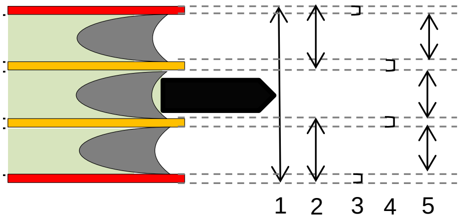
6: No impact (vessel width to inner edges of beams) = 8.5m

The Wash and North Norfolk Coast SAC – shrimp beam trawls



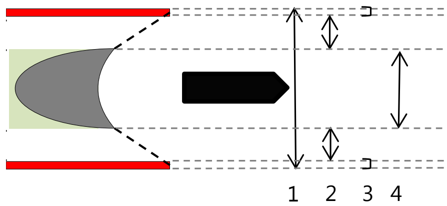
1. Full gear width to outer edges of beams = 18m
2. Full width of each beam = 7m
3. Beam shoes on inner and outer edges of gear = 0.24m
4. Ground rope = 6.52m
5. No impact (vessel width to inner edges of beams) = 4m

Margate and Long Sands – UK under-15m triple rig otter trawls



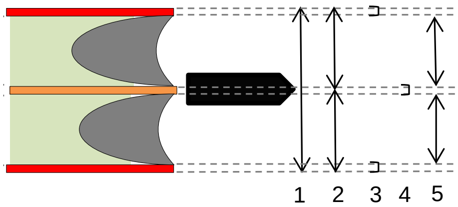
1. Full gear width to outer edges of gear = 21m
2. Full width of each net = 7.4m
3. Otter doors = 0.95m
4. Skids between nets = 0.25m
5. Ground rope = 6.2m

Margate and Long Sands – UK under-15m single rig otter trawls



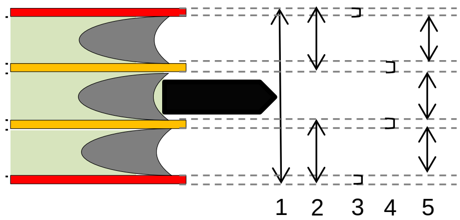
1. Full gear width to outer edges of gear = 22.5m
2. Sweeps = 6.5m
3. Otter doors = 0.8m
4. Ground rope = 7.9m

Margate and Long Sands – UK over-15m twin otter trawls



1. Full gear width to outer edges of gear = 30.5m
2. Full width of each net = 15.25m
3. Otter doors = 0.75m
4. Skid between nets = 0.2m
5. Ground rope = 14.4m

Margate and Long Sands – non-UK over-15m triple rig trawls



1. Full gear width to outer edges of gear = 29.9m
2. Full width of each net = 10.25m
3. Otter doors = 1.0m
4. Skids between nets = 0.3m
5. Ground rope = 9.1m

Figure 4.1 Widths of individual gear components used to buffer VMS tracks for different vessel types in the assessments

4.2 VMS Footprint Polygon Analysis

The 'footprint' of fishing impact was analysed by creating tracks between consecutive 'fishing' VMS pings from individual vessels using 2009–2013 data (Figure 4.2). The tracks were then sequentially buffered to reflect the width of the individual gear components of typical fishing vessels in each site (Figure 4.1, Figure 4.3).

A polygon was then created for each gear component by joining together the respective individual buffered tracks, and overlain on the habitat map (Figure 4.4). Where polygons for different gear components overlapped, the component with greater impact was used, with overlapping areas subtracted from the lower impact polygons. The polygons were clipped to the SAC area, and the area of each habitat or biotope impacted by each gear components was calculated in GIS, and compared to the overall area of the habitat or biotope.

The tracks created between sequential VMS pings may not represent the actual path of the fishing vessel, and there are alternative methods for interpolating tracks between VMS pings. However, comparison of plotter tracks and VMS pings (Lee, 2012), showed that there can be a good correspondence between the pings and the actual vessel track. Furthermore, the analysis was based on five years of data combined, and therefore is considered to provide a good approximation of the footprint of fishing activity over this time period.

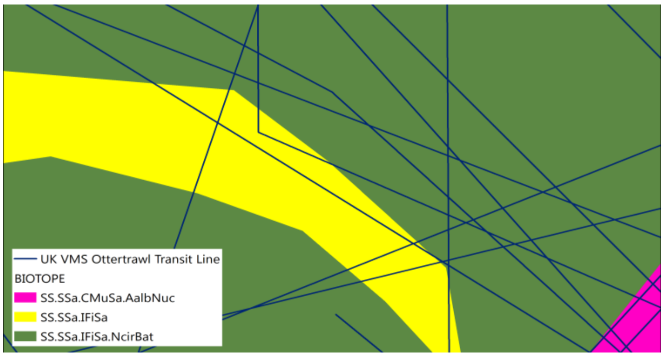


Figure 4.2 **Examples of tracks created between VMS pings**

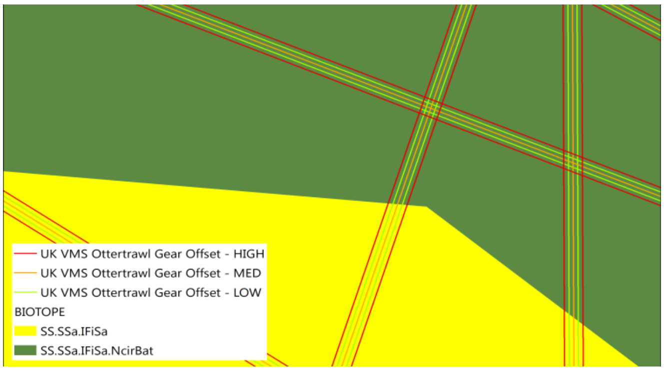


Figure 4.3 **Examples of tracks for individual gear components**

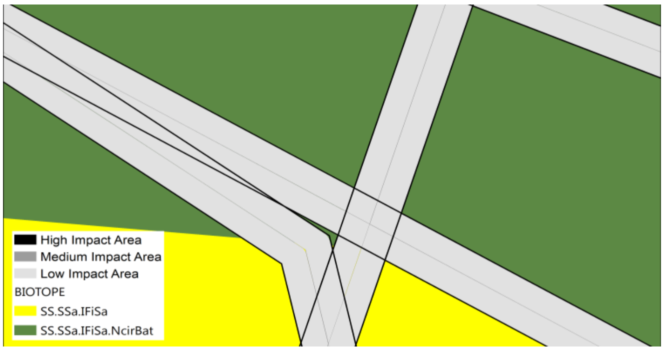


Figure 4.4 **Example of VMS footprint polygons for individual gear components**

4.3 VMS Frequency of Exposure Analysis

To assess the number of times that an area is impacted, we superimposed a grid onto the VMS tracks (created for the VMS footprint polygon analysis), and calculated the number of tracks that crossed each grid cell. Grid cell size was 250 m. This was 10–15 times larger than the width of the gear, therefore more than one track per cell does not necessarily mean that the same area of seabed is impacted multiple times. A higher resolution grid (for example, that equates with the swept width of the gear) was unmanageable in terms of data processing for the whole site, but could potentially be carried out for smaller areas.

The frequency of exposure figures (Figure 4.5) provide important information on the frequency with which different parts of the site are disturbed by fishing, which can be related to information on the recovery time of the component habitats and biotopes. Even in areas of relatively high frequency of impact (e.g. 12–24 trawl passes per year), this represents the passage of a 14–24m trawl within a 250 m area. Therefore, even in grid cells with the highest level of fishing effort, it is possible that an individual area of a biotope is disturbed only once or twice per year.

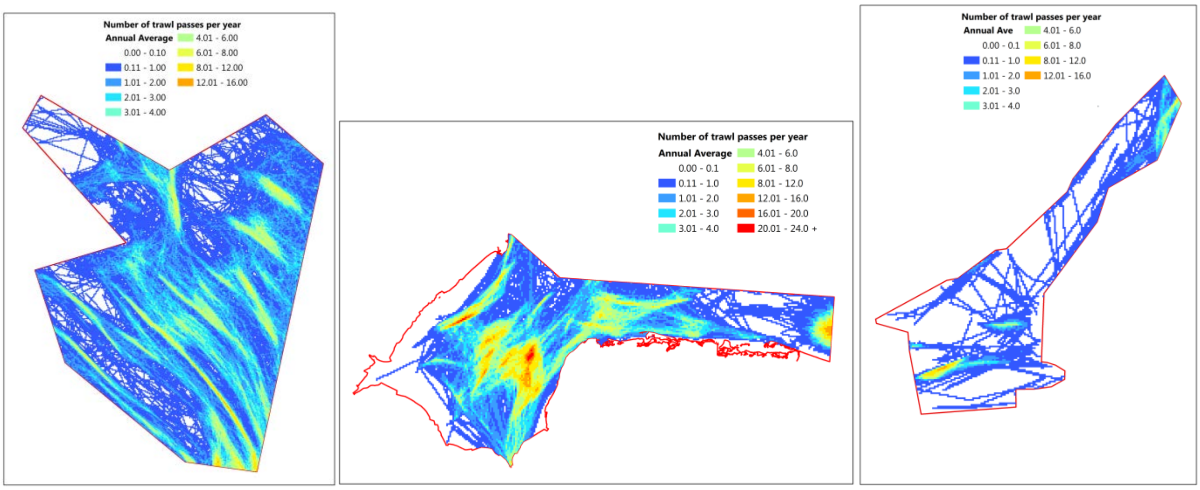


Figure 4.5 **Example frequency of impact figures for North Norfolk Sandbanks and Saturn Reef SCI (left), The Wash and North Norfolk Coast SAC (middle) and Margate and Long Sands SCI (right), annual average number of trawl passes per 250 m grid cell as recorded by VMS tracks**

4.4 Under-15m Exposure Analysis

Smaller vessels do not use VMS and an alternative method of establishing the footprint of their fishing activity was required, especially where they represent a significant proportion of fishing activity. Therefore, we used information from interviews with the fishing industry to assess exposure for under-15m vessels in Margate and Long Sands SCI and The Wash and North Norfolk Coast SAC. There was no under-15m beam trawling activity in North Norfolk Sandbanks and Saturn Reef SCI. Interviews included a mapping exercise where skippers indicated the areas they fished (for different species, with different gears where relevant, and at different times of year) by drawing on a copy of an admiralty chart.

The swept area for each fishing polygon for each fisherman per month was calculated with the following formula:

$$\textit{Swept area (km}^2\textit{) = Number of days fishing in the polygon x Number of tows per day x Tow speed (in km/hr) x Gear width (in km)}$$

In the case of Margate and Long Sands SCI, where fishermen use both single rig otter trawls with sweeps to target cod, towed at around 2.8 knots, and triple rig otter trawls without sweeps to target sole, towed at around 1.5 knots, the swept area for each gear type was calculated separately. Because the configurations of the gears used by different fishermen are similar, an average overall gear width was used for each gear type. In The Wash and North Norfolk Coast SAC, fishermen on under-15m vessels use different beam lengths (ranging from three to eight metres) relating to the size of the vessel, therefore the actual combined beam width for each interviewee was used.

The polygons for each interviewee were digitised and overlain on the biotope map, and the area of each biotope in each polygon was calculated in GIS. The swept areas calculated above were then applied pro-rata to the biotopes within each polygon, and further pro-rated according to the percentage of the gear footprint attributed to each gear component. These areas were then summed across the interviewees for each biotope.

The swept areas were then scaled up by an appropriate factor, to account for the whole under-15m fleet that is active within each site. In Margate and Long Sands SCI, this was a factor of two, based on an estimate of the number of vessels interviewed, and the overall number of under-15m vessels active in the site. In The Wash and North Norfolk Coast SAC, originally a scaling factor of three was used, based on the number of vessels interviewed compared to the number of under-15m vessels active in the site, but this was subsequently adjusted based on data provided by the two brown shrimp processors that process all brown shrimp landings from The Wash, and include data on the number of landings made (i.e. number of fishing days) by each vessel and the trip length for a sample of vessels. This allowed an overall number of days' fishing by the under-15m vessels to be calculated, and the swept area to be scaled up by an appropriate factor, specific to each site.

This provided an estimate of the area of each biotope impacted by the individual gear components, per month (and per quarter, or per year), which was compared to the overall area of each biotope.

4.5 Plotter Data

Fishing vessel plotter data[7] has been compiled by The Crown Estate and NFFO's UK Fishermen's Information Mapping (UKFIM) project. The plotter data held for the sites were considered for the assessments. The data for UKFIM were provided voluntarily by participating fishermen, and therefore some areas have better coverage than others, according to the willingness of individual fishermen to provide their data. Drawing conclusions from the data must be done with care, as it was not always clear what the plotter marks represented (e.g. fishing lines to navigate to for preferred fishing grounds; actual tow lines representing fishing activity; fasts which are avoided for fishing as gear may become snagged) or the timescale associated with the tracks. Additionally, plotters and plotter information may be shared between fishermen, and therefore the information stored on an individual plotter may relate to the activity of different vessels.

The UKFIM plotter data were variable between the three sites:

- North Norfolk Sandbanks and Saturn Reef SCI: The data show a large number of tracks for beam trawls, predominantly following the lines of the sandbanks (along the flanks or within the troughs) together with some information for dredges and unknown gear. The data for beam trawls do not add any additional information over and above that provided by the VMS data.
- The Wash and North Norfolk Coast SAC: only a few individual plots were present in the site, which did not provide a useful picture either of areas where fishing activity occurs, or where it does not occur. The lines appeared to relate more to bathymetry than to fishing activity.

- Margate and Long Sands SCI: There are tracks for beam trawls and bottom trawls in the northern part of the site and through channels, and a few tracks relating to 'other trawls' in the southern part of the site. The data do not provide a comprehensive picture either of areas

7 Data collected by fishermen using on-board marine navigation systems that integrate global positioning system data with an electronic navigational chart, which can be used to record specific locations and tracks (e.g. fishing tows, locations of 'fasts' where gear has snagged, and additional information for seafloor mapping (bathymetry etc).

where fishing activity occurs, or where it does not occur. For the larger vessels, the plotter data do not add any additional information over and above that provided by the VMS data. For the smaller vessels, the data do not appear to reflect their fishing areas.

The UKFIM plotter data were therefore not used for the assessments, as they did not add any useful information additional to that provided by the VMS data, and previous work (Lee, 2012) has shown good correspondence between plotter data and VMS pings. For plotter data to be useful, greater clarity is needed on what individual tracks represent and the extent to which they reflect fishing intensity.

Plotter data were also received from some individual fishing vessels, and were converted to GIS. However the tracks represented the activity of a single vessel and could not be used to draw conclusions about the activity of the whole fleet within the site. They were therefore not used within the assessments.

5 Assessing Natural Disturbance

Many subtidal sandbanks are subject to high levels of natural disturbance by tidal flows and/or waves. These natural processes are important to the maintenance of subtidal sandbank features and the benthic invertebrates living in these environments are adapted to high levels of natural physical disturbance. To consider fishing disturbance in the context of natural disturbance, we carried out modelling to determine the levels of seabed disturbance from natural processes. Natural disturbance was quantified using data on:

- Bathymetry (water depth, from the European Marine Observation and Data Network (EMODnet), UK Hydrographic Office (UKHO) and General Bathymetric Chart of the Oceans (GEBCO), resolution ~150 m by ~220 m, sufficient to resolve the sandbank features present in the sites);
- Seabed type (broadly indicative of grain size distribution, from a composite of EMODnet, British Geological Survey and Defra's 'hard substrates' layers, categorised zone boundaries);
- Tidal current speed (frequency distribution of depth mean tidal current speed, Atlas of UK Marine Renewable Energy Resources, resolution ~1.6 km by 1.8 km);
- Wave height frequency distribution (ABPmer SEASTATES wave hindcast database, 31 years of hourly hindcast data, approximately 5 km resolution).

The outputs provide:

- an estimate of the proportion of time that:
  - sediments are disturbed by currents, by waves, and by currents or waves;
  - mobile bedforms of 2.5 cm height or more are present in each model cell;
- an estimate of the average number of days per year that:
  - sediments are disturbed by currents, by waves, and by currents or waves;
  - mobile bedforms of 2.5 cm height or more are present in each model cell;

The proportion of time that sediments are mobile provides an indication of the level of natural disturbance in the site. At a certain level of disturbance, mobile bedforms such as sand ripples form, and move rapidly (e.g. tens of metres per day). The presence of these mobile bedforms indicates that the top layer of sediment is being continually reworked to a depth equivalent to at least the ripple height. The simultaneous presence of fauna indicates that they are both adapted and used to such conditions. The level of natural disturbance can also be expressed as the average number of days during which sediments are mobile or mobile bedforms occur. This can be compared to the number of passes of fishing gear in a month or in a year to provide an indication of relative levels of fishing and natural disturbance, although it is recognised that fishing can cause impacts that natural disturbance of sediments does not (e.g. penetration into the sediment causing crushing of infauna).

For each site, we generated a range of outputs, including the proportion of time and the average number of days per month and per year that sediments are mobile and that mobile bedforms are present. This included (for annual outputs) a range of indicative sediment grain sizes (assuming uniform grain size throughout the site), and for sediment grain sizes according to the UKSeaMap sediment classification (varying grain size in the site). Examples are provided in Figure 5.1 and Figure 5.2. Full details and outputs are provided in Appendix G.

In general, current-induced disturbance is more likely to be more frequent, uniform and persistent, and of a relatively lower magnitude than wave-induced disturbance, which is more likely to be episodic, seasonal and with short-term fluctuations in magnitude and direction (between individual waves and wave groups), and (especially in shallower water) may be of a relatively higher magnitude.

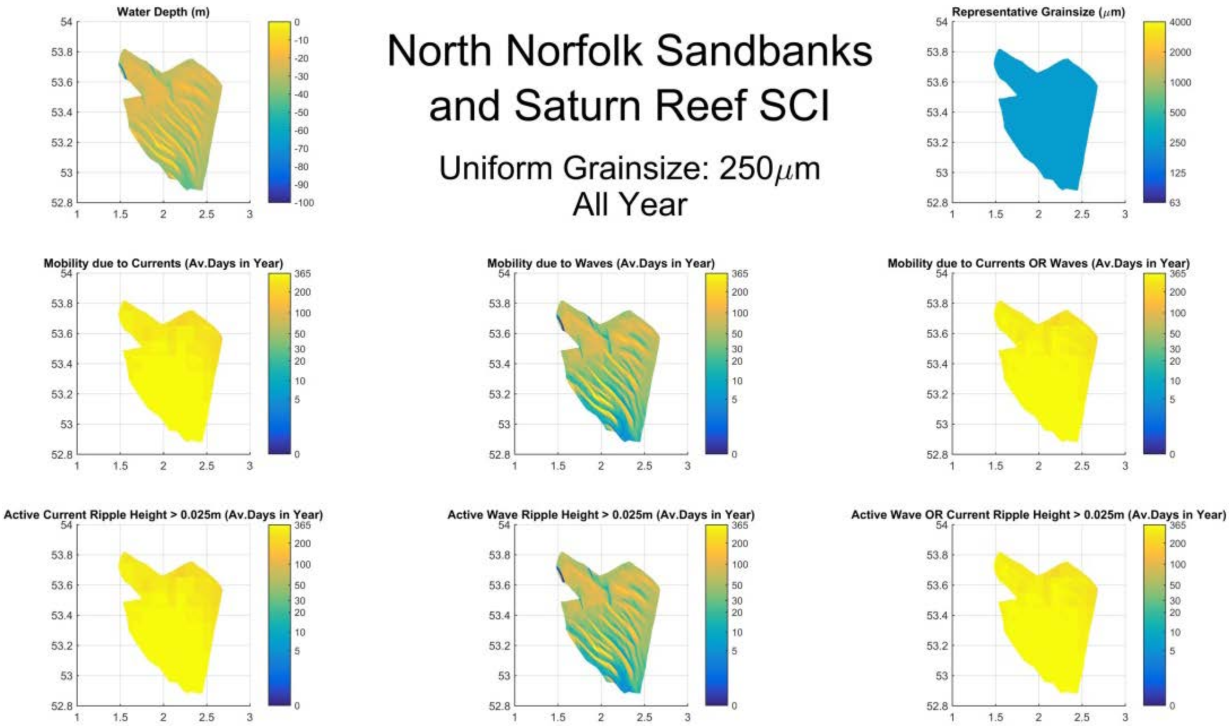


Figure 5.1 Example outputs of the natural disturbance modelling – number of days per year that sediments are mobile (middle row) and mobile bedforms are present (bottom row) in the North Norfolk Sandbanks and Saturn Reef SCI due to currents (left), waves (middle), and currents and waves combined (right)

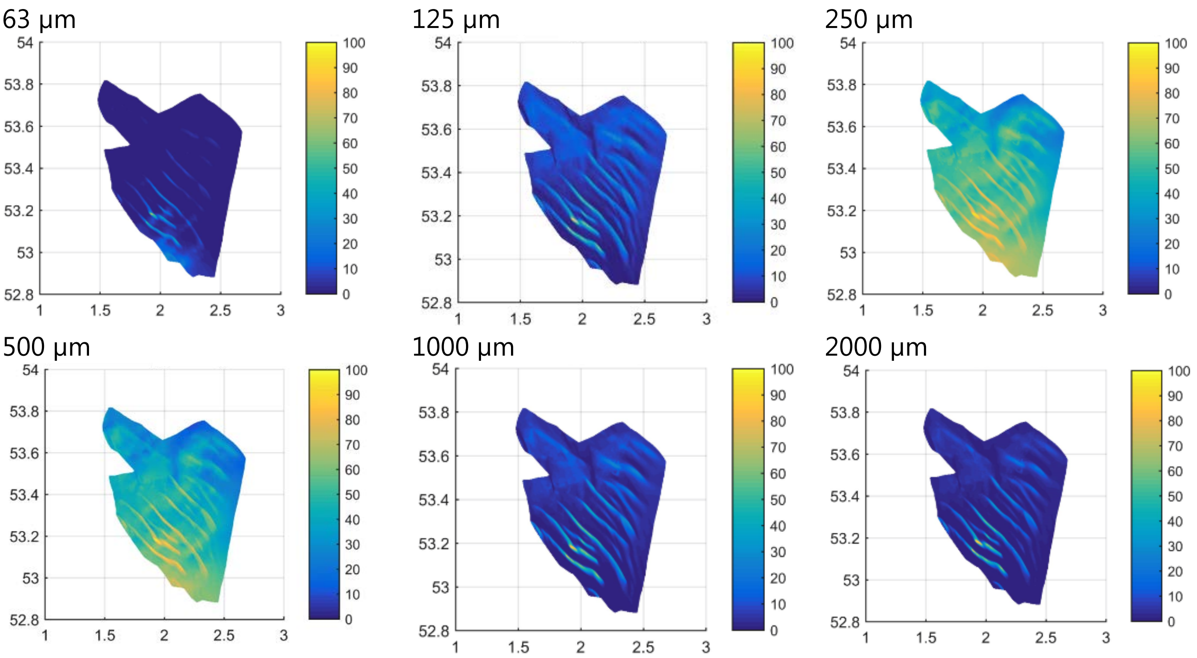


Figure 5.2 Example outputs of the natural disturbance modelling – proportion of time that mobile bedforms of 2.5 cm height are present in the North Norfolk Sandbanks and Saturn Reef SCI due to waves or currents for different sediment grain sizes

6 Approach to Assessments of Fishing Activity

The assessments of the impact of fishing activity were based on the vulnerability of the individual habitats or biotopes to pressures that might arise from fishing. The vulnerability is a function of sensitivity (based on tolerance and recoverability) to individual pressures and the exposure to those pressures arising from fishing (Figure 6.1).

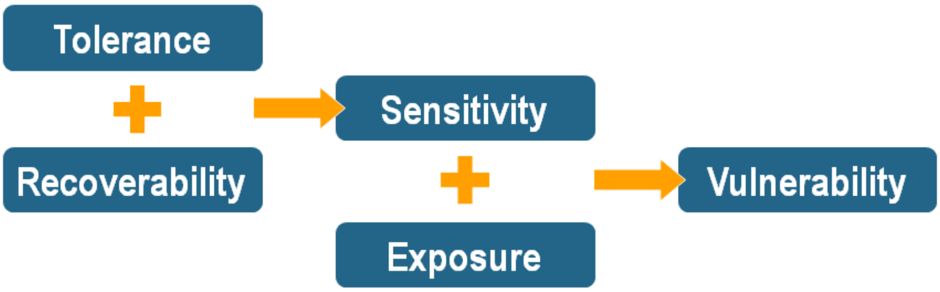


Figure 6.1 Vulnerability, based on sensitivity and exposure

6.1 Sensitivity

Sensitivity is a measure of the likelihood of change when a pressure is applied to a feature and is a function of the ability of the feature to tolerate change and its ability to recover. A feature is defined as very sensitive when it is easily adversely affected by human activity (low tolerance) and/or it has low recoverability (recovery is only achieved after a prolonged period, if at all). The tolerance and recoverability are combined to determine sensitivity as shown in Table 2.

To assess sensitivity, we used the scales of tolerance and recoverability identified in ABPmer (2013). These scales have been informed by other sensitivity assessment approaches, and are based on the MB0102 Defra project (Tillin *et al.*, 2010), which has been used extensively by regulators to support decisions on UK MPA planning and management. Full details of the scales of tolerance and recoverability are provided in the individual assessment reports (ABPmer & Ichthys Marine, 2015a,b,c).

Sensitivity was assessed for each habitat or biotope (depending on the level of detail of the habitat data in each site), and took into account the habitat and its characterising species (those named in the biotope description). Where only habitat data were available, typical characterising species for that habitat, as described in the conservation advice, were included. The assessments of sensitivity were precautionary, adopting the assessment of the most sensitive part or species of the biotope.

Table 2 Sensitivity, based on tolerance and recoverability

Recovery	Tolerance			
	None	Low	Medium	High
Low	Very High	High	Low	Not Sensitive
Medium	High	Medium	Low	Not Sensitive
High	Medium	Medium	Low	Not Sensitive
Very High	Low	Low	Low	Not Sensitive

An assessment of **not sensitive** indicates that the assessed pressure is not expected to lead to significant effects on structural habitat elements or characterising species. A feature is assessed as having **low sensitivity** to a given pressure level where tolerance is assessed as medium so that there is no significant impact but recovery may take between six months to more than six years. Alternatively the tolerance threshold may be none, or low, but recovery is rapid (within six months). **Medium sensitivity** is where tolerance is categorised as none but where recovery takes place within two years, or those where tolerance is low (the pressure leads to a significant effect) and recovery is predicted to occur within two to five years (medium to high recovery). Features assessed as being of **high sensitivity** experience significant impacts following the pressure (no to low tolerance) with full recovery requiring at least three years. The feature may not be recovered after six years. Features assessed as having **very high sensitivity** are those that are predicted to have no tolerance to the pressure (75% decline of assessed elements), and where full recovery is predicted to take more than six years.

6.2 Exposure

Exposure to fishing was based on the methods described in section 4 and on the basis of the footprint or swept area of the fishing activity (from individual gear components relating to each pressure) on each habitat or biotope, compared to the overall size of the habitat or biotope in the site. This required a combination of the over-15m swept area and VMS footprint polygons for over-15m vessels, complemented by frequency of impact, and combined with under-15m swept area. The categorisation of exposure to seabed disturbance was based on the scale in Table 3. For VMS footprint polygon analysis, this related to the area affected by fishing over a five-year period.

The exposure was assessed on the basis of individual gear components, so that the sensitivity of the biotopes to the pressures exerted by those individual gear components (e.g. based on penetration depth) can be assessed. Exposure to pressures such as siltation, and biological removal of target and non-target species, was assessed in relation to the exposure to seabed disturbance.

Table 3 Exposure categories

Exposure Category	Percentage of Habitat/Biotope Affected
None	No overlap between fishing activity and the habitat/biotope
Low	0–10%
Moderate	11–75%
High	75–150%
Very high	>150%

6.3 Vulnerability

Vulnerability is a measure of the degree to which a feature is sensitive to a pressure and exposed to that pressure. Vulnerability can be considered to be an expression of the likely significance of effects; where features have high vulnerability they are more likely to be changed by the activity-related pressures under consideration. The vulnerability of the assessed features, based on sensitivity and exposure, is described in Table 4.

Table 4 Vulnerability, based on sensitivity and exposure

Exposure	Sensitivity			
	None	Low	Medium	High
Low	Not Vulnerable	Not Vulnerable	Low	Moderate
Moderate	Not Vulnerable	Low	Moderate	High
High	Not Vulnerable	Moderate	Moderate	High
Very High	Not Vulnerable	Moderate	High	High

6.4 Integrity

The 'integrity of the site' has been defined as 'the coherence of the site's ecological structure and function, across its whole area, or the habitats, complex of habitats and/or populations of species for which the site is or will be classified'[8]. Judgement of whether effects may constitute an adverse effect for the purposes of Article 6(3) must consider only habitat types or species listed in Annex I or Annex II of the Directive, provided that any effects on other habitats or species do not affect the coherence of the network (European Commission, 2000).

Site integrity therefore must be considered in relation to the site's conservation objectives and should focus on and be limited to those objectives. It is therefore important to consider the current state of the site and its designated features, and understand the baseline for this assessment.

The assessment of integrity was based on the level of vulnerability to fishing impacts, and whether this might constitute an adverse effect on the integrity (AEOI) of the site. Vulnerability can be considered as an expression of the likely significance of effects. The significance of any effects, particularly for low vulnerability pathways, will depend on whether the baseline includes existing levels of fishing activity, and should also be considered in relation to the conservation objective of the site. Where the conservation objective is to 'maintain', this indicates that the feature is in favourable condition, given the existing levels of activity in the site.

Levels of fishing disturbance and the vulnerability of different pathways were also considered in the context of levels of natural disturbance at the site. Where areas are subject to high levels of natural disturbance, it is arguable whether 'low vulnerability' pathways constitute an AEOI or not. Potential sources of in-combination effects from relevant projects, plans and activities were also considered to give an overall view of integrity. The significance of impacts has been considered in relation to levels of natural disturbance in the site.

8 PPG 9, UK Department of the Environment, October 1994.

7 Conclusions

7.1 Overview of Assessments

A summary of the conclusions of the assessments is provided for each site below, with the details provided in ABPmer & Ichthys Marine 2015a, 2015b and 2015c.

7.1.1 North Norfolk Sandbanks and Saturn Reef SCI

Based on the assessments of sensitivity and exposure of each habitat in North Norfolk Sandbanks and Saturn Reef SCI, in relation to the pressures exerted by individual gear components:

- Under the scenario that assumed all beam trawlers are conventional beam trawlers:
  - Shallow and deep disturbance on all habitats — low vulnerability, except for deep disturbance on deep circalittoral sand which is assessed as moderate vulnerability;
  - Biological disturbance through removal of target and non-target species for all habitats — low vulnerability.

- Under the scenario that assumes all UK beam trawlers are conventional beam trawlers and all non-UK beam trawlers are pulse wing trawlers:
  - Shallow and deep disturbance on all habitats — low vulnerability.

There were no gear-habitat interactions that resulted in an assessment of high vulnerability, and under scenario 2, which most closely reflects current fishing patterns in the site, there were no moderate or high vulnerability pathways. It is uncertain whether low vulnerability overall might constitute an adverse effect on the integrity of the site, particularly as disturbance from fishing activity is low relative to levels of natural disturbance in the site, with mobile bedforms being present for much of the time. The significance of beam and pulse trawling effects will also depend, to some extent, on the baseline against which achievement of the conservation objectives is assessed, particularly whether this baseline includes existing levels of fishing activity. There are also uncertainties surrounding the habitat data in the site, the condition of the features and advice on operations, and long-term impacts of pulse trawling on the features.

Dutch pulse wing trawler (Photo by S.F. Walmsley)

The assessments of vulnerability should be considered in relation to the conservation objective of the site, which is to 'restore'. This indicates that the sandbank feature is not in favourable condition, although there is no direct evidence of the sandbanks being damaged or in deterioration. However, JNCC (2012) highlights that the area is subject to "*unprecedented levels of obstruction from infrastructure associated with oil and gas activities*" and there is uncertainty concerning the level of abrasion pressure from beam trawling.

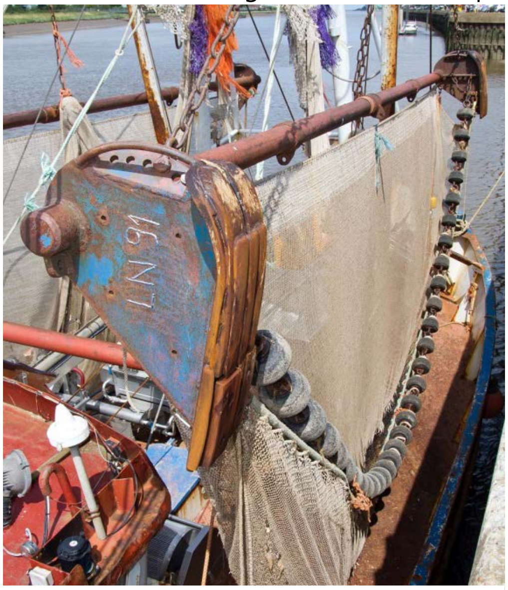
7.1.2 The Wash and North Norfolk Coast SAC

Based on the assessments of sensitivity and exposure of each habitat and biotope in The Wash and North Norfolk Coast SAC, in relation to the pressures exerted by individual gear components, the following vulnerability levels were determined (all other biotope/pressure combinations were no vulnerability):

- Surface abrasion for sublittoral biogenic reefs — moderate vulnerability;
- Removal of target and non-target species for:
  - *N. cirrosa* and *Bathyporeia* in infralittoral fine sand — low vulnerability;
  - *Echinocardium cordatum* and *Ensis* spp. in lower shore and shallow sublittoral slightly muddy fine sand — low vulnerability;
  - *A. alba* and *N. nitidosa* in circalittoral muddy sand or slightly mixed sediment — low vulnerability;
  - *Mysella bidentata* and *Abra* spp. in infralittoral sandy mud — low vulnerability;
  - Sublittoral mixed sediments — low vulnerability;
  - *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment — low vulnerability;
- Shallow disturbance for sublittoral mud and sublittoral biogenic reefs — low vulnerability;
- Surface abrasion, shallow disturbance and removal of target and non-target species for *Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment — low vulnerability.

There were no gear-habitat interactions that resulted in an assessment of high vulnerability. Based on current evidence it is possible to conclude that shrimp beam trawling in The Wash and North Norfolk Coast SAC may have been causing an adverse effect on integrity (AEOI) of the sublittoral biogenic reefs (*Sabellaria*), but mitigation measures have been implemented for this habitat. There is uncertainty whether there will be an AEOI from removal of target and non-target species, as characterising species may occur at relatively higher abundance where fishing for brown shrimp reduces predation pressure.

There is uncertainty whether abrasion and shallow disturbance will cause an AEOI on habitats and biotopes assessed as low vulnerability to this pressure. It is likely that, due to the small area of these habitats and biotopes in the site, exposure has been over-estimated, and therefore this reduces the likelihood of an AEOI. Additionally, disturbance from fishing activity is low relative to natural disturbance in the site, which results in mobile bedforms being present for much of the time.



Shrimp beam trawler in The Wash (Photo by R. Blyth-Skyrme)

The significance of these effects will depend on the baseline against which achievement of the conservation objectives is assessed and whether this baseline takes account of existing fishing levels. For 'low' impacts, managers and Competent Authorities will need to decide whether these constitute an AEOI, particularly as these areas are typically subject to high levels of natural disturbance.

7.1.3 Margate and Long Sands SCI

Based on the assessments of sensitivity and exposure of each habitat and biotope in Margate and Long Sands SCI, in relation to the pressures exerted by individual gear components, the following vulnerability levels were determined (all other biotope/pressure combinations were no vulnerability):

- *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand — moderate vulnerability to surface abrasion, due to the high level of exposure by under-15m vessels; *Magelona mirabilis* is a surface deposit-feeder that may be affected by surface abrasion.
- Dense *L. conchilega* and other polychaetes in tide-swept infralittoral sand and mixed gravelly sand — low vulnerability to deep disturbance, due to the large amount of fishing that takes place on this biotope, predominantly from the under-15m vessels.
- *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand — low vulnerability to deep disturbance, due to its medium sensitivity to this pressure.
- *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment — low vulnerability to deep disturbance, due to its low sensitivity but moderate level of exposure.
- Polychaete worm reefs on subtidal sediment — low vulnerability to surface abrasion, and no to low vulnerability to shallow and deep disturbance.

All other gear/habitat interactions resulted in an assessment of no vulnerability — there were no assessments of high vulnerability. Competent authorities would need to determine whether the low vulnerability might constitute an adverse effect on the integrity of the site. The significance of these effects will depend on the baseline against which achievement of the conservation objectives is assessed, particularly whether this baseline includes existing levels of fishing activity.

The assessments of vulnerability should be considered in relation to the conservation objective of the site which is to 'maintain'. This indicates that based on evidence available to NE at the time, the sandbank feature was considered to be in favourable condition, given the existing levels of fishing activity in the site. For 'low' impacts it is therefore arguable whether these constitute an AEOI, particularly where these areas are subject to high levels of natural disturbance.

Net from a triple rig otter trawl from an under-10m vessel in Margate and Long Sands SCI

7.2 Contribution of Methods to Reducing Uncertainty

The key data gaps and uncertainties that were identified through conducting the initial shadow assessments, and the contribution of the methods developed by the project to addressing them, are provided in Table 5.

Table 5 Data gaps and uncertainties identified in the initial assessments, and contribution of project methods to addressing them

Data Gaps or Uncertainties in Initial Assessments	Contribution of Methods Developed to Addressing Data Gaps or Reducing Uncertainty
VMS ping data provide a reasonable picture of the distribution of fishing effort, but assumptions were made regarding gear dimensions and fishing speed to assess swept area.	Estimates of swept area have been improved through the use of information on towing speed (from VMS), gear type and gear configuration (from skippers).
Analysis of swept area does not give an indication of the spatial distribution of fishing activity and of areas that are not impacted.	Estimates of actual footprint of over-15m fishing activity have been improved through the analysis of VMS footprint polygons, created from tracks between fishing pings and buffered to reflect width of individual gear components.
	Frequency of impact analysis provides a useful picture of the level of intensity of fishing pressure at a high spatial resolution. Analysis of small areas at a higher spatial resolution (equivalent to the swept width of the gear) provides a clear picture of the frequency of repeated trawl passes per year.
Lack of information on fishing patterns and intensity for under-15m vessels.	Interviews with skippers of under-15m vessels explored gear configurations, fishing behaviour (tow speed, number of tows per day, pattern of fishing throughout the year) and spatial mapping of fishing areas. This allowed estimates of swept area of different habitats and biotopes to be developed for the under-15m vessels. For the Wash and North Norfolk Coast SAC, data from processors provided information on average trip length and numbers of landings made that improved estimates of under-15m fleet effort and therefore swept area. Uncertainties remain in relation to scaling up from interviewees to the whole under-15m fleet for Margate and Long Sands SCI, and the distribution of fishing effort within individual mapped polygons, which may over- or under-estimate swept area on particular habitats/biotopes.
Impacts of the gears in use in the sites are uncertain. Literature on fishing impacts often do not provide a clear specification of the gear nor substrate type.	Modelling of gear impacts (sediment resuspension and penetration of individual gear components) has provided specific pressure levels for the gears, but empirical evidence is limited.
Levels of natural disturbance.	Modelling of natural disturbance levels enables the disturbance from fishing to be put in the context of physical conditions at the site and the likely vulnerability of species and communities to disturbance.
Conservation objectives and designated features/sub-features are not always clearly specified.	Natural England are in the process of updating their advice on sites. The generic revised supplementary advice table and advice on operations was used in the assessments. The most up-to-date habitat data were requested from statutory nature conservation bodies but in some cases were not available or did not reflect the habitat data being used for formal assessments.

8 Key Findings and Recommendations

8.1 Key Findings

Key findings of the project are:

- Assessments of fishing in MPAs should be based on impacts and exposure at the level of individual gear components.
- The methods developed in this project for assessing exposure to fishing, and the impacts of the gears, have improved the evidence base on which assessments are based, reducing uncertainty and the need for precaution.
- VMS footprint polygons provide a clearer picture of the actual areas impacted and not impacted by fishing, and a more accurate visualisation and assessment of the scale of impacts in relation to the scale of the site. These can be combined with swept area calculations to help inform the bounds of uncertainty in relation to the assessment of exposure.
- Engagement with industry provides improved information on fishing patterns, gear types and configurations, particularly for smaller vessels. However, parts of the industry are not aware of the ongoing process of assessing fishing in MPAs, and trust needs to be built between regulators and industry to improve industry's involvement.
- Numerical models of the physical impacts of the gears demonstrate the differences in impacts between gear components and the area over which those impacts occur. This enables the assessments to be based on the anticipated impacts of the gears in use in the sites, rather than estimates from the literature, which may be based on much larger or heavier gears, and on different substrates.
- Natural disturbance modelling provides a good indication of the frequency of disturbance of the top layers of sediment. However, fishing gears will cause some impacts (penetration, causing crushing of organisms) that differ from the effects of natural disturbance, and this has been assessed through consideration of shallow or deep disturbance pressures attributable to the footprint of individual gear components.
- Plotter data have the potential to provide information on areas impacted by fishing, but the data have a number of limitations and uncertainties (see section 4.5), which mean that they do not necessarily provide an accurate picture of areas affected and unaffected by fishing.
- Thresholds of acceptable levels of impact do not exist, and judgements on site integrity must be site-specific. The ability to determine impacts from fisheries within sites in a consistent manner is hindered greatly by the limited information available on habitat and community distribution within sites, habitat and community natural variability and change over time, and by the drive to consider ever greater detail where information is available.
- The methods developed under this project provide an approach for assessing fisheries in MPAs at the habitat, feature and gear-component level, and is repeatable for other sites.

The project demonstrates that, in general, the key limiting factors in being able to determine impacts from fisheries within sites in a consistent manner are:

- Knowledge of habitat distribution — some European Marine Sites (and Marine Conservation Zones) are well described, but others are not, and the data have not been collected in a consistent manner, whilst the rationale for combining new survey data with old data is also not clearly defined. This means that fishery managers are greatly limited in their ability to reliably assess impacts and avoid having to take a very precautionary approach to management.

- Knowledge of community change over time — studies including Hinz *et al.* (2004) and Reiss and Kröncke (2005) have shown that there is seasonal and annual variability in benthic community diversity and abundance, and that the changes can be considerable. Without good understanding of these natural processes, it is possible to incorrectly assume that changes over time are due to anthropogenic impacts.
- The desire to drill down into further detail where data are available — whilst it is tempting to use data where they are collected, there is inevitably a point at which available data must be considered sufficient in order to allow for a consistent approach to assessing impacts to be taken nationally, whilst also being achievable in the context of budgetary constraints for data collection.
- Knowledge of the spatial distribution of fishing effort for the under-15 m fishing fleet — in part, this issue will be addressed through the release of the 12–15 m VMS data that are currently being collected, but there is considerable effort exerted by the under-12 m fleet in some sites, and these are yet to be covered by VMS.
- The absence of detailed descriptions of gears and gear components and/or habitats and communities in scientific studies — relatively small changes in these different study elements can mean that impacts from fishing activities can be dramatically lessened or increased. However, few studies in the literature provide a sufficient level of detail of these elements in order to be confident in applying the results to specific fisheries and sites.

8.2 Key Uncertainties and Limitations

Specifically for this project, key uncertainties and limitations were identified as follows:

Under-15m fishing activity:

- VMS data were not available for under-15m vessels for this study. Therefore, it was not possible to map the fishing activity of under-15 m vessels with the same level of accuracy as the over-15m vessels, particularly when estimating the area of habitat affected by fishing gear.
- The scaling up of under-15m swept area from interviewees to represent the whole under-15m fleet may over- or under-estimate the overall swept area. This can potentially have a large effect on the overall results, depending on the relative importance of activity by under-15m vessels in a site.
- For The Wash, the use of processors' landings data allowed a more accurate estimate of the scaling factor required. The accuracy of the distribution of swept area across the different biotopes will also depend on how representative the fishing patterns of the interviewed skipper were of the whole fleet.

VMS data:

- VMS records contain unknown gear types (in this study around a third of the UK VMS records had unknown gears) due to the method employed by the MMO in assigning gear type to VMS records from log books. Non-UK VMS records contain gear types based on the primary gear type in the EU fleet register, which may not accurately reflect the gear actually being used in the VMS data records.
- The use of fishing vessels for guard ship duty related to cables, windfarms, and oil and gas installations, can result in a large number of pings with 'unknown' gear type, that can significantly affect the outcomes of an assessment, depending on how these pings are treated. An example of this, showing pings of 'unknown' gear type, and pings identified as guard ship duty, is shown in Figure 8.1. Cable installation for the London Array windfarm took place in 2011 and 2012.
- The speed rule for identifying 'fishing' activity (>0–6 knots) may result in misclassification of pings as 'fishing' or 'not fishing'.

- Since VMS pings are only recorded every two hours (approximately), the vessel tracks used in the analysis may not accurately reflect the actual track of the fishing vessels. The straight line drawn between consecutive VMS pings may over- or under-estimate the area impacted, as the actual track of fishing tows may not follow the line drawn between the pings. This is a reflection of the fact that VMS was not introduced to provide fine-scale spatial resolution of fishing activity, but is a fisheries enforcement tool.

Habitat data:

- The assessments are highly dependent on the habitat data on which they are based, which were highly variable between sites. We had some difficulty obtaining the most recent habitat information for the sites under consideration, and:
  - For The Wash and North Norfolk Coast, it was confirmed that we did not receive the same data as the regulators are using for their assessments;
  - Recent (2013) survey data for NNSSR, which have reportedly improved knowledge on the habitats and biotopes present in the site, were not available for us to use;
  - The information available on the Margate and Long Sands SCI was presented at the level of biotopes, although there was considerable interpolation of data between survey points which may not give an accurate reflection of the extent of individual biotopes.

Baseline:

- The conclusion of the assessments is dependent on the baseline against which achievement of the conservation objectives is assessed and whether this baseline takes account of existing fishing levels when the site was designated.

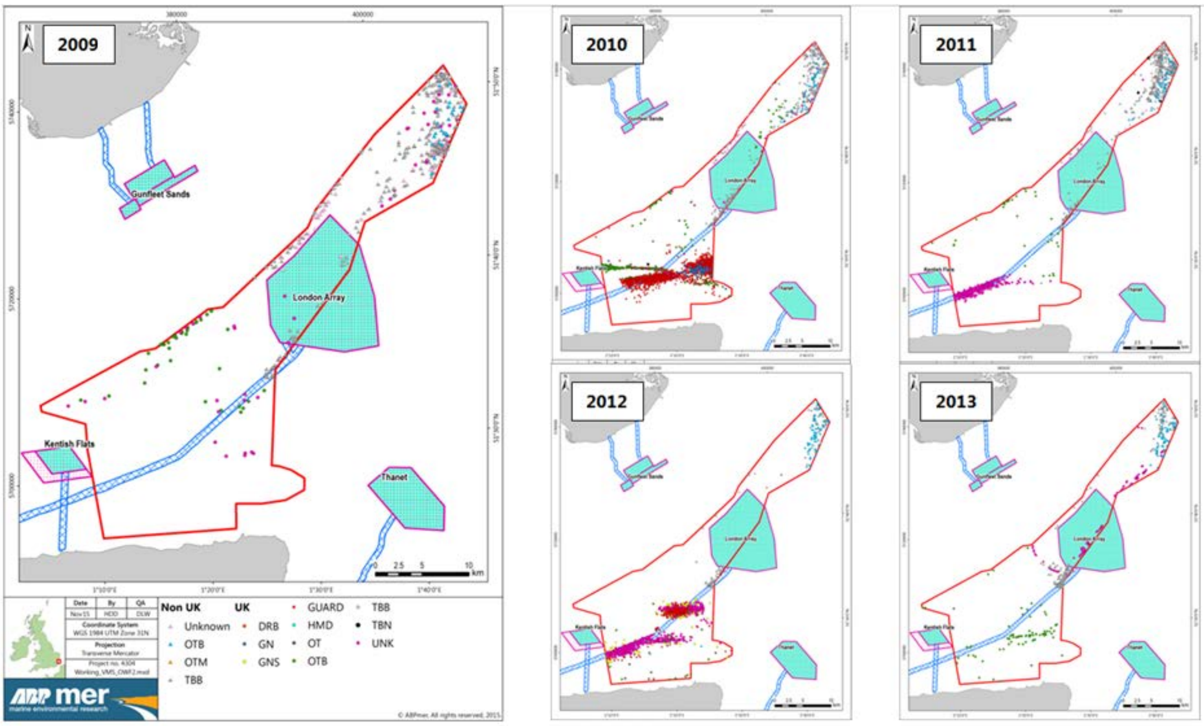


Figure 8.1 **VMS pings by gear type, by year, for over-15m vessels in Margate and Long Sands SCI, in relation to the London Array windfarm and cable installation**

8.3 Recommendations

- Assessments of fishing in MPAs should be based on impacts and exposure at the level of individual gear components.
- Considerable care needs to be taken in assuming fishing impacts on habitats on the basis of published literature, because gear types, habitat types and fishing strategies are commonly poorly described in studies, and may be quite different to those found within sites.
- Fishing disturbance should be considered in the context of levels of natural disturbance. Assessments of the significance of trawling pressure should take account of the levels of natural disturbance, because the levels of natural disturbance are the most important factor governing the structure and function of benthic communities associated with subtidal sandbank habitats. Further development of natural disturbance modelling could consider the link between the natural sediment motion accompanied by the physical passage of the gear on physiological functioning of epifauna and infauna,
- There needs to be clarity and transparency on the knowledge of designated features, sub-features and site conservation objectives. Updated information and advice on sites should be made publically available as soon as possible.
- The significance of any effects from fishing should be considered in relation to the conservation objective of the site and there is a need for clarity of the baseline against which achievement of the conservation objectives is assessed, particularly whether this baseline includes existing levels of fishing activity. Where the conservation objective is to 'maintain' the feature is assumed to be in favourable condition, given the existing levels of fishing activity in the site. For low vulnerability pathways it is arguable whether these constitute an AEOI, particularly where areas are subject to higher levels of natural disturbance.
- Approaches to assessing fisheries in MPAs need to be further developed and agreed, including the development of guidance on determining significance of impacts, and whether baselines include fishing. A Working Group could be set up to address these issues and move the process forward. This should include consideration of how such assessments and judgements on integrity are made in other industry sectors, and how this can be applied to fisheries.
- The scale and frequency of benthic disturbance from fishing that would still maintain (and/or restore) the condition of the site and its features and be acceptable should be discussed and agreed with SNCBs. This is likely to vary on a case-by-case basis and be dependent on the vulnerability of features (as well as the agreed baseline).

Methodologies:

- Estimates of swept area by the under-15m vessels should be checked and ground-truthed: the data on the numbers of landings for The Wash and North Norfolk Coast SAC were particularly useful in this regard. Skippers from the under-15m vessels and/or fishermen's representatives can also provide important clarification on data, and sufficient interviews should be carried out to obtain a high relative sample size from relevant fleets.
- Since 2012, VMS has been a requirement for over-12m vessels and is being progressively rolled out across the 12–15m fleet. When these data become available, they will provide a much-improved picture of fishing activity for 12–15m vessels. Some sites, particularly inshore sites where there is a lot of activity by smaller vessels, will still require additional information on activity of smaller vessels.
- Further development of the methods to assess exposure, to obtain a more accurate picture of the actual footprint of fishing activity on the seabed, could use more frequent pings coupled with information on when gear is being shot and hauled. Use of mobile phone-based vessel tracking systems could provide similar information to VMS for smaller vessels.

- The plotter data (where these show individual fishing tows) for an individual vessel, could be compared with the calculations of swept area and of VMS footprint for that vessel to allow an assessment of the accuracy of the VMS data analysis methods in relation to the actual footprint of fishing activity.

Data sources:

- The method for linking VMS pings to logbook information should be improved and should be based on the start and end date of each fishing trip, regardless of the ICES rectangle reported, in order to reduce the number of pings with 'unknown' gear type.
- When fishing vessels are employed in guard ship duty, there should be a way of the vessel reporting this to the MMO, so that VMS pings associated with guard ship activity can be identified as such.
- The speed rule used to identify 'fishing' activity for VMS pings should be revised, based on the actual range of speeds used for fishing for different vessel sizes and gear types.
- Research studies into impacts of fishing should provide clear and detailed information on gear type, dimensions and configurations, and habitat/substrate type, to enable conclusions to be applied to other areas.
- There is a need for further research into the actual impacts of the gears in the site, and further research into impacts of pulse trawling, including longer-term impacts and effects of repeated exposure. Where studies are undertaken, careful consideration and reporting needs to be made of the specific gear components and configurations.
- There should be high confidence in the habitat data for sites (including presence/absence and condition), to an adequate level of detail against which to assess sensitivity to impacts of fishing.

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10 Abbreviations/Acronyms

AA	Appropriate Assessment
ABPmer	ABP Marine Environmental Research Ltd
AEOI	Adverse effect on integrity
EFF	European Fisheries Fund
EMS	European Marine Site
EMODnet	European Marine Observation and Data Network
GEBCO	General Bathymetric Chart of the Oceans
Ichthys Marine	Ichthys Marine Ecological Consulting Ltd
LSE	Likely Significant Effect
MCZ	Marine Conservation Zone
MMO	Marine Management Organisation
NAEOI	No adverse effect on integrity
NFFO	National Federation of Fishermen's Organisations
SAC	Special Area of Conservation
SCI	Site of Community Importance
SeaFish	Sea Fish Industry Authority
SPA	Special Protection Area
UKHO	United Kingdom Hydrographic Office
VMS	Vessel Monitoring System

Cardinal points/directions are used unless otherwise stated.

SI units are used unless otherwise stated.

Appendices

A Interview Forms

B Modelling of Physical Impacts of Fishing Gears

C The Effects upon the Habitat and Ecosystem Exerted by the *Crangon* Fisheries in the Wash

D Physical and Biological Impacts of Beam and Pulse Trawling — Summary of BENTHIS Field Trial Results

E Biological and Ecological Impacts

F Exposure Analysis — VMS and Interviews

G Modelling of Natural Disturbance

ABP Marine Environmental Research Ltd (ABPmer)
Quayside Suite, Medina Chambers, Town Quay, Southampton SO14 2AQ

T +44 (0)23 80 711840
F +44 (0)23 80 711841
E enquiries@abpmer.co.uk

www.abpmer.co.uk

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