Offshore Wind Evidence + Change Programme

Delivery Options for Strategic Marine Net Gain

Assessing Potential Future ‘Demand’ for Marine Net Gain

THE CROWN ESTATE

ABP mer

Executive Summary

To support the work of the T&F Group, ABPmer were tasked with estimating the potential future demand for MNG interventions at marine plan region level based on estimates of future development activity. This report presents the estimates of forecast potential future 'demand' for marine net gain (MNG) interventions at national and regional (marine plan) level in the period to 2050 based on assumptions. It seeks to identify the scale of future development activity and combine information on potential project impacts and future project development to establish a potential level of demand for MNG. The analysis is limited to English waters.

The analysis highlights the challenges of forecasting the scale, location, and timing of future development activity particularly over decadal time scales. Given that environmental impacts tend to be site specific, any assessment of residual impacts from marine development activity will come with a large uncertainty. In addition, ahead of policy development for Marine Net Gain (MNG), there is currently a high level of uncertainty concerning how any MNG requirements might be determined and therefore many assumptions have been required in translating estimates of residual impact into a potential MNG demand. Consequently, the analysis should be seen as providing an order of magnitude indicative potential MNG requirement at this stage.

The analysis indicates that future marine development will potentially result in the combined loss of/change to subtidal mud, sand, and gravel habitats of the order of 25 to 30 km² per epoch in the period to 2050, although this value is uncertain and dependent on assumptions about levels of future development activity and their spatial footprint on the seabed. The main sectors contributing to subtidal habitat loss/change are predicted to be offshore wind and marine aggregates sectors which account for up to 90 % of the habitat loss/change based on the assumptions used in the analysis. Potential loss calculated by the analysis for intertidal habitat (over 1,000 ha intertidal sediment and 1,000 ha saltmarsh nationally per decade) was considered to be a significant overestimate. A more realistic estimate of potential demand was thought to less than half of the above estimate, the requirements for which could be met from the supply of intertidal habitat creation/restoration and enhancement opportunities, particularly given the recent upsurge in interest in coastal restoration projects.

There are significant challenges in seeking to quantify the spatial extent and intensity of permanent and temporary disturbance and residual impacts to mobile species groups. Such information is not typically available within statutory assessments and where quantified assessments are provided these are subject to high levels of uncertainty. Incorporating species impacts within MNG is likely to be especially challenging and require the collection of significant additional information and development of new assessment tools within EIA processes. However, the analysis identifies that future development will also lead to permanent (project lifetime) and temporary disturbance of subtidal habitats. This is estimated to be around 70 to 115 km² per epoch (permanent disturbance) and 65 to 85 km² per epoch (temporary disturbance).

It was not possible within the constraints of this study to develop quantitative assessments for species impacts, however the study sought to identify the number of projects within marine plan regions over different time periods which might give rise to an MNG requirement. This analysis indicates that MNG measures for mobile species could be required in all marine plan regions in the period to 2050.

The overall scale of past and current restoration/enhancement and recovery interventions would appear to be at a level that, if continued, could help to deliver MNG, depending on the form that MNG takes. However, it should be recognised that in subtidal environments, it will be difficult to recreate significant areas of replacement habitat. MNG may therefore need to focus on creation or enhancement of intertidal or coastal habitats or alternatively look to improve the condition of subtidal habitats (through pressure removal), noting that this latter option could only be delivered as part of a strategic approach led by government.

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Document Control

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1. Introduction

There is increasing recognition of the need for greater action to restore our marine environment in the face of a continued decline in marine biodiversity. Net gain[1] has been identified as a potentially important mechanism that can contribute to halting and reversing marine biodiversity loss. From autumn 2023, two years following royal ascent of the Environment Act, it will be mandatory for all in scope developments in the terrestrial and intertidal environment to deliver a biodiversity net gain of 10 %. Although there is no formal net gain policy as yet for the marine environment, Government has committed to developing such a policy, and has held a first consultation on the principles of marine net gain (MNG) (Defra, 2022[2]).

The Strategic Net Gain Targets Task and Finish Group (T&F Group), funded by the Offshore Wind Evidence and Change Programme, completed its first report in October 2021, setting out a number of strategic targets for marine and intertidal net gain (Offshore Wind Evidence and Change Programme, 2021[3]). These targets were widely consulted on, and well supported by a range of marine stakeholders. In addition, the T&F Group set out a number of assumptions and recommendations for further consideration in the development of a policy for MNG.

Building on its first report, the T&F Group is now working to develop delivery options for strategic net gain. The aim of this projects is to identify and agree recommendations for a more local delivery of strategic net gain targets for the improvement and recovery/restoration of the marine and intertidal environments, which can be used as a basis for determining net gain targets for marine industry sectors, including offshore wind. ABPmer has been commissioned to support the work of the T & F Group.

To support the work of the T&F Group, ABPmer were tasked with developing a database of existing and planned marine restoration/enhancement and recovery projects to identify what interventions were already being undertaken, and then to estimate potential future demand for MNG interventions for England at a marine plan region level, based on estimates of future development activity.

This report presents the outputs from this latter task. It seeks to identify the scale of future development activity on a regional scale (marine plan region) and combine information on potential project impacts and future project development to establish a potential level of demand for MNG at regional level.

2. Approach to estimating future demand

Two elements have been included in the analysis:

- An assessment of potential residual impacts to subtidal habitats (mud, sand, gravel), intertidal habitats (saltmarsh, intertidal sediment) and species groups from future development activity in the period to 2050; and
- Translation of these residual impacts into an indicative demand for MNG.

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[1] Net gain is an approach to development that aims to leave the natural environment in a measurably better state than beforehand. This means protecting, restoring, or creating environmental features that are of greater ecological value to wildlife, habitats, and people than any losses associated with the original project.

[2] Defra. 2022. Consultation on the Principles of Marine Net Gain. Available at: https://consult.defra.gov.uk/defra-net-gain-consultation-team/consultation-on-the-principles-of-marine-net-gain/ [Accessed 23/06/23].

[3] Offshore Wind Evidence and Change Programme. 2021. Strategic Net Gain Targets for Coastal and Marine Environments - Task and Finish Group Final Report, October 2021. Available at: https://www.marinedataexchange.co.uk/details/3513/2021-strategic-net-gain-task-and-finish-group-offshore-wind-evidence-and-change-programme-strategic-net-gain-targets-for-coastal-and-marine-environments/summary [Accessed 23/06/23].

2.1 Approach to estimating residual impacts to habitats and species

The assessment has sought to make best use of existing studies. ABPmer & eftec (2022[4]) undertook an analysis of the scale of future marine development activity for a wide range of marine sectors. Separately eftec et al. (2021[5]) completed an analysis of potential development affecting intertidal habitat (by local authority area) as part of a study exploring the potential market for biodiversity net gain credits. Both studies have informed the approach to the assessment in this study.

Residual impacts to habitats and species have been assessed as follows:

- Subtidal habitats:
  - Forecasts of future development activity[6] have been based on ABPmer & eftec (2022[4]) and updated following advice from the T&F Group;
  - Annual forecasts of levels of development activity have been made for the period 2023 to 2050 with assumptions made regarding the distribution of levels of activity across marine plan regions (combining inshore and offshore marine plan areas where relevant);
  - Residual impacts have been calculated based on assumptions for each sector (see Appendix A) for:
    - Area of direct habitat loss/change;
    - Area of permanently disturbed habitat (habitat considered to be regularly disturbed over the lifetime of the development); and
    - Area of temporarily disturbed habitat (habitat considered to be disturbed only during construction or irregularly during operation).
- Residual impacts have been assigned to marine plan regions and distributed across broad habitat types (EUNIS level 3: Sublittoral coarse sediment A5.1 (gravel), Sublittoral sands/muddy sands A5.2 (sand) and Sublittoral cohesive mud and sandy mud A5.3 (mud)) based on assumptions. For most offshore development, in the absence of information on the specific location of developments, it has been assumed that mud, sand and gravel habitats will be affected pro rata to their spatial extent in each marine plan region. For marine aggregates, it has been assumed that only sand and gravel habitats will be affected pro rata to their spatial extent in each marine plan region as these are the resources targeted by marine aggregate producers; and
  - Areas of affected habitat (mud, sand, and gravel) subject to loss/change, permanent disturbance, or temporary disturbance, have then been calculated using a simple spreadsheet model (available from the authors on request) for each marine plan region for the epochs; 2023-2030, 2031-2040 and 2041 - 2050.

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[4] ABPmer & eftec. 2022. Marine Net Gain. Sector Analysis. ABPmer Report No. R.3875. A report produced by ABPmer for Defra Offshore Wind Enabling Actions Programme, April 2022. Available at: https://randd.defra.gov.uk/ProjectDetails?ProjectId=21049 [Accessed 23/06/23].

[5] eftec, WSP & ABPmer. 2021. Biodiversity Net Gain: Market analysis study, February 2021. Available at: https://randd.defra.gov.uk/ProjectDetails?ProjectID=20608 [Accessed 23/06/23].

[6] Aggregates, aquaculture (shellfish), aquaculture (seaweed), carbon capture usage and storage, coastal development (regeneration - subtidal infrastructure), offshore wind farms, oil and gas, ports, power interconnectors and transmission lines, power stations, recreational boating (subtidal infrastructure development), telecommunication cables, tidal range energy, tidal stream energy, wastewater treatment outfalls and wave power.

- Intertidal habitats:
  - Estimates of annual intertidal habitat loss (intertidal sediment and saltmarsh) by local authority area (from eftec et al., 2021[5]) were used to estimate annual intertidal habitat loss by marine plan region, including locations within MPAs.
- Species (for subtidal projects only):
  - Assumptions have been made on the relative significance of residual impacts to species groups (fish, birds, and marine mammals) including mortality and disturbance during construction or operation (see Appendix A); and
  - Forecast future development activity levels (see subtidal habitats above) have been used to identify the number of projects that may require species measures to offset residual impact. In making these estimates no account has been taken of possible requirements to implement compensatory measures or measures of equivalent ecological value in relation to features protected by European or national site designations.

For subtidal (and intertidal) habitats, information on the spatial extent and degree of residual impact is generally available from Environmental Statements. While these assessments tend to be quite conservative in line with relevant guidance, they do provide a meaningful basis from which to assess a project's residual impacts.

For species impacts, while Environmental Statements include assessments of impacts to mobile species groups, such impacts are generally not quantified, or where they are quantified, estimates are subject to high levels of uncertainty (for example, estimates of seabird collision mortality from offshore wind farm development). If species impacts are to be incorporated within MNG, depending on the approach taken, this could require additional information to be collected and analysed by developers as part of their development applications.

2.2 Indicative potential future demand for MNG

Information on the potential scale and nature of residual impact from future development activity has been used to inform an indicative potential requirement for MNG.

Ahead of policy development by Defra, there is no clear basis for translating residual development impacts into an MNG demand. To estimate a possible level of future demand that can be compared to possible future supply of restoration/enhancement or recovery initiatives, tailored assumptions, based on available scientific evidence, have been applied. The assumptions used should not be taken to infer any policy preference, nor any agreed position on the assumptions used.

For the purposes of modelling potential future demand for MNG, the following assumptions were made:

- **Habitat loss/change** - a factor of 2.2 has been used to identify the MNG requirement in relation to habitat loss/change for both intertidal and subtidal impacts. This is based on the factor of 2 that has been applied for compensation of intertidal habitat loss in European sites (Morris et al, 2016[7]) with an uplift of 10 % to achieve net gain.
- **Permanent habitat disturbance** - a factor of 1.1 has been applied to permanent habitat disturbance for subtidal projects. In effect this assumes a 50 % loss of function from the disturbed habitat.

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[7] Morris, R., Harley, M., Cottle, R., Banks, B., Doody, J., Brown, A., Weston, A., Hart, R., Prince, S. 2016. Review of the Effectiveness of Natura 2000 Sites Compensation Measures in England. Contract Reference: WC1076. Available at: http://www.humbernature.co.uk/admin/resources/13694wc1076finalreport-1.pdf

- **Temporary habitat disturbance** - a factor of 0.05 has been applied to temporary habitat disturbance in subtidal mud and sand habitats and a factor of 0.25 applied to subtidal gravel habitats, as gravel habitats typically take longer to recover compared to mud and sand habitats (MarESA[8]).
- **Species features** - where the scale of residual impact from a subtidal project is assessed as 'moderate' or 'high' for either construction or operation, it has been assumed to trigger a requirement for mobile species measures (fish, birds, or mammals) but it has not been possible within this study to quantify that requirement.

The assessment of potential future demand has been made at the same level of granularity as the assessment of potential residual impact (i.e., subtidal mud, sand, and gravel habitat; intertidal sediment and saltmarsh habitat). In presenting the analysis in this way, ahead of MNG policy development, it does not seek to presume that MNG would require like-for-like replacement of residual impacts. Rather, it allows closer comparison with the information on potential supply of MNG interventions.

2.3 Recognising uncertainties

There are many uncertainties in seeking to project the scale, timing and location of future development activity, the residual impact of such development and the requirements to achieve MNG. It is not feasible to assign estimates of uncertainty to many of these elements and therefore not appropriate to undertake any kind of formal uncertainty analysis. The key elements contributing to uncertainty include:

- Future scale, location, and timing of development activity - these can be projected based on past and current trends. For established sectors it is probably accurate within a factor of 3 (±300%), but for emerging sectors it may be accurate within an order of magnitude;
- Residual impacts:
  - Habitat spatial scale - information has been drawn from EIAs, sector reviews and experience of the contractor. While the scale of impact depends to some extent on site specific factors, at regional/national level the estimates are considered to be accurate within a factor of 3;
  - Habitat type - given that the specific location of future development is generally unknown, habitat type has typically been inferred based on the relative distribution of mud, sand, and gravel habitats within a marine plan region. At regional level the estimates may be accurate within a factor of 3;
  - Species - the significance of residual impacts to species from different development types has been based on the judgement of the contractor. The number of projects giving rise to species impacts has the same levels of uncertainty pertaining to future development;
- MNG demand:
  - The multiplier used to estimate habitat demand is based on limited evidence. It is noted that a Biodiversity Net Gain (BNG) style metric might result in higher levels of demand based on currently available case studies. Depending on the development of MNG policy the requirement could be higher or lower than calculated in this study by an unknown amount;
  - Potential demand has been split across broad habitat types (subtidal mud, sand, and gravel) and intertidal sediment and saltmarsh. It is currently uncertain to what extent, if at all, MNG might demand or encourage a like-for-like policy and thus each of these potential demands is uncertain to an unknown degree.

[8] MarESA database https://www.marlin.ac.uk/sensitivity/sensitivity_rationale

The estimates of residual impact within this study are considered quite conservative based on extensive existing experience of EIA outcomes for marine developments across a wide range of sectors. The estimated scale of future activity is also considered to be an overestimate, particularly for emerging sectors such as shellfish and seaweed aquaculture where expansion tends to occur more slowly than anticipated in strategy documents. The translation of residual impacts to estimates of future demand is based on best judgement from the available evidence and considering the precautionary principle. Greater certainty will only become available once MNG policy has been clarified.

Given the above uncertainties, at this time the analysis provides only an order of magnitude estimate of what might be required to deliver MNG.

It is noted that The Crown Estate is initiating a project to digitally map the seabed resource needed to meet future demand as well as the enhanced co-ordination of future activities to 2050 (TCE[9]). The outcome of The Crown Estate project could help to clarify some of the assumptions about the location, scale and timing of future development and reduce some of the uncertainties.

3. Model results

Due to the many assumptions that have needed to be made in order to perform the analysis, all the analysis presented below should be treated as indicative and preliminary.

3.1 Subtidal habitats

A summary of the key results from the assessment are provided in Table 1 (subtidal habitats affected by marine plan region, impact type and epoch) and Table 2 (indicative demand for MNG by marine plan region, impact type and epoch).

Table 1. Estimated subtidal habitat area impacts (km²) by marine plan region, impact type and epoch

Marine plan region	Habitat impact	Habitat	2023-2030	2031-2040	2041-2050
South West	Loss/change	Mud	0.20	0.54	0.52
		Sand	0.66	2.40	2.31
		Gravel	0.45	2.30	2.21
	Permanent disturbance	Mud	1.81	2.79	2.71
		Sand	3.59	7.05	6.62
		Gravel	2.12	5.48	5.00
	Temporary disturbance	Mud	0.11	1.75	1.75
		Sand	0.60	9.58	9.58
		Gravel	0.63	10.58	10.58
North West	Loss/change	Mud	0.81	1.36	1.35
		Sand	1.45	2.27	2.26
		Gravel	0.37	0.58	0.58

[9] https://www.thecrownestate.co.uk/en-gb/media-and-insights/news/2023-the-crown-estate-to-digitally-map-scenarios-to-inform-co-ordinated-approach-to-future-seabed-use/

Marine plan region	Habitat impact	Habitat	2023-2030	2031-2040	2041-2050
	Permanent disturbance	Mud	1.87	3.67	3.67
		Sand	3.36	6.02	6.02
		Gravel	0.69	1.34	1.34
	Temporary disturbance	Mud	3.39	0.44	0.43
		Sand	4.63	0.60	0.59
		Gravel	1.21	0.15	0.15
North East	Loss/change	Mud	0.07	0.47	0.47
		Sand	0.23	5.67	5.65
		Gravel	0.01	0.49	0.49
	Permanent disturbance	Mud	0.69	1.16	1.16
		Sand	2.40	7.20	7.20
		Gravel	0.16	0.57	0.57
	Temporary disturbance	Mud	0.08	2.40	2.37
		Sand	1.15	33.67	33.24
		Gravel	0.10	2.97	2.93
East	Loss/change	Mud	0.20	0.19	0.19
		Sand	12.09	8.43	8.41
		Gravel	5.00	3.44	3.44
	Permanent disturbance	Mud	1.28	1.62	1.62
		Sand	16.85	24.47	24.47
		Gravel	6.52	9.58	9.58
	Temporary disturbance	Mud	0.32	0.13	0.12
		Sand	35.46	14.23	13.88
		Gravel	14.88	5.96	5.81
South East	Loss/change	Mud	0.08	0.11	0.12
		Sand	0.20	0.31	0.45
		Gravel	0.04	0.08	0.15
	Permanent disturbance	Mud	0.76	1.23	1.29
		Sand	2.00	5.52	6.14
		Gravel	0.69	2.43	2.75
	Temporary disturbance	Mud	0.05	0.07	0.07
		Sand	0.59	0.74	0.75
		Gravel	0.29	0.36	0.37
South	Loss/change	Mud	0.42	0.50	0.50
		Sand	1.70	2.03	2.03

Marine plan region	Habitat impact	Habitat	2023-2030	2031-2040	2041-2050
		Gravel	4.86	5.69	5.69
	Permanent disturbance	Mud	3.43	4.53	4.53
		Sand	7.09	9.72	9.72
		Gravel	14.77	22.17	22.17
	Temporary disturbance	Mud	0.17	0.06	0.06
		Sand	0.65	0.25	0.25
		Gravel	2.51	0.86	0.86
National	Loss/change	Mud	1.78	3.16	3.15
		Sand	16.32	21.12	21.12
		Gravel	10.72	12.59	12.55
	Permanent disturbance	Mud	9.84	15.01	14.98
		Sand	35.30	59.98	60.16
		Gravel	24.95	41.57	41.41
	Temporary disturbance	Mud	4.12	4.86	4.82
		Sand	43.08	59.07	58.29
		Gravel	19.62	20.87	20.69

Table 2. Indicative potential subtidal habitat demand (km²) by marine plan region, impact type and epoch

Marine plan region	Habitat impact	Habitat	2023-2030	2031-2040	2041-2050
South West	Loss/change	Mud	0.44	1.19	1.15
		Sand	1.45	5.28	5.09
		Gravel	0.98	5.07	4.86
	Permanent disturbance	Mud	1.99	3.07	2.98
		Sand	3.95	7.76	7.28
		Gravel	2.33	6.03	5.50
	Temporary disturbance	Mud	0.01	0.09	0.09
		Sand	0.03	0.48	0.48
		Gravel	0.16	2.64	2.64
North West	Loss/change	Mud	1.79	2.99	2.97
		Sand	3.19	5.00	4.98
		Gravel	0.80	1.27	1.27
	Permanent disturbance	Mud	2.06	4.03	4.03
		Sand	3.70	6.62	6.62
		Gravel	0.76	1.48	1.48

Marine plan region	Habitat impact	Habitat	2023-2030	2031-2040	2041-2050
	Temporary disturbance	Mud	0.17	0.02	0.02
		Sand	0.23	0.03	0.03
		Gravel	0.30	0.04	0.04
North East	Loss/change	Mud	0.16	1.04	1.04
		Sand	0.50	12.48	12.43
		Gravel	0.02	1.07	1.07
	Permanent disturbance	Mud	0.76	1.28	1.28
		Sand	2.64	7.92	7.92
		Gravel	0.17	0.63	0.63
	Temporary disturbance	Mud	0.00	0.12	0.12
		Sand	0.06	1.68	1.66
		Gravel	0.02	0.74	0.73
East	Loss/change	Mud	0.44	0.42	0.42
		Sand	26.61	18.55	18.51
		Gravel	11.00	7.58	7.56
	Permanent disturbance	Mud	1.40	1.79	1.79
		Sand	18.54	26.92	26.92
		Gravel	7.17	10.54	10.54
	Temporary disturbance	Mud	0.02	0.01	0.01
		Sand	1.77	0.71	0.69
		Gravel	3.72	1.49	1.45
South East	Loss/change	Mud	0.17	0.23	0.26
		Sand	0.43	0.69	0.99
		Gravel	0.08	0.18	0.34
	Permanent disturbance	Mud	0.83	1.35	1.41
		Sand	2.20	6.07	6.75
		Gravel	0.76	2.67	3.02
	Temporary disturbance	Mud	0.00	0.00	0.00
		Sand	0.03	0.04	0.04
		Gravel	0.07	0.09	0.09
South	Loss/change	Mud	0.92	1.09	1.09
		Sand	3.74	4.46	4.46
		Gravel	10.69	12.52	12.52
	Permanent disturbance	Mud	3.77	4.98	4.98
		Sand	7.80	10.69	10.69

Marine plan region	Habitat impact	Habitat	2023-2030	2031-2040	2041-2050
		Gravel	16.25	24.39	24.39
	Temporary disturbance	Mud	0.01	0.00	0.00
		Sand	0.03	0.01	0.01
		Gravel	0.63	0.21	0.21
National	Loss/change	Mud	3.92	6.96	6.93
		Sand	35.91	46.45	46.46
		Gravel	23.59	27.69	27.61
	Permanent disturbance	Mud	10.82	16.51	16.48
		Sand	38.82	65.98	66.18
		Gravel	27.44	45.73	45.55
	Temporary disturbance	Mud	0.21	0.24	0.24
		Sand	2.15	2.95	2.91
		Gravel	4.90	5.22	5.17

Table 1 indicates that at a national (England) scale, habitat loss/change from future development could be of the order of 25 to 30 km² per decade in the period to 2050 resulting in a potential demand for MNG of 60 to 75 km² (Table 2). While these spatial extents may seem large in themselves, they are small relative to the spatial extents of the respective habitats within each marine plan region (Table 3), there is a total of around 200,000 km² of subtidal mud, sand, and gravel in English waters.

Table 3. Areas of subtidal mud, sand, and gravel (km²) within each marine plan region

Marine Plan Region	Mud	Sand	Gravel
South West	5,857	32,009	35,461
North West	2,160	2953	777
North East	3,220	45,107	3,977
East	341	38,077	15,995
South East	176	1,893	981
South	759	2,897	11,592
Total	12,513	122,935	68,783

Potential demand varies by region, habitat type and epoch, reflecting differences in estimated levels of future development activity.

Figure 1 provides a summary of potential MNG demand in relation to habitat loss/change by marine plan region in the period 2023 - 2050. The greatest levels of potential demand for sand and gravel habitats may be in East and South marine plan regions. The main drivers of this demand are offshore wind development and marine aggregates.

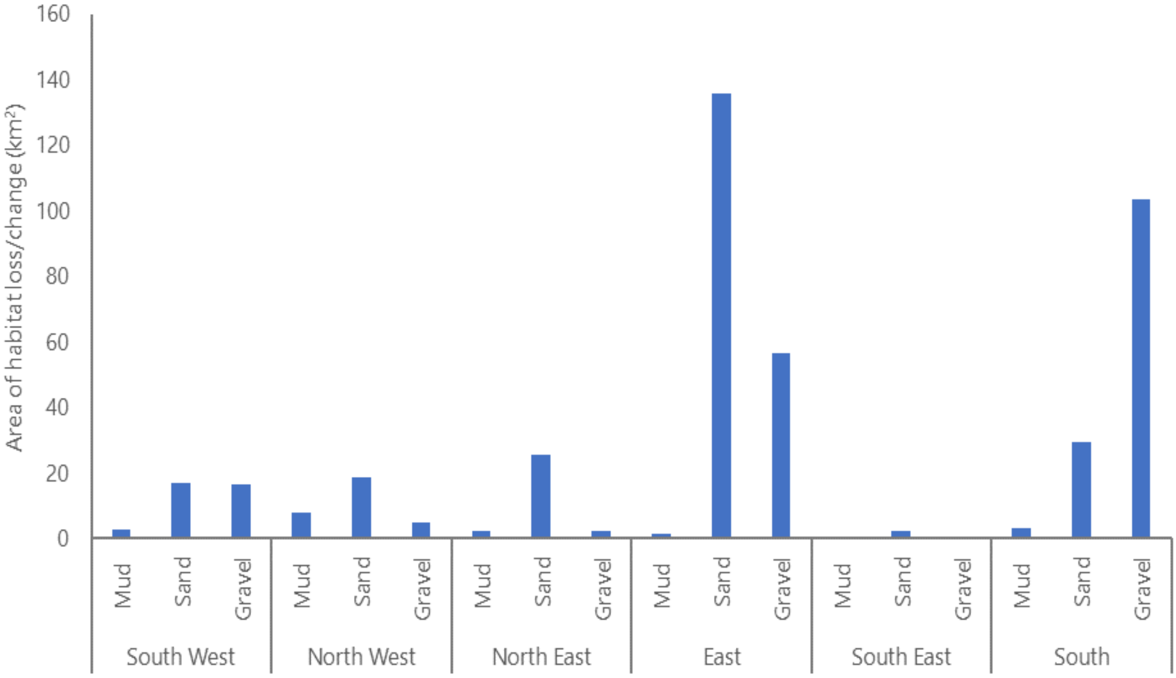

Figure 1. Potential MNG demand (km²) in relation to habitat loss/change by habitat type by marine plan region in the period 2023 - 2050

The estimated residual impact of marine aggregate extraction accounts for around 30 to 40 % of potential demand in relation to subtidal sand and gravel habitat loss/change and around 40-60 % of subtidal sand and gravel demand in relation to permanent habitat disturbance based on the assumptions used in the assessment. Marine aggregate extraction is primarily focused in the East and South marine plan regions and thus accounts for the potentially much greater MNG demand for subtidal sand and gravel habitats in these regions. While new marine aggregate development may be a significant driver of MNG demand in relation to subtidal sand and gravel habitats, where marine aggregate producers relinquish existing licences, as a result of resources become depleted over time, it may be that these relinquished areas could contribute to MNG targets. Relinquished areas are left with a suitable covering of underlying substrate and once recovered from any direct or indirect impacts of marine aggregate extraction would be expected to have ecological structure and function comparable to natural habitats.

The estimated residual impact of offshore wind development accounts for around 50-60 % of potential demand in relation to subtidal mud, sand, and gravel habitat loss/change and around 80–90 % of subtidal mud, sand, and gravel demand in relation to temporary habitat disturbance based on the assumptions used in the assessment.

All other sectors make relatively small contributions to residual impact and potential MNG demand.

Given the challenges of successfully creating new subtidal mud, sand, or gravel habitat, it may be necessary to provide flexibility in MNG solutions, for example by allowing pressure reduction measures to be applied as MNG in place of creation of new areas. Table 4 presents an indicative estimate (by marine plan region and epoch) of what MNG demand might comprise if habitat loss/change, habitat permanent disturbance and habitat temporary disturbance were conflated to a single metric. For simplicity this has been achieved by summing the areas of permanent and temporary habitat disturbance and adding the habitat loss/change values multiplied by a factor of 3 (to recognise that a larger area of habitat would need to be protected from disturbance to offset functional impacts form habitat loss/change).

Table 4 (and Figure 2) indicate that in East and South marine plan regions, significant pressure reduction initiatives might be required to meet potential MNG demand in the period to 2050 of the order of 270 to 380 km² per decade across English waters. Over 30% of this demand might be in both East and South marine plan regions reflecting the key activities driving this potential demand (offshore wind and marine aggregates).

It should be noted that while the absolute values might appear larger, the scale of potential future demand for pressure reduction is relatively small compared to current pressure reduction measures implemented within MPAs. These equate to pressure reduction measures of around 550 km² (subtidal mud), 10,200 km² (subtidal sand) and 4,300 km² (subtidal gravel) (based on ABPmer (2023[10])). On this basis, further pressure reduction (primarily from bottom-towed fishing gears) might be a potential mechanism for delivering MNG, although such measures could not be delivered by industry.

Table 4. Indicative potential subtidal habitat demand (km²) by epoch (commuted to habitat disturbance)

Marine plan region	Habitat type	2023-2030	2031 - 2040	2041-2050
South West	Mud	3.33	6.73	6.53
	Sand	8.34	24.08	23.02
	Gravel	5.44	23.88	22.71
North West	Mud	7.60	13.02	12.96
	Sand	13.49	21.66	21.58
	Gravel	3.48	5.34	5.32
North East	Mud	1.24	4.53	4.52
	Sand	4.18	47.04	46.87
	Gravel	0.26	4.58	4.56
East	Mud	2.74	3.05	3.05
	Sand	100.13	83.28	83.15
	Gravel	43.90	34.76	34.67
South East	Mud	1.36	2.05	2.20
	Sand	3.52	8.17	9.77
	Gravel	1.08	3.30	4.14
South	Mud	6.53	8.25	8.25
	Sand	19.04	24.07	24.07
	Gravel	48.96	62.16	62.16
National	*Mud*	*22.80*	*37.63*	*37.51*
	Sand	*148.70*	*208.29*	*208.46*
	Gravel	*103.13*	*134.03*	*133.56*

[10] ABPmer. 2023. Delivery Options for Strategic Marine Net Gain, Analysis of existing recovery and restoration projects and proposals, ABPmer Report No. R.4275. A report produced by ABPmer for OWEC: Strategic MNG Delivery Task and Finish Group, May 2023.

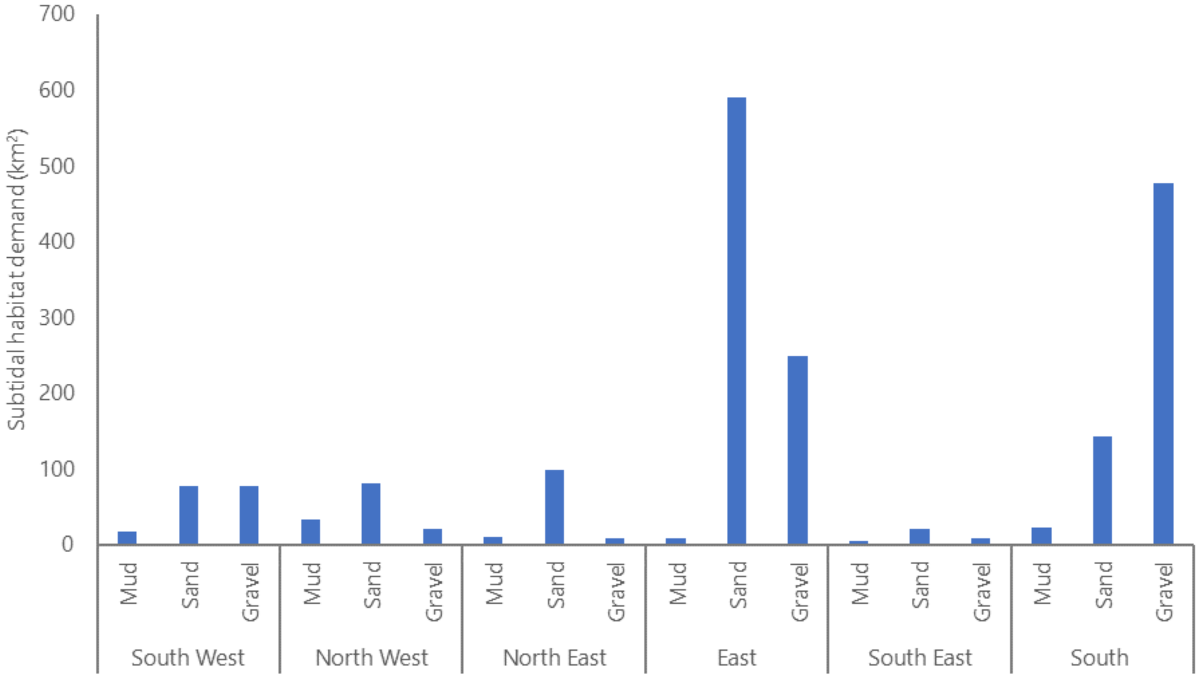

Figure 2. Potential MNG demand (km²) in relation to subtidal habitat (commuted to disturbance impacts) by habitat type by marine plan region in the period 2023 -2050

3.2 Intertidal habitats

Table 5 presents a summary of indicative intertidal demand for MNG by marine plan region and epoch in relation to loss of intertidal sediment and saltmarsh, also summarised in Figure 3. Based on the method applied, estimates of losses for intertidal sediment and saltmarsh are assumed to be equal.

The indicative levels of intertidal MNG demand in relation to habitat loss (Table 5) are comparable in scale with the estimates for subtidal habitat demand (Table 2) based on the method used. However, the estimates are considered to be highly conservative based on the report authors' experience of relevant projects around the English coast. For example, in the South marine plan region alone, the estimates suggest a demand for 40 ha of intertidal sediment and 40 ha saltmarsh p.a., which does not accord with current experiences of rates of intertidal habitat loss from development projects, which are an order of magnitude lower.

The analysis has not taken account of possible requirements for compensatory measures under the Habitats Regulations or for measures of equivalent ecological value under the Marine & Coastal Access Act 2009 where the features affected are associated with sites protected for nature conservation. It is noted that at least 80 % of estuarine and 50 % of coastal areas are subject to site-based habitat protection under the Habitats Regulations and Marine & Coastal Access Act. These are likely to be the primary drivers for intertidal habitat interventions as a result of development project impacts, with the demand for net gain on top of these other statutory requirements.

It is noted that the database of interventions developed through the first call for evidence has identified a total of 48 initiatives that have created mudflat habitat (1,198 ha) and 100 initiatives that have created saltmarsh habitat (1,622 ha) over the past 20 years or so. It is recognised that these interventions have been undertaken in response to a range of drivers including as compensatory measures for development impacts, mitigation for sea level rise and for conservation purposes.

Table 5. Indicative potential intertidal habitat demand (km²) by habitat type, epoch, and marine plan region

Marine plan region	Habitat type	2023-2030	2031 - 2040	2041-2050
South West	Intertidal sediment	1.8	2.3	2.3
	Saltmarsh	1.8	2.3	2.3
North West	Intertidal sediment	0.8	1.0	1.0
	Saltmarsh	0.8	1.0	1.0
North East	Intertidal sediment	0.8	1.0	1.0
	Saltmarsh	0.8	1.0	1.0
East	Intertidal sediment	0.9	1.2	1.2
	Saltmarsh	0.9	1.2	1.2
South East	Intertidal sediment	1.8	2.3	2.3
	Saltmarsh	1.8	2.3	2.3
South	Intertidal sediment	3.1	3.9	3.9
	Saltmarsh	3.1	3.9	3.9
Total (National)	*Intertidal sediment*	*9.3*	*11.6*	*11.6*
	Saltmarsh	*9.3*	*11.6*	*11.6*

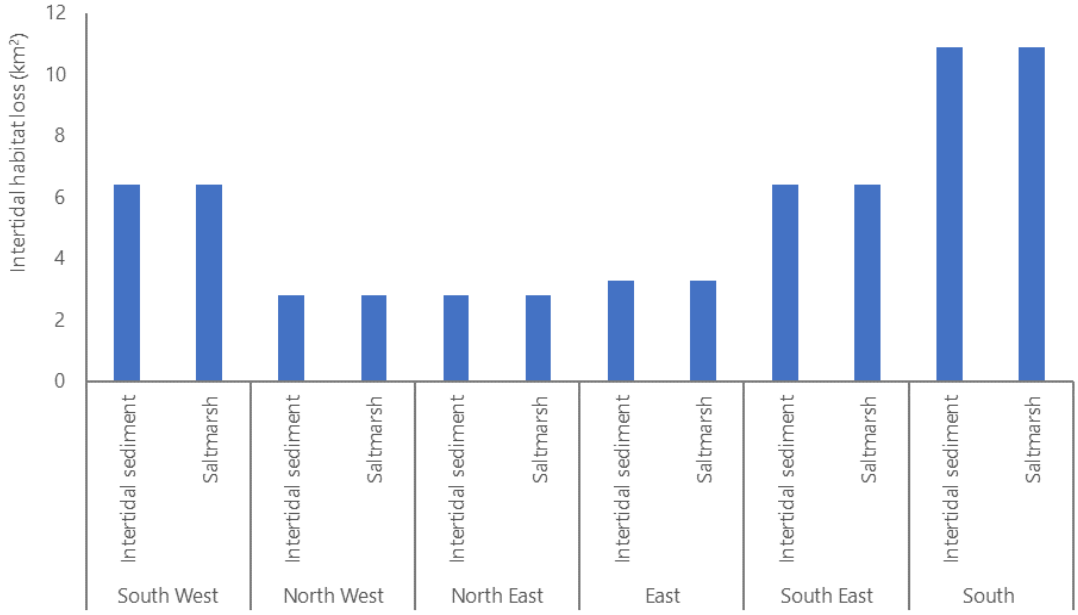

Figure 3. Potential MNG demand (km²) in relation to intertidal habitat loss by habitat type by marine plan region in the period 2023 - 2050

Marine Management Organisation (MMO, 2019[11]) identifies potential opportunities for intertidal habitat creation and restoration through interventions such as managed realignment, regulated tidal exchange and beneficial use of dredged material around the coast of England. This study identified many tens of thousands of hectares (hundreds of km²) of opportunity indicating a large scope for future intertidal interventions. It is likely that the possible supply of intertidal habitat creation/restoration and enhancement projects can readily meet the likely demand for MNG.

3.3 Species impacts (subtidal)

Table 6 and Figure 4 present a summary of the number of projects potentially requiring MNG measures for species, by marine plan region and epoch.

Table 6. Number of development projects per epoch that may require MNG species measures for mobile feature groups (birds, fish, marine mammals)

Mobile feature impact	South West	North West	North East	East	South East	South	*National*
2023-2030							
Bird mortality	1	2	1	6	0	2	*12*
Bird disturbance	1	3	1	6	0	2	*13*
Fish mortality	1	2	0	0	1	1	*5*
Fish disturbance	7	8	7	21	4	6	*53*
Marine mammal mortality	0	0	0	0	0	0	*0*
Marine mammal disturbance	1	2	1	13	0	2	*19*
2031-2040							
Bird mortality	6	6	12	6	0	0	*30*
Bird disturbance	7	6	12	6	0	0	*31*
Fish mortality	2	2	0	0	1	1	*6*
Fish disturbance	6	7	9	26	4	12	*64*
Marine mammal mortality	0	0	0	0	0	0	*0*
Marine mammal disturbance	6	6	12	16	0	0	*40*
2041-2050							
Bird mortality	6	6	12	6	0	0	*30*
Bird disturbance	6	6	12	6	1	0	*31*
Fish mortality	1	1	0	0	3	1	*6*
Fish disturbance	5	7	9	26	5	12	*64*
Marine mammal mortality	0	0	0	0	0	0	*0*
Marine mammal disturbance	6	6	12	16	0	0	*40*

[11] Marine Management Organisation. 2019. Identifying sites suitable for marine habitat restoration or creation (MMO1135). Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/798829/20190430_MMO1135_Identifying_sites_for_habitat_creation_datalayers_Report_a.pdf [Accessed 23/06/23].

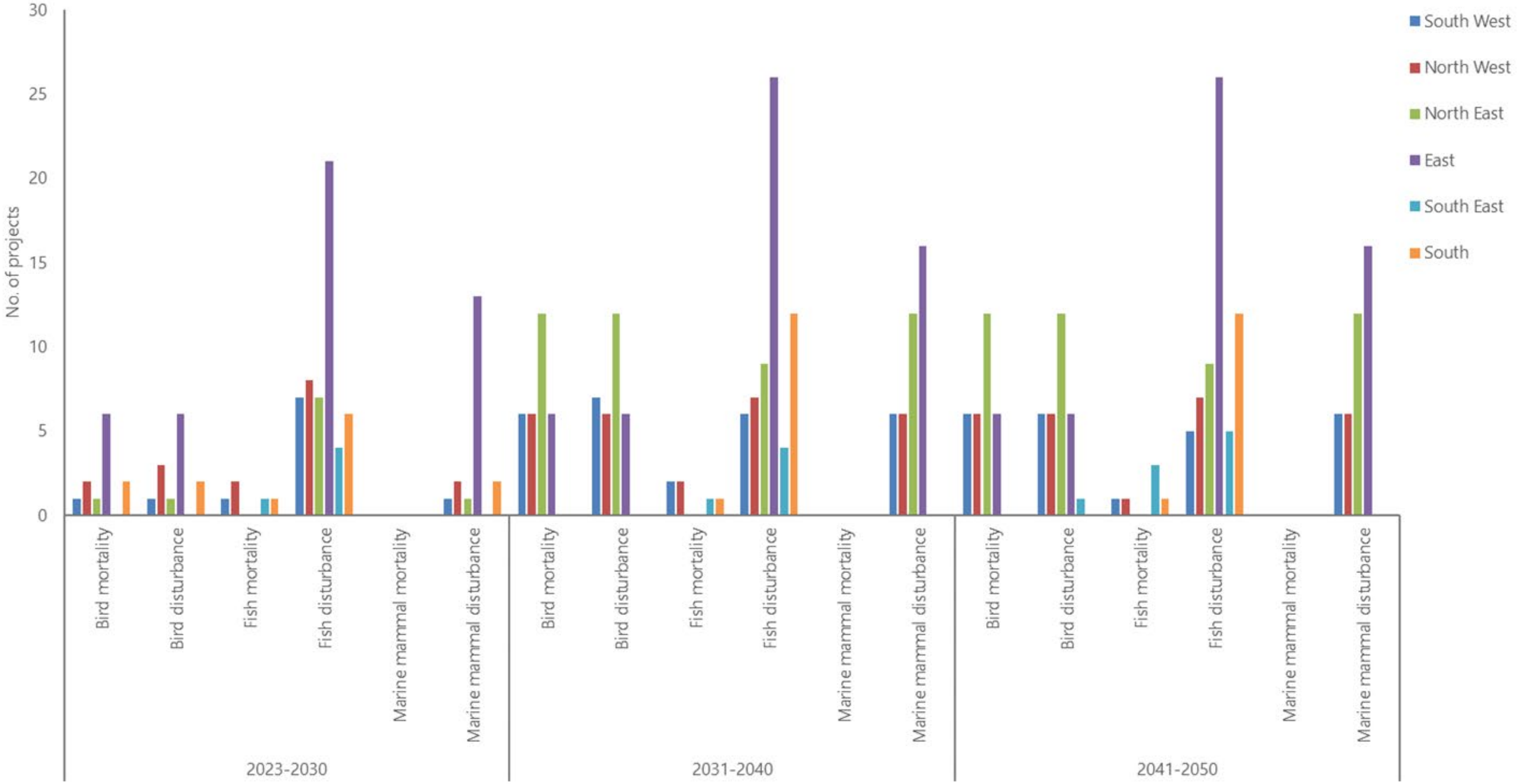

Figure 4. Potential MNG demand (number of projects) in relation to species impacts by pressure, marine plan region and epoch

As noted above, it has not been possible to meaningfully quantify the residual impacts of development on species groups within this study. In the absence of quantified impacts for species groups, it has not been possible, to refine the scale of species impacts, nor define what MNG might require in terms of species measures. Given the complexities and uncertainties, development of a meaningful and robust approach to quantifying residual species impacts and determining MNG requirements is likely to present an ongoing challenge to policy makers.

The assessment indicates that development projects resulting in residual impacts that may require MNG species measures are likely to occur in all marine plan regions across all epochs. Greater levels of intervention may be required in the East and North East marine plan regions due to the greater number of projects in these areas giving rise to residual impacts on mobile species groups.

Key sectors giving rise to potential demand for MNG species measures include offshore wind, oil and gas and port development. Offshore wind potentially affects birds, fish, and mammals while oil and gas development primarily affects fish and mammals (underwater noise). Port development projects may also generate high levels of underwater noise, but given the location of major ports within estuaries, residual impacts are more likely to be confined to fish as marine mammals are typically located in coastal and offshore areas.

The analysis has not taken account of possible requirements for compensatory measures under the Habitats Regulations or for measures of equivalent ecological value under the Marine & Coastal Access Act 2009 where the features affected are associated with sites protected for nature conservation. In relation to birds, it is likely that the Habitats Regulations will be the primary driver of measures to offset residual impacts. The Habitats Regulations may also be the main driver for actions in relation to marine mammals. It will also be the case that some MNG measures taken to address habitat impacts will also benefit mobile features.

Information on the number of existing/planned initiatives for fish/birds/marine mammals has been extracted from the restoration and recovery projects database (ABPmer, 2023[10]) and is shown in Table 7. This evidence indicates that initiatives for fish, birds and marine mammals are being progressed across most marine plan regions. Due to the limitations of the analysis, it is not possible to identify whether the number and nature of such initiatives might be at a level consistent with the level of activity that might be required to deliver MNG for species. It is recognised that measures to improve the quality of seabed habitats is likely to contribute to supporting mobile species' populations (through increases in prey abundance). Separately, fisheries management measures will also contribute to supporting mobile species populations.

Table 7. Indicative numbers of existing/planned initiatives for fish, birds, and marine mammals by marine plan region

Existing/ planned mobile feature initiatives	South West	North West	North East	East	South East	South
Fish (inc. migratory fish)	-	8	-	2	-	2
Birds (seabirds, waterbirds)	3	-	10	3	1	6
Marine mammals	3	1	1	1	2	1

4. Discussion

The analysis highlights the challenges in seeking to project the scale, location, and timing of future development activity. Environmental impacts are often very site specific. Thus, the spatial location of future development is important in understanding specific impacts/residual impacts and strategically linking development to the optimal locations to deliver MNG.

Ahead of policy development for MNG, there is currently a high level of uncertainty concerning how any requirement for MNG might be determined and thus many assumptions have been required in translating estimates of residual impact into a potential MNG demand. Consequently, the analysis should be seen as providing an order of magnitude indicative potential MNG requirement at this stage. Greater clarity will come once MNG policy has been determined. The Crown Estate's work to digitally map the seabed resource needed to meet future demand as well as the enhanced co-ordination of future activities out to 2050 could also help to reduce uncertainties surrounding future marine development and its spatial impacts.

It is noted that the policy approach to MNG has not yet been determined. While the analysis presents information relating to subtidal habitat loss/change, permanent disturbance and temporary disturbance, intertidal habitat loss, and subtidal species impacts, the actual scope of MNG may differ. While EIAs and wider environmental assessments typically include information that enables the direct loss/change of habitat to be assessed, they generally include less quantified information on the spatial extent and intensity of disturbance or species impacts. Should MNG policy seek to include wider aspects of project residual impacts, this could require developers to undertake more detailed assessment of disturbance and species impacts, and to provide additional information as part of their consent applications. Given the limitations of current scientific assessment tools, this will be challenging and potentially contentious.

4.1 Subtidal habitat

The analysis indicates that future marine development will potentially result in the combined loss of/change to subtidal mud, sand, and gravel habitats of the order of 25 to 30 km² per decade in the period to 2050. Given the uncertainties surrounding the location of future development, it is difficult to be more precise about the specific habitats and biotopes that will be affected. The main sectors contributing to subtidal habitat loss/change are predicted to be offshore wind and marine aggregates which account for up to 90 % of the habitat loss/change based on the assumptions used in the analysis.

The analysis identifies that future development will also lead to permanent (project lifetime) and temporary disturbance of subtidal habitats. This is estimated to be around 70 to 115 km² per epoch (permanent disturbance) and 65 to 85 km² per epoch (temporary disturbance). Based on the assumptions used in the study, marine aggregates are likely to be the primary sector contributing to permanent disturbance and offshore wind the primary sector contributing to temporary disturbance.

It is recognised that there is limited opportunity to recreate subtidal habitats in the marine environment as the scale of decommissioning activities on the seabed is and will remain small relative to the potential impacts from new development in the period to 2050. In order to facilitate MNG for subtidal habitats, it is likely to be necessary for any MNG regime to provide for subtidal impacts to be offset in a non like-for-like manner either through pressure reduction measures on subtidal habitat or creation of intertidal habitat. Both options would appear to be feasible based on indicative potential demand for MNG and the potential supply of interventions, depending on policy decisions by government. However, as there is limited scope for marine industries to reduce disturbance of marine habitats from their own activities, pressure reduction measures involving other marine sectors (such as fisheries) could only be pursued as part of a strategic approach led by government.

Any approach to estimate MNG demand will need to carefully consider how to include the marine aggregates sector. The absolute impact of the sector is a function of its total footprint in the marine environment, a combination of the spatial extent of Active Dredge Zones (ADZ - within which aggregate is extracted) and Secondary Impact Zones

(SIZ - the area within which the effects of sediment deposition on the seabed from dredging activities are experienced). Most licences issued are for renewal of existing (15 year) licences. These renewals do not necessarily lead to an increase in the footprint of existing dredging activity. Where new licences are sought these may result in one or more existing licences being relinquished, again potentially resulting in no increase to combined ADZ or SIZ. Conversely, it might be argued that MNG is a new policy and that it should apply to all new or renewal licences even if the overall footprint of marine aggregate dredging does not change.

4.2 Intertidal habitat

The analysis suggests that the calculated potential demand for intertidal habitat (over 1,000 ha intertidal sediment and 1,000 ha saltmarsh nationally per decade) may be a significant overestimate. It is considered that a more realistic estimate of potential demand (less than half of the above estimates) could be met from the supply of intertidal habitat creation/restoration and enhancement opportunities, particularly given the recent upsurge in interest in coastal restoration projects.

4.3 Species groups

There are significant challenges in seeking to quantify residual impacts to species groups and how species impacts might be incorporated into MNG. While Environmental Statements assess impacts to mobile species groups, such assessments generally tend to be qualitative and there is a lack of robust quantitative information. It has therefore not been possible within the constraints of this study to develop quantitative assessments of residual impact or potential MNG demand. Rather, the analysis has sought to identify the number of projects within marine plan regions over different time periods that might give rise to an MNG requirement. This analysis indicates that MNG measures for mobile species could be required in all marine plan regions in the period to 2050. Given that many of the mobile features that will be affected are afforded site-based protection due to their association with MPAs, it is likely that some of the residual impacts will be addressed under the Habitats Regulations and Marine and Coastal Access Act, with demand for net gain on top of these other statutory requirements.

5. Conclusions

Forecasting the scale, location and timing of future development activity is inherently challenging particularly over decadal time scales. Given that environmental impacts tend to be site-specific, any assessment of residual impacts from marine development activity will come with a large uncertainty. Similarly, given that MNG policy is in its infancy, it is also currently uncertain how residual impacts might be translated into a demand for MNG interventions. Nevertheless, it is helpful to start considering these issues now, as recognised by the recent announcement by The Crown Estate concerning its future spatial scenarios project which, inter alia, will enable identification of areas for restoration/recovery interventions within a wider marine spatial planning process. Greater clarity concerning MNG requirements will come as MNG policy becomes better defined.

It is likely to be feasible to assess residual impacts to subtidal and intertidal habitats based on information contained within Environmental Statements or wider environmental assessments, particularly measures of habitat loss/change. Such information could be used to calculate an MNG demand (within a metric) or to refine a financial contributions-based approach.

There are significant challenges in seeking to quantify the spatial extent and intensity of permanent and temporary disturbance, and residual impacts to mobile species groups. Such information is not typically available within statutory assessments and where quantified assessments are provided these are subject to high levels of uncertainty. Incorporating species impacts within MNG is likely to be especially challenging and require the collection of significant additional information and development of new assessment tools within EIA processes.

In simple terms, the overall scale of past and current restoration/enhancement and recovery interventions would appear to be at a level that, if continued, could help to deliver MNG, depending on the form that MNG takes. However, it should be recognised that in subtidal environments, it will be difficult to recreate significant areas of replacement habitat. MNG may therefore need to or alternatively look to improve the condition of subtidal habitats (through pressure removal, primarily bottom-trawling fishing pressure). This latter option could only be delivered as part of a strategic approach led by government.

6. Abbreviations/Acronyms

ADZ	Active Dredge Zone
BMAPA	British Marine Aggregate Producers Association
BNG	Biodiversity Net Gain
EIA	Environmental Impact Assessment
EUNIS	European Nature Information System
GW	Gigawatt
HVDV	High Voltage Direct Current
LPA	Local Planning Authority
LSO	Long Sea Outfall
MarESA	Marine Evidence based Sensitivity Assessment
MLW	Mean Low Water
MMO	Marine Management Organisation
MNG	Marine Net Gain
MPA	Maine Protected Area
MW	Megawatt
OWEC	Offshore Wind Evidence and Change Programme
PIZ	Primary Impact Zone
SIZ	Secondary Impact Zone
T&F Group	Strategic Net Gain Task and Finish Group
TCE	The Crown Estate

Appendices

Appendix A. Assumptions for estimating future demand

Aggregates

- Assume indicative 3 new licence applications p.a. across marine plan regions pro rata to existing number of licences in each marine region (The Crown Estate and BMAPA, 2021[12])[13];
- Assume average Active Dredge Zone (ADZ) size for each new site as indicative of permanent habitat change for 15 years of licence (plus 5 years recovery) (The Crown Estate and BMAPA, 2021[12])[14];
- Assume average Secondary Impact Zone (SIZ) size (for combined sediment plume and bedform effects) as 3 x ADZ for each new site as indicative of habitat disturbance for 15 years of licence[15];
- Habitat affected assumed to comprise subtidal sands and gravels; and
- Assume mortality and disturbance of mobile species as negligible (N) or low (L) for all development locations.

Aquaculture (shellfish)

- Assume footprint of mussel farms increases linearly to meet 2030 and 2040 aquaculture strategy goals;
- Assume 1,000 tonnes of shellfish (mussels) every two-year growing cycle (i.e., 500 tonnes p.a.) occupies an area 5.46–7.26 km² (average 6.36 km²);
- Assume even distribution of new development across marine plan areas;
- Assume development occurs proportionally over mud, sand, and gravel habitats;
- Assume 0.1% of footprint subject to permanent habitat change over lifetime of development (anchors);
- Assume 6.6% (Wilding, T.A. & Nickell, T.D. 2013[16], and ABPmer & Maritek, 2021[17])[18] area of footprint subject to permanent habitat change over lifetime of development (to 2050);

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[12] The Crown Estate and BMAPA. 2021. Marine Aggregate Extraction 2021. The area involved – 24th annual report. Available at: https://www.thecrownestate.co.uk/media/4242/the-area-involved-24th-annual-report.pdf (Accessed 23/06/23].

[13] Based on TCE and BMAPA, (2021[12]) there are 29 licences in East marine plan areas, 24 in South marine plan areas, three in South West marine plan areas and two in North West marine plan areas.

[14] Based on TCE and BMAPA (2021[12]), there are 64 existing licences (includes 6 in Welsh waters) with a total licensed area of 1068 km² and an ADZ of 106 km². On this basis an average ADZ per licensed site is approximately 1.66 km².

[15] Based on visual review of PIZ and SIZ in various marine aggregate EIAs.

[16] Wilding, T.A. & Nickell, T.D. 2013. Changes in Benthos Associated with Mussel (Mytilus edulis L.) Farms on the West-Coast of Scotland. PLoS ONE 8(7): e68313. Available at: https://doi.org/10.1371/journal.pone.0068313 [Accessed 23/06/23].

[17] ABPmer & Maritek. 2021. Prospects and Opportunities for Large-scale Restorative Aquaculture in Scotland. Report to Crown Estate Scotland, December 2021. Available at: https://www.crownestatescotland.com/resources/documents/prospects-and-opportunities-for-large-scale-restorative-aquaculture-in-scotland-low-res [Accessed 23/06/23].

[18] Wilding, T.A. & Nickell, T.D. 2013[16] indicate habitat impacts limited to roughly 5 m either side of mussel lines; ABPmer & Maritek (2021[17]) indicate layout of mussel farm would entail 6 km of headlines in area of 0.91 km². Together these studies indicate that main habitat impacts would occur on 6.6 % of farm footprint.

- Assume negligible habitat disturbance outside of development footprint; and
- Assume mortality and disturbance of mobile species during operation as negligible (N) or low (L) for all development locations.

Aquaculture (seaweed)

- Assume footprint of seaweed farms increases linearly to meet 2030 and 2040 aquaculture strategy goals;
- Assume footprint of seaweed farms requires 1.05 km² for annual production of 40 tonnes kelp (based on ABPmer & Maritek, 2021[17]);
- Assume even distribution of new development across marine plan areas;
- Assume development occurs proportionally over mud, sand, and gravel habitats;
- Assume 0.1% of footprint subject to permanent habitat change over lifetime of development (anchors);
- Assume 1% of footprint subject to regular habitat disturbance over lifetime of development (mooring chains); and
- Assume mortality and disturbance of mobile species during construction and operation is negligible (N) (fish and birds) or low (L) (marine mammals - entanglement risk) for all development locations.

Carbon capture usage and storage

- Assume two projects progress in mid 2020s (East Coast Cluster (Teesside), HyNet (North West)) and two further projects progress in mid 2030s (Zero Carbon Humber and Bacton);
- Assume each pipeline has 100 km length:
  - Assume 5% of this length leads to direct habitat change (rock armouring, cable crossings) with width of 5 m;
  - Assume temporary habitat disturbance during installation along length of pipeline and width of 5 m;
- Assume development occurs proportionally over mud, sand, and gravel habitats; and
- Assume mortality and disturbance of mobile species during construction and operation is negligible (N) or low (L).

Coastal development (regeneration) (subtidal elements)

- Includes works to existing river and coastal walls, and works to bridges and public piers;
- Assume indicative 5 new licence applications p.a. entailing subtidal works split across marine plan regions pro rata;
- Assume development occurs proportionally over mud and sand habitats;
- Assume subtidal footprint of marine works is 1 ha;
- Assume 50% of footprint subject to permanent habitat change over lifetime of development;
- Assume 50% of footprint subject to habitat disturbance during construction; and
- Assume mortality of mobile species during construction and operation is negligible (N) and disturbance of mobile species during construction and operation is low (fish and birds) or negligible (N) (marine mammals) for all development locations.

Offshore wind farms

- Assume 2 GW installed capacity consented p.a. in English waters to 2030;
- Assume 2 GW installed capacity consented p.a. in English waters from 2031 to 2050;
- Assume projects to 2030 are located in planned development locations (pro rata to estimated capacity) Based on ABPmer & eftec (2022[4]);
- Assume projects from 2030 are located in North East marine plan areas (40%), East marine plan areas (20%), South West marine plan area (20%) North West marine plan area (20%);
- Development area is 150 km² per GW;
- Assume development occurs proportionally over mud, sand, and gravel habitats;
- Assume impacts of fixed and potential future floating offshore wind are similar;
- Assume 0.5% of development footprint subject to permanent habitat change over lifetime of development (foundation/scour protection with 40 m radius);
- Assume 1.5% of array footprint subject to habitat disturbance during construction (assume 300 km of intra-array cabling per 1 GW development with disturbance width of 5 m);
- Assume 5% of this intra-array cable area is subject to direct habitat change (rock armouring, mattressing);
- Assume 300 km of export cable (two HVDV cables @150km per 1 GW development) with disturbance width of 5 m during construction);
- Assume 5%[19] of this export cable area is subject to direct habitat change (rock armouring, mattressing);
- Assume entire export cable area subject to temporary disturbance during construction;
- Assume mortality of mobile species during construction is negligible (N) (birds and mammals) or low (L) (fish). Assume mortality of bird species during operation is moderate and mortality of fish and mammals during operation is negligible (N);
- Assume disturbance of mobile species during construction is moderate (fish, birds, and mammals); and
- Assume disturbance of mobile species during operation is moderate (birds) or low (fish, mammals).

Oil and gas

- Assume one exploration (seismic survey) licence p.a. in English waters (East marine plan areas);
- Assume 1 exploration (drilling) licence p.a. in English waters (East marine plan areas);
- Assume 1 decommissioning projects p.a. in English waters (East marine plan areas) with no residual footprint (and thus ignored for purposes of the assessment);
- Assume footprint of marine works for exploration (drilling) projects is 0.5 ha;
- Assume development occurs proportionally over mud, sand, and gravel habitats;
- Assume 50% of footprint subject to permanent habitat change over lifetime of development (wellhead);
- Assume 50% of footprint subject to habitat disturbance during construction;

[19] It is recognised that amount of rock armouring required can be very variable depending on location e.g., much higher percentage of rock armouring required for some Irish Sea windfarm export cables.

- Assume mortality and disturbance of mobile species during drilling is low (L) or negligible (N);
- Assume mortality of mobile species is low (L) or negligible (N) during seismic surveys; and
- Assume disturbance of mobile species is low (birds) or moderate (fish and mammals) during seismic surveys.

Ports

- Assume level of applications remains constant over time (10 x small, 5 x medium, 4 x large p.a.) spread across marine plan regions pro rata to existing number of ports[20];
- Assume footprints of works below MLW are 0.1 ha (small projects); 1 ha (medium projects) and 100 ha (large projects - to account for dredging requirements);
- Assume development occurs equally over mud and sand habitats;
- For small and medium projects:
  - Assume 50% of footprint subject to permanent habitat change over lifetime of development (reclamation/structures);
  - Assume 50% of footprint subject to habitat disturbance over the lifetime of the development (maintenance dredging);
  - Assume mortality and disturbance of mobile species during construction and operation is low (fish and birds, marine mammals) for all development locations;
- For large projects:
  - Assume 5% of footprint subject to permanent habitat change (reclamation/structures);
  - Assume 50% footprint subject to habitat disturbance over the lifetime of the development (maintenance dredging);
  - Assume mortality of mobile species during construction and operation is low (L) (fish, birds, marine mammals) for all development locations;
  - Assume disturbance of mobile species during construction is moderate (M) (fish) or low (L) (birds, mammals); and
  - Assume disturbance of mobile species during operation is low (L).

Power interconnectors and transmission lines

- Assume 1 x licence application p.a. for 100 km length of cable in English waters below MLW;
- Assume evenly distributed across marine plan areas;
- Assume development occurs proportionally over mud, sand, and gravel habitats;

[20] MMO (2017). Analysis for the North East, North West, South East and South West marine plan areas. Project MMO 1127. https://www.gov.uk/government/publications/futures-analysis-for-the-north-east-north-west-south-east-and-south-west-marine-plan-areas-mmo-1127 [Accessed 23/6/23]. Report indicates the following numbers of major/minor ports - NE = 8; NW = 10; SE = 9; SW = 23. Department for Transport. 2018. Port and domestic waterborne freight statistics: data tables (PORT). https://www.gov.uk/government/statistical-data-sets/port-and-domestic-waterborne-freight-statistics-port#all-port-traffic-totals-major-and-minor [Accessed 23/06/23], indicates the following numbers of major/minor ports - S = 47; E = 18.

- Assume footprint of cable is 5 m width over length of cable (100 km) = 0.5 km^2 (50 ha);
- Assume 5% of this cable area is subject to direct habitat change (rock armouring, mattressing);
- Assume footprint of cable subject to temporary habitat disturbance during construction; and
- Assume mortality of mobile species during construction and operation is negligible (N) and disturbance of mobile species during construction and operation is low (fish and birds) or negligible (N) (marine mammals) for all development locations.

Power stations

- Assume one new large coastal power station built per decade in North West (mid 2030s) and South East (2040s) marine plan areas;
- Assume subtidal footprint of each development is 5 ha;
- Assume development occurs equally over mud, sand, and gravel habitats;
- Assume 50% of footprint subject to permanent habitat change over lifetime of development (reclamation/structures);
- Assume 50% of footprint subject to temporary habitat disturbance over the lifetime of the development (construction dredging);
- Assume mortality and disturbance of mobile species during construction is low (fish and birds, marine mammals) for all development locations;
- Assume mortality during operation is high (H) (fish) or low (birds, marine mammals); and
- Assume disturbance of mobile species during operation is low.

Recreational boating (subtidal elements)

- Assume 20 small projects p.a. in English waters with below MLW of 0.05 ha;
- Assume 10 medium projects in English waters with footprint below MLW of 0.5 ha;
- Assume 1 large project in English waters with footprint below MLW of 2 ha;
- Assume projects pro rata to number of ports across marine plan areas;
- Assume development occurs equally over mud and sand habitats;
- Assume 50% of footprint subject to permanent habitat change over lifetime of development (reclamation/structures);
- Assume 50% of footprint subject to habitat disturbance over the lifetime of the development (maintenance dredging); and
- Assume mortality of mobile species during construction and operation is negligible (N) and disturbance of mobile species during construction and operation is low (fish and birds) or negligible (N) (marine mammals) for all development locations.

Telecommunication cables

- Assume 1 x marine licence application p.a. for 100 km length of cable in English waters below MLW;
- Assume evenly distributed across marine plan areas;

- Assume development occurs proportionally over mud, sand, and gravel habitats;
- Assume footprint of cable is 1 m width over length of cable (100 km) = 0.1 km² (10 ha);
- Assume 5% of this cable area is subject to direct habitat change over width of 5 m (rock armouring, mattressing);
- Assume footprint of cable subject to temporary habitat disturbance during construction; and
- Assume mortality and disturbance of mobile species during construction and operation is negligible (N).

Tidal range energy

- Assume one development every ten years sequentially in NW, SW, and SE marine plan areas;
- Assume 20 ha of subtidal habitat subject to direct change (lagoon wall);
- Assume 100 ha of subtidal habitat subject to habitat disturbance during operation (maintenance dredging inside lagoon);
- Assume development occurs proportionally over mud, sand, and gravel habitats;
- Assume mortality of mobile species during construction is low (L) (fish, birds, marine mammals) for all development locations;
- Assume mortality of mobile species during operation is High (fish) or low (birds, mammals (assuming mitigation measures implemented));
- Assume disturbance of mobile species during construction is moderate (M) (fish, birds) or low (L) (mammals); and
- Assume disturbance of mobile species during operation is low (L).

Tidal stream energy

- Assume 1 MW p.a. installed in English waters pro rata across NW, SW, S and SE marine plan areas to 2050;
- Assume development occurs proportionally over mud, sand, and gravel habitats;
- Assume 0.5 ha of footprint per MW subject to permanent habitat change over lifetime of development (foundations);
- Assume 2.5 ha of footprint per MW subject to regular habitat disturbance over lifetime of development (mooring chains, scour);
- Assume 10 km of export cable with disturbance width of 5 m during construction (0.05 km²);
- Assume 5% of this export cable area is subject to direct habitat change (rock armouring, mattressing);
- Assume entire export cable area subject to temporary disturbance during construction;
- Assume mortality of mobile species during construction is low (L) (fish, birds, marine mammals) for all development locations;
- Assume mortality of mobile species during operation is Moderate (M) (fish) or low (L) (birds, marine mammals (assuming mitigation implemented)); and
- Assume disturbance of mobile species during construction and operation is low (L).

Wastewater treatment outfalls

- Assume three new LSOs are constructed p.a. pro rata across marine plan areas;
- Assume the maximum footprint of each LSO during construction is 1 ha (2 km x 5 m width);
- Assume 5% of footprint subject to permanent habitat change over lifetime of development outfall diffuser head);
- Assume 50% of footprint subject to habitat disturbance during operation (organic enrichment based on deposition model);
- Assume development occurs equally over mud and sand habitats;
- Assume mortality of mobile species during construction and operation is low (L); and
- Assume disturbance of mobile species during construction and operation is low (L).

Wave power

- Assume 1 MW p.a. installed in SW marine plan area to 2030 rising to 4 MW p.a. from 2031 to 2050;
- Assume development occurs proportionally over mud, sand, and gravel habitats;
- Assume 0.5 ha of footprint per MW subject to permanent habitat change over lifetime of development (foundations);
- Assume 2.5 ha of footprint per MW subject to regular habitat disturbance over lifetime of development (mooring chains, scour);
- Assume 10 km of export cable with disturbance width of 5 m during construction (0.05 km^2);
- Assume 5% of this export cable area is subject to direct habitat change (rock armouring, mattressing);
- Assume entire export cable area subject to temporary disturbance during construction; and
- Assume mortality and disturbance of mobile species during construction and operation is low (L) (fish, birds, marine mammals) for all development locations.

Intertidal habitat

The eftec BNG market analysis study estimated direct loss of intertidal sediment and saltmarsh habitat based on the number of coastal planning applications in each LPA area and standard assumptions about the average scale of habitat loss. The estimates were made for the 10-year period 2011 to 2020.

- Assume losses of intertidal sediment and saltmarsh as a result of development activity continue at these levels in the period to 2050 with the same geographic distribution;
- Assume there is no temporary disturbance of intertidal habitat; and
- Assume mortality of mobile species as negligible (N); assume disturbance of mobile species is low (L) (fish and birds) and negligible (mammals) for all development locations.