Cyfoeth Naturiol Cymru
Natural Resources Wales

Marine Physical Processes Guidance to inform Environmental Impact Assessment (EIA)

Guidance note

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What is this document about?

The purpose of this guidance note is to provide advice on how to complete physical processes assessments to support applications for major marine, coastal and estuarine projects.

The guidance explains the process you should follow, the questions you should consider and the information we expect to see in an assessment. The guidance covers methods for baseline (undisturbed) characterisation of the physical environment around your project site and approaches to develop understanding of likely changes caused by your project.

We have prepared this guidance as part of our role as environmental advisor. In this role, NRW Advisory provide advice to developers, our staff in the regulatory arm of the organisation (NRW Permitting Service) and other regulatory organisations on likely environmental effects from marine development proposals and activities.

This guidance note does not:

- comprise legal advice and should not be interpreted as such. Project proposers should seek their own independent legal advice on any matters arising in connection with this note in respect to a specific activity or development project.
- prejudice any advice that NRW might provide as part of any application for a specific activity or development project.

This guidance note is a major revision to the previous guidance with the same title that was published in April 2020. This revision provides additional information and clarification where required to bring the guidance up-to-date. The two evidence reports which provide the foundation of the guidance (dated 2017 and 2018) have not been updated.

Who is this document for?

This guidance is for anyone seeking to manage or undertake environmental or ecological impact assessments for a proposed marine development or activity where a physical processes assessment is required. The guidance will also benefit NRW staff. The guidance is principally aimed at large-scale development projects. It should be seen as scalable in this respect, but there is other guidance specifically aimed at smaller projects, which can be accessed from our website: Natural Resources Wales / Marine and coastal physical processes assessments

Contact for queries and feedback

For technical queries or feedback on this guidance note, contact the Marine and Coastal Ecosystems Team: Marine.Coastal.Ecosystems.Team@cyfoethnaturiolcymru.gov.uk

For project-specific queries, contact the Marine Area Advice and Management Team: marine.advice@cyfoethnaturiolcymru.gov.uk

Version History

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To report issues or problems with this guidance contact: guidance.development@cyfoethnaturiolcymru.gov.uk

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1. Introduction

'Physical processes' refers to the characteristics and behaviour of the waves, tides, sediment and seabed around your project site; this is sometimes termed 'marine processes' or 'coastal processes.' Section 1.1 gives a summary of physical processes.

Coastal and marine developments can cause detrimental change to the environment and therefore their impact on the marine environment needs to be quantified; for example, in an Environmental Impact Assessment (EIA). Physical processes are important because they affect many aspects of the wider marine environment, such as fisheries and benthic habitats, as well as being important in their own right. Assessing the impact of a project is mandated in both devolved (Welsh) and UK law (Section 1.2).

This guidance explains the information required and processes to follow when developing a physical processes assessment to support an application for a major marine or coastal project. In your physical processes assessment, you will need to include:

- A description of your project and the baseline physical characteristics for the area that your project could affect (this area is termed the 'zone of influence'),
- Conceptual understanding of the behaviour and interaction of the physical systems within your project zone of influence,
- Assessment of the changes to physical processes and physical environment caused by your project, and how this relates to the wider environment.

This guidance is intended to inform projects that are required to carry out an EIA (Section 1.3), but may also be applicable larger, more complex, non-EIA projects. These are termed 'major' projects in this guidance. Example projects or activities that can be considered 'major' include:

- Port and harbour developments,
- Aggregate extraction,
- Power stations (including nuclear),
- Offshore wind, including floating offshore wind,
- Other renewable energy developments including wave and tidal energy, hydrogen production or carbon storage,
- Sub-sea cables (especially where they make landfall or pass close to or through a designated feature).

Advice for assessment of smaller projects is given in a companion piece of guidance: Completing a coastal or physical processes assessment for small scale projects (PDF). If you are uncertain which is the most appropriate guidance to follow for your size of project, you can contact NRWs discretionary advice service (DAS). DAS can provide a range of support to you both before and during the application process, details of this is available on our website: Our service to developers. **In general, we find that developers who engage with NRW prior to licence submission produce higher quality applications which facilitates determination of their permissions.**

This guidance does not cover water quality or contaminated sediment assessments.

1.1 Physical processes and their importance

'Physical processes' involves the following topics and their interaction:

- Hydrodynamics (waves, tidal currents, water levels and stratification),
- Geology, sediments and sediment transport,
- The shape of the coast (topography) and seabed (bathymetry), often termed morphology, and their variation in time (termed morphodynamics).

It should be noted that interaction between these is circular; i.e. waves and currents affect sediment transport, which changes the shape of the bathymetry, and the change in bathymetry affects the waves and currents etc.

Environmental impact is often considered using a source-pathway-receptor model; Figure 1 illustrates this concept. Physical processes can be both a pathway and a receptor:

- An example pathway would be an increase in turbulence in the water column (caused presence of an offshore structure) leading to changes in stratification affecting primary production (an ecological receptor),
- Physical processes receptors are commonly morphology; for example, if a coastal project interrupts longshore sediment transport, it might cause a reduction in downdrift beach width (the receptor) with implications for intertidal habitats, coastal flood protection, tourist amenity and more.

For more examples, see Figure 2 of [Evidence report 243.]

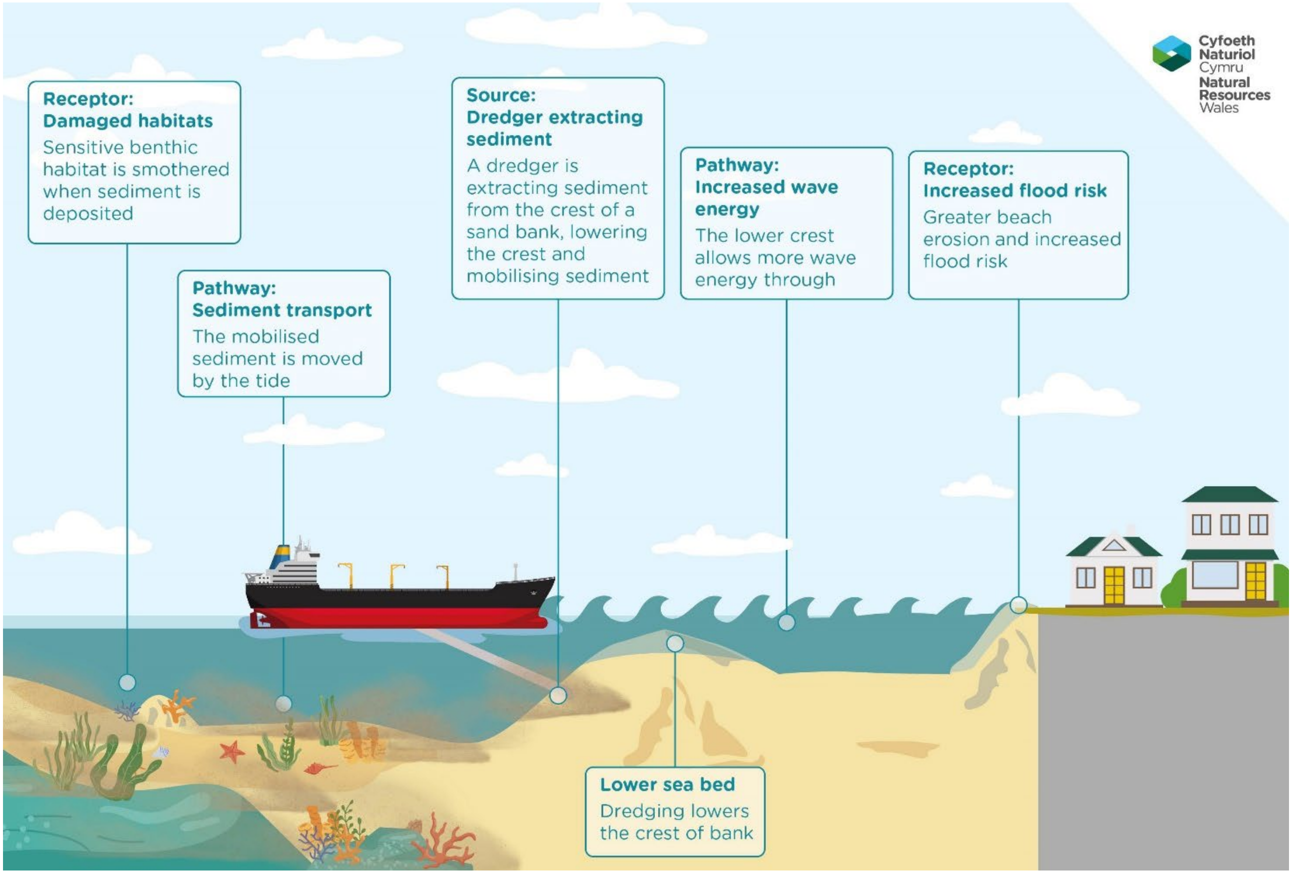

Figure 1:A schematic of the source-pathway-receptor concept giving two hypothetical examples of potential impacts caused by an aggregate dredging project.

1.2 Legislative and policy framework

It may help you to understand the legislation that mandates the requirement for an environmental impact assessment (including physical processes) for your project: information on this can be found on our website: Legislation, policy and information for marine Environmental Impact Assessment (EIA).

Marine and coastal projects may require a range of potential permits or licences, and these will need to be determined on a project specific basis. It is the responsibility of the applicant to satisfy themselves that they have obtained all relevant consents and authorisations.

Section 58 of the Marine and Coastal Access Act 2009 (MCAA) requires all public bodies to take authorisation or enforcement decisions (s. 58(4)) that affect or might affect the UK marine area in accordance with the UK Marine Policy Statement 2011 (MPS) and relevant Marine Plans (see Marine Planning (gov.wales)), unless relevant considerations indicate otherwise (s. 58(1)). For developments affecting the Welsh marine area you should refer to the Welsh National Marine Plan (gov.wales). Projects that are cross-border will also need to refer to English Marine Plans (see Marine plan areas in England (gov.uk))

1.3 The EIA process

EIA is required for certain project applications before a licence decision is made. There are three stages to the EIA process:

1. **EIA screening**. It is established whether your project will require an EIA at this point. Some projects will need an EIA by default but others will only require an EIA if the relevant licencing authority believe a significant effect on the environment cannot be ruled out, for example. see Request an environmental impact assessment (EIA) screening opinion for a marine licence.

2. **EIA scoping**. At this stage, the aspects that need to be considered in the full EIA are determined. EIA scoping for marine projects is covered in the NRW guidance What to include in your marine development scoping report for EIA. **Note that where there is any doubt about the importance of a pathway or likely impact on a receptor, it should be scoped in**. You do not need a formal physical processes assessment at this stage, but you will require a good understanding of the physical environment related to your project and evidence of the likely impacts to determine if any physical processes aspects could be scoped out.

3. **Full EIA**. At this stage, the environmental impact of your project is assessed via the development of an Environmental Statement (ES). Unless all physical processes aspects have been scoped out in the second stage, you will need a physical processes assessment as part of the ES. To facilitate assessment, we recommend your physical processes assessment should be a separate chapter, rather than combined with other receptors such as water quality or benthic ecology; however clear links to other related chapters should be provided.

For further, marine specific, information see Environmental Impact Assessment for marine activities on our website.

1.4 Other uses of a physical processes assessment

Any development or activity that has the potential to have a significant effect on a Special Area of Conservation (SAC), Special Protection Area (SPA) or a Ramsar site will require a Habitats Regulation Assessment (HRA), and this will require understanding of the impact of a project on physical processes. Information on marine HRAs can be found on our website: How a Habitats Regulations Assessment is undertaken in the marine licensing process.

Most coastal and marine projects require a Water Framework Directive (WFD) assessment. The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 (often termed the WFD Regulations 2017) splits rivers, estuaries and coastal areas into different water bodies. The directive requires projects to demonstrate they do not cause deterioration to a water body. Deterioration is based on a range of factors; one is hydro-morphology (i.e., physical processes) and so a physical processes assessment may be required. NRW guidance on WFD, GN078: Complying with the WFD Regulations 2017, can be requested from WFDWales@cyfoethnaturiolcymru.gov.uk. Information about the Welsh water bodies can be found at the website Water Watch Wales (Arsylwi Dyfroedd Cymru for Welsh language version).

1.5 Key NRW Evidence reports

This guidance document is primarily based on two evidence reports, one about approaches to numerical modelling and one about survey and monitoring:

- Advice to Inform Development of Guidance on Marine, Coastal and Estuarine Physical Processes Numerical Modelling Assessments (PDF)
- Guidance of Best Practice for Marine and Coastal Physical Processes Baseline Survey and Monitoring Requirements to Inform EIA of Major Development Projects (PDF)

The two evidence reports provide more detail and background to these topics than provided in this guidance note. Therefore, it is recommended that these evidence reports are also used in the preparation of your assessment.

Another, closely linked, evidence report considers physical processes assessments for smaller projects: Advice on physical processes for small-scale marine and coastal projects (PDF).There is an associated guidance note that summarises this evidence report: Completing a coastal or physical processes assessment for small scale projects (PDF). This may also be useful to refer to, especially if your project is of intermediate size.

Section 7.1 of this document provides details of other relevant guidance, both from NRW and from other sources.

2. Conceptual understanding and characterisation of baseline conditions

It is important to have a good conceptual understanding of the physical systems surrounding your project to allow you to assess the environmental impact of your project. ‘Conceptual understanding’ requires knowledge of:

- the ‘baseline,’ or current, conditions in the area surrounding your project,
- how these conditions have changed in the past and will change in future,
- the links between the various components of the physical environment; for example, understanding how sediment supply from eroding cliffs affects a nearby beach. You could use the source – pathway – receptor model to consider these connections.

Baseline characterisation is also used as the reference point against which you will compare the impacts of your project.

A summary of the stages in developing conceptual understanding is given in Figure 2.

The first stage should be a desktop study to ascertain the existing knowledge of the area, what data are already available and what is required (i.e. a gap analysis). A literature review of any academic papers and past reports on your study area will help you understand historical change, the key processes in your area and likely zone of influence (Section 2.2 of this guidance).

Once you have determined what suitable data sets exist, you will be able to determine data gaps and plan your data collection (Section 2.3 of this guidance). It is important to note that as you develop your conceptual understanding of the environment around your project, you may need to collect additional data to refine your knowledge.

Numerical modelling of the baseline condition can be instructive in building conceptual understanding when paired with insights from collected data. If you plan to use numerical modelling to support your baseline characterisation, you should follow the numerical modelling guidance in Section 3.2 of this guidance.

You may be required to collect physical processes data to monitor the performance and environmental impact of your project (see Section 4). The data collection approaches discussed in Section 2.3 will also be relevant to that aspect of your project. You should consider this monitoring aspect at the baseline characterisation stage because using the same measurement locations and approaches for both will allow you to easily compare the pre- and post-development results and improve your findings.

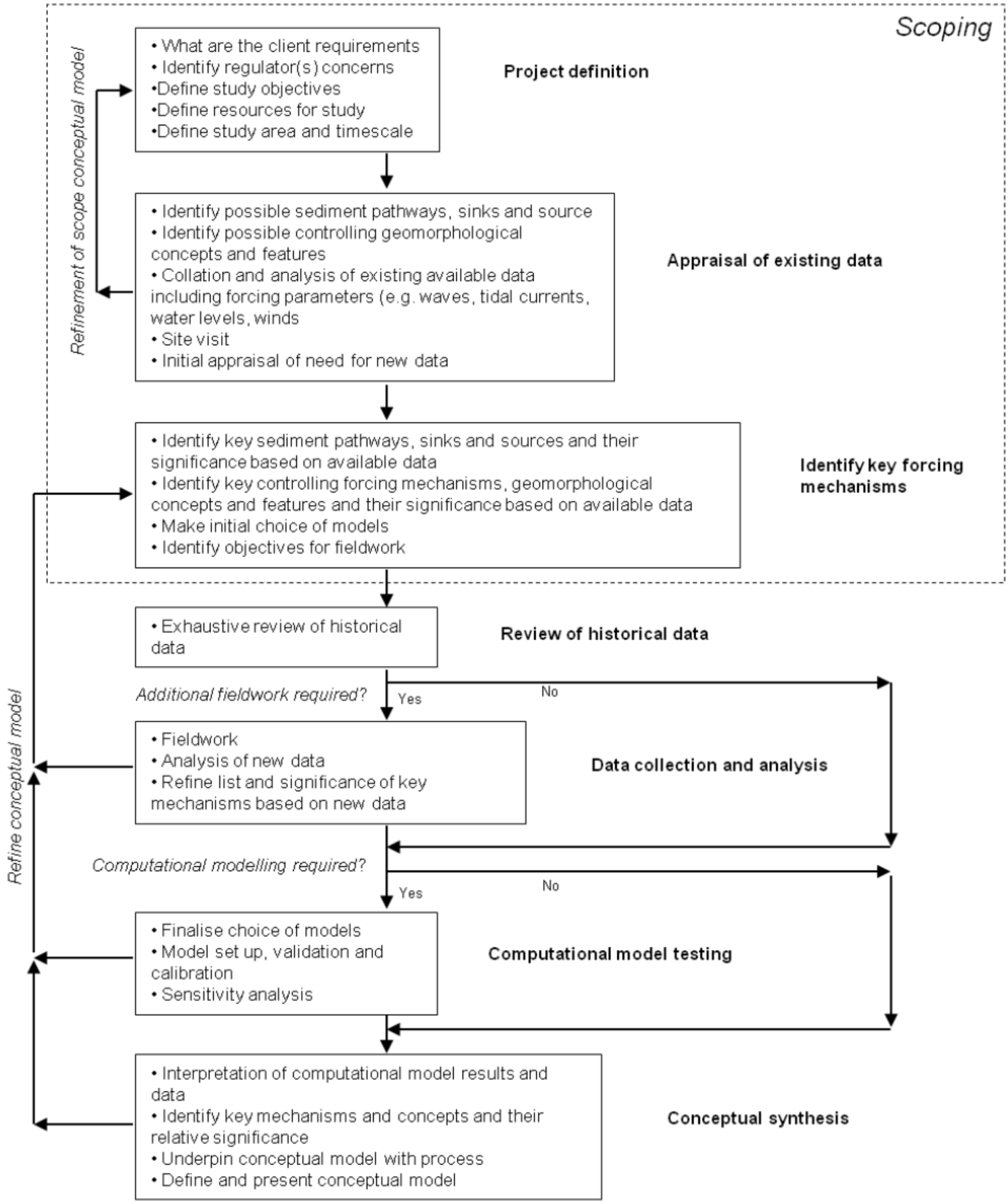

Figure 2: A summary of stages of development of a conceptual model from [Guidance of Best Practice for Marine and Coastal Physical Processes Baseline Survey and Monitoring Requirements to Inform EIA of Major Development Projects (PDF)]

2.1 Initial project description

It is important that you thoroughly describe your project or activity within your physical processes assessment, including accurate maps at an adequate scale. This allows NRW to assess your application and allows you to define the likely impacts of your project.

Where the exact specifics of your project are unknown at the application stage (e.g. type or number of tidal stream turbines at an energy extraction site), then you should use a Rochdale Envelope approach (see Nationally Significant Infrastructure Projects - Advice Note Nine: Rochdale Envelope (www.gov.uk)). In brief, this means assessing a 'realistic worst case' scenario for the range of development options. We recommend that you discuss this with NRW at the pre-application stage.

2.2 Zone of influence

The zone of influence is the region that may be affected by your project. You will need to establish the maximum zone of influence to help you design your data collection strategy.

For large projects, likely zones of influence can be hard to define; you should make use of information such as:

- Maximum spring tidal excursion ellipses,
- Littoral sediment cell or sub-cell boundaries to determine maximum extent of changes to nearby coastlines,
- Numerical modelling or field evidence from analogous developments for changes to wave conditions (see Section 3.3 of this guidance for advice on what is considered analogous),
- Literature review of existing reports or academic publications covering your project area.

Note that as you refine your conceptual understanding of your project and site, you may need to revise your zone of influence.

For an illustration of the zone of influence, see Appendix B of Completing a coastal or physical processes assessment for small-scale projects (PDF) which uses rules designed for small-scale projects to calculate the zone of influence for a hypothetical project.

2.3 Data requirements and collection methods

Table 1 provides a list of the types of data you will need to obtain as part of your baseline characterisation. You may not need to collect all of the listed data; this will depend on what data are already available, the specifics of your project or activity (Section 2.1) and its zone of influence (Section 2.2). You will find it helpful to consider the types of questions you wish to answer in your assessment of impact (Section 3.1) when defining the types of data you need to obtain. **We strongly recommend you engage with NRW in the pre-application stage to agree on data requirements, survey plan and methodology, before you start your data collection.**

Table 1: Types of physical data required for baseline understanding of a project.

Theme	Parameter
Hydrodynamics	• Tidal regime (water level range, current speed and direction) • Wind wave and swell wave conditions (wave height, period and direction) • Residual water movement • Surge water levels and currents • Temperature, salinity and stratification
Sediments and Geology	• Characteristics of seabed sediments • Particle size and density • Lithology (origin, composition) • Thickness of sediment units (including consolidation and change over time) • Suspended sediment concentrations • Seabed mobility • Sediment transport pathways and rates
Topography/ morphology	• Bathymetry and its variability • Bedforms, other notable seabed features and their mobility • Coastal topography, configuration and notable features

Some data may be available from existing sources, for example wave data from Cefas WaveNet; a list of data sources and repositories are given in Section 5.2 of this guidance. **When making use of previously collected data, it is important that you can demonstrate that the data are reliable and still valid for the intended purpose (i.e. not out-of-date).** For example, in areas of mobile seabed, bathymetry can change rapidly and significantly with time meaning that data collected several years ago may be inaccurate today. This data set may still be useful for understanding how an area is changing and therefore contribute to conceptual understanding but would not be representative of baseline conditions.

Where existing data are not available or is not suitable, you will need to collect your own data. When doing this, it is important to follow these data collection principles:

- The data collection strategy must be specific to physical processes. While other assessments, e.g. benthic ecology, may require similar data, the sampling locations and methods are likely to be different,
- The data should provide appropriate temporal and spatial coverage and resolution, ensuring important processes (e.g. storms) are captured,
- The data should be collected and analysed in accordance with recognised standards (See Section 8 and Appendix B of Guidance of Best Practice for Marine and Coastal Physical Processes Baseline Survey and Monitoring Requirements to Inform EIA of Major Development Projects (PDF)),
- The type of data collected should be appropriate for EIA and for the objectives of data requirements set out in Section 6.2 of Guidance of Best Practice for Marine and

Coastal Physical Processes Baseline Survey and Monitoring Requirements to Inform EIA of Major Development Projects (PDF),

- The data should be accompanied by sufficient metadata (descriptions of the data source, location, date, time, time-step, instrument used, etc.) such that their context and limitations are understood. These requirements are set out in MEDIN (2019) Brief guidance notes for the production of discovery metadata for the Marine Environmental Data and Information Network (PDF),
- Quality Control procedures should be undertaken on any data used (an assessment of the data quality, checking whether the data conform to the expected ranges of values; non-conforming data are flagged or excluded) to reduce uncertainty,
- Data must also be of sufficiently high accuracy that potential inherent error in the field data is small in comparison to the absolute values (e.g. the tidal range) and the natural range of the parameter in question (e.g. spring-neap variability in tidal range),
- The distance between the location(s) of the measurement(s) and the location(s) of interest should be minimized: the greater the offset distance and the greater the spatial complexity, the less representative the data will be of the key site of interest.

Further details about suggested data collection methodology and strategy are given in Sections 6 and 8 of Guidance of Best Practice for Marine and Coastal Physical Processes Baseline Survey and Monitoring Requirements to Inform EIA of Major Development Projects (PDF). Note that, contrary to the report, NRW expect multibeam, rather than single beam, bathymetry for major projects.

2.4 Climate change allowances

Baseline conditions are not static: average conditions can be expected to change over the course of many projects due to climate change. Therefore, it is important you include climate change allowances both in your description of the baseline conditions and in your impact assessment (Section 3 of this guidance).

At the time of writing, the most up to date Welsh Government guidance for wave height allowances (Adapting to Climate Change: Guidance for Flood and Coastal Erosion Risk Management Authorities in Wales (gov.wales)) suggests using a 5% increase in extreme wave height until 2055 and a 10% increase beyond that. Consideration to sea level rise is also given in the Adapting to Climate Change: Guidance for Flood and Coastal Erosion Risk Management Authorities in Wales (gov.wales) guidance document and the approach described there should be followed. These recommendations are given without prejudice and we expect that the guidance will be updated periodically; therefore you should use the most up-to-date guidance at the time of your assessment.

3. Assessment of change and likely impacts

Assessment of change to the physical environment for major projects often focusses on numerical modelling (Section 3.2 of this guidance) and this is expected for most large projects, but should not necessarily be viewed as an essential requirement, nor should numerical modelling without reference to your conceptual understanding be deemed sufficient. A decision tree to help you choose the most appropriate assessment strategy for your project is given in Figure 3. The decision tree may not fit all projects, and the encapsulated advice does not prejudice NRW advice on assessment strategies for future projects. However, the underlying concept is true for all projects: the appropriate method of assessment depends on the data available, environmental characteristics in your zone of influence (e.g. whether 3D processes such as stratification are important), the complexity of the project, the capability of models to simulate it, and taking a proportionate approach based on the scale and environmental risk of the project. **Even a small and simple project might need detailed modelling if its zone of influence overlaps with a sensitive habitat or species.**

3.1 Definition of potential impacts to be assessed

Using your project description and your conceptual understanding of the physical processes within your project's zone of influence, you can define the questions about impact to physical processes that your assessment methodology will need to consider. Potential changes to the physical marine environment can be seen as falling into three main categories:

- 'Sediment disturbance' related change: mobilisation of sediment and changes to suspended sediment concentrations (creation of sediment plumes), which may lead to changes in bed level and habitat type elsewhere when sediment settles,
- 'Blockage' related changes: changes to wave, current/flow and sediment transport regimes caused by the presence of your project; this includes changes to turbulence and scour development.
- 'Bed level' related changes: changes caused by the direct modification of the seabed level affecting the propagation of waves, currents and sediment transport.

Section 5 of Guidance of Best Practice for Marine and Coastal Physical Processes Baseline Survey and Monitoring Requirements to Inform EIA of Major Development Projects (PDF) gives examples of sector specific questions for each of the major project types in Section 1 of this document. A generalised list of questions that can be used for projects or activities outside of that list are given in Appendix A of this guidance document.

We recommend that you provide description of the potential impacts on the environment caused by your project following the source – pathway – receptor model.

Note that consideration must also be given to other nearby developments and potential cumulative impacts (see Section 5 of this guidance).

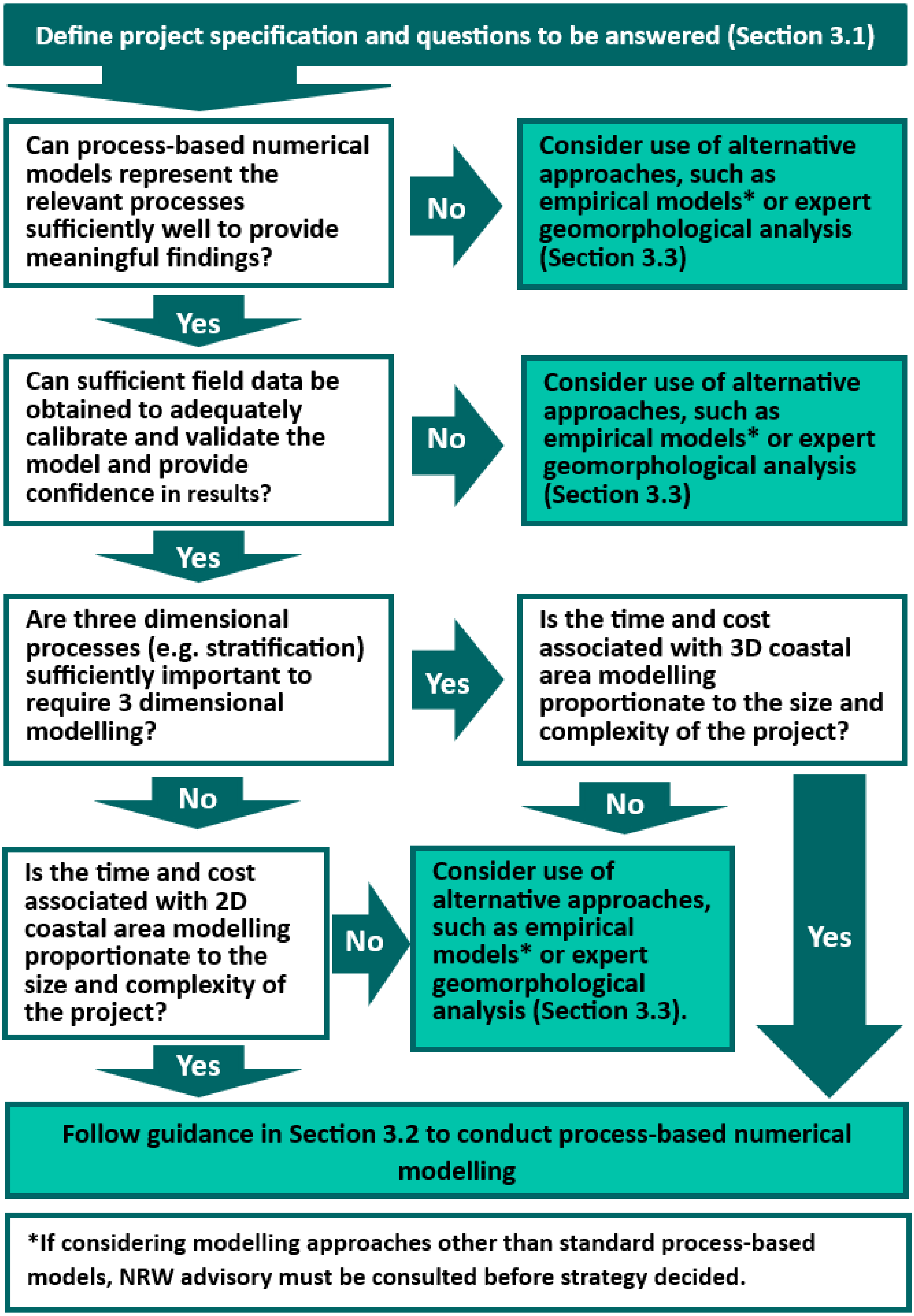

Figure 3: A decision tree to help you decide which approach to modelling to use in your impact assessment.

3.2 Numerical modelling

'Process based' numerical models are normally used for EIA; these solve equations that represent a range of physical processes over a spatial grid. For more details, see Section 3 of Advice to Inform Development of Guidance on Marine, Coastal and Estuarine Physical Processes Numerical Modelling Assessments (PDF).

While other modelling approaches are available, validation and interpretation is often difficult; therefore any use of other model types must be discussed with NRW at the pre-application stage. This section only considers process based models. Before the use of any models it is important to justify their use and understand their limitations.

A suggested staged approach for successful numerical modelling is given below:

1. Start a model journal to encapsulate process and findings,
2. Define project and questions (Sections 2.1, 2.2, 3.1 of this guidance),
3. Collect supporting data (Section 3.2.1 of this guidance),
4. Complete model set-up (Section 3.2.2 of this guidance),
5. Conduct calibration, validation and uncertainty analysis (Section 3.2.3 of this guidance),
6. Use the model to conduct simulations, (Section 3.2.4 of this guidance),
7. Interpret and present results, report findings (Section 3.2.5 of this guidance).
8. Reference and archive simulations.

More detail on suggested process is given in Advice to Inform Development of Guidance on Marine, Coastal and Estuarine Physical Processes Numerical Modelling Assessments (PDF), and some key recommendations on what NRW consider best practice is given in the following sub sections.

3.2.1 Modelling-specific supporting data considerations

The collation of supporting data can be achieved by following the guidance on baseline characterisation in Section 2 of this document. However, there are a number of points that apply specifically to data collection for modelling purposes:

1. **Boundary Conditions:** It is important to consider the planned positions and types of forcing at your model boundaries and ensure that suitable data are available to force these boundaries. For projects with sizable model domains (area covered by the model), it is likely that boundary conditions will come from larger models (e.g. a global tide or wave model). For smaller projects, with smaller domains, measured data might be more appropriate; this is particularly the case for boundaries in shallow water where global models may be inaccurate. For estuarine projects, it is important not to neglect the fluvial input to the model.

2. **Bathymetry:** You should ensure that the resolution of your bathymetry is of a similar or finer resolution to your model grid resolution. There is little merit in a fine model grid (and associated computational expense) if the measured bathymetry is coarse and so gridded depths are based on sparse interpolation.

3. **Calibration and validation data:** You should ensure that you have sufficient measurement points, durations and data types to allow for a comprehensive calibration and validation of your model. Further consideration is given in Section 3.2.3.

3.2.2 Important considerations when setting up your model

The models, or modules in a modelling suite, that you use will depend on the project environment and the questions that need answering. The expectation is that physical process studies for most large projects would couple a wave model, hydrodynamic (tide) model and sediment transport / morphology model. If you plan on leaving out an important process, for example not simulating waves for an offshore project, this must be properly justified, with evidence, and should be discussed with NRW advisory at the pre-application stage.

When setting up your model domain and model grid there are three main considerations:

1. Ensure that your model domain is large enough that neither boundary effects (inconsistencies that often occur close to the boundary due to imperfect model forcing) propagate into the model as far as the zone of influence of your project, nor impacts of your project spread close to the boundary (where the presence of the boundary may cause error in the modelled impacts).

2. Select a fine enough grid such that important morphological and hydrodynamical features can be resolved.

3. Conduct sensitivity testing of your chosen mesh to ensure that choice of mesh resolution and layout (in the case of nested or unstructured meshes) is not affecting your results. At the same time, you should inspect the mesh for instabilities.

3.2.3 Model calibration and validation

Model calibration takes place while setting up your model (Section 3.2.2), but due to the similarity with validation is included here.

Calibration involves varying a range of 'tuneable' parameters to make model results match observed data. You should test and report on a range of input values to assess the sensitivity of the model to changes in parameters.

Validation is the process of testing your calibrated model to ensure the calibration was successful; if validation shows that the initial calibration was not suitable, you must re-do the calibration process.

Validity of your model should not be decided on the basis of a single test but on the findings of the overall assessment. You should discuss your validation results in the context of your model, the characteristics of the physical environment and the receptors present in your zone of influence. When presenting your validation, NRW expect to see:

- Time series plots comparing measured and modelled parameters. For clarity, you should present each parameter in separate plot.
- Quantitative metric-based measurement of model performance. You must provide error statistics (e.g. root mean square error) and presentation of bias and correlation or model skill is also recommended. You can find discussion of suitable metrics in Section 4.8 of Advice to Inform Development of Guidance on Marine, Coastal and Estuarine Physical Processes Numerical Modelling Assessments (PDF).
- Like with like comparison: for example, if you are using a depth averaged current model, you should validate against measured currents averaged over depth; if a 3D model is being used, then validation of current variation through the water column should be provided.

The time periods, data frequencies and parameters that you need calibrate and validate against vary depending on the processes simulated:

- At least one spring-neap cycle should be tested for tidal models, data intervals should properly represent the tidal curve: 15 minutes is recommended. Tidal heights, current speed and direction must be tested. If stratification is important, results will need to be compared against temperature and salinity to demonstrate the model captures this.
- Wave models should be calibrated and validated against time periods where both calm and storm conditions are present. When wave models are coupled with tidal models, you should include both spring and neap tide periods to ensure wave-current interaction is adequately represented. We recommend data intervals of 1 hour or less to adequately capture storm peaks. Wave height, period and direction must be tested.
- It is challenging to calibrate and validate sediment transport models. It is easier to calibrate and validate against morphological change, especially for coastal projects where intertidal profiles are commonly available and easy to collect. Validation may still be required for projects in sensitive and morphodynamically active areas and should be discussed in the pre-application stage.

You must use different time periods for calibration and validation; ideally, different locations should be used to increase confidence in model performance. The number of data locations required depends on the size and complexity of your domain, but should cover key areas of interest. The key areas may not be your project location but the location of expected environmental impact.

3.2.4 Using your model

You should model a sufficient number of scenarios to properly represent the range of wave and tidal conditions likely to occur at the site of your project or activity; for example simulations of both extreme storms and low wave conditions. In some cases simulation for construction, operation and decommissioning (see Section 6) may be required, such as when large amounts of sediment may be suspended during construction. Simulations including sea level rise should also be undertaken for long duration projects, particularly those at the coast.

Process based models are largely restricted to short-term simulations and so you should consider the approach you are going to take to extrapolate from a short-term simulation to the likely effects over your project duration. Morphological acceleration factors (MORFACs) are sometimes used (See section 4.9 of [Advice to Inform Development of Guidance on Marine, Coastal and Estuarine Physical Processes Numerical Modelling Assessments (PDF)](#)); these multiply morphological change by a factor every timestep to make each timestep present a longer time period. However, caution should be used when applying this approach because it can introduce instabilities into the model and changes may not represent reality. If you choose to use the MORFAC approach, you must test the sensitivity of your results to different factors and present the results to evidence your choice of factor.

3.2.5 Items to include in the modelling report

When reporting on your modelling activities, you should include:

- Justification for the choice of any model used (ID, 2D, 3D etc.),
- Technical description of the model(s) and examples of similar previous applications.
- The basis for the definition of the model domain,
- The basis for the type of mesh and resolution chosen,
- The basis for selection of model boundary conditions,
- The nature of any sensitivity tests undertaken,
- The basis for selection of critical model parameter values (e.g. bed roughness, bed sediment size), and method of representation in the model,
- The methods used for model calibration and validation
- The magnitude of errors / bias in the modelling results using standard metrics (Section 3.2.3 of this guidance note) and the potential implications for the conclusions reached,
- When visualising validation and results, you must ensure that graphs are clearly readable and at a suitable scale to allow assessment of your findings.

3.3 Other assessment approaches

NRW expect assessment via numerical modelling for most large projects: where numerical modelling is seen as either unfeasible or disproportionate, you must demonstrate why this is the case. In such cases, you will need to rely on other methods to assess the impact of your project. These could include:

- Historical trend analysis
- Empirical models
- Qualitative evidence, such as consideration of analogous projects
- Physical models

Expert geomorphological assessment (EGA) is often used to bring together a range of assessment techniques that have been applied to a project and can be a robust means of drawing conclusions from the available evidence.

EGA must be evidence-based, NRW will not accept findings that rely only on a statement about the experience of the expert conducting the assessment.

If you use empirical models, the equations used, their source, the inputs and any assumptions made must be clearly described and justified. A useful summary of different analysis approaches can be found at Analysis and modelling (estuary-guide.net).

Understanding of impact developed in analogous projects is often used to inform project impacts. NRW will only accept findings based on this if the projects used as analogies are of similar scale and in similar environments (sediment type and availability, water depth, wave and tidal forcing), or, for cases where there are no relevant projects in similar environments, where evidence-based consideration is given to the likely effect of the different setting on the project impact. Predictions of impact based on findings from projects in different environmental settings will be given less weight in the assessment of your project.

4. Monitoring

Many large projects will require the developer to conduct ongoing monitoring, especially where there are uncertainties over impact and adaptive management may be required (see our website Using adaptive management for marine developments). Any monitoring should follow the data collection processes described in Section 2 of this guidance, further monitoring specific information is given in Section 7 of Guidance of Best Practice for Marine and Coastal Physical Processes Baseline Survey and Monitoring Requirements to Inform EIA of Major Development Projects (PDF, 1.9MB).

You should follow these monitoring design principles:

- Ensure data can fulfil the monitoring objectives/ hypotheses,
- Consider the likely trend of change of a pathway or receptor, and how is that likely to change both naturally and anthropogenically in the future,
- What is the likely future impact of different management interventions on the site and adjacent features?
- What is the likely impact of climate- related changes on the site in the future?

- What are the likely future short-term impacts on the site due to short-term events i.e. storms?
- What is the site’s current condition and ability to recover/ site resilience?
- Which parameters should be investigated?
- How should the parameters of interest be measured?
- The time of year/ frequency with which the parameter will be measured,
- The establishment of review periods providing the ability to stop or modify the monitoring exercise if the measurements suggest no change,
- The identification of appropriate thresholds of change,
- Identification of remedial action.

5. Cumulative and in-combination effects

It is important to consider how potential changes to physical processes arising from your project may interact and combine with impacts from other projects and activities (including those that are not built but that have permissions in place), and whether there is potential for a cumulative or in combination effect on a sensitive receptor. This is a requirement under policy Gov_01 of the Welsh National Marine Plan (gov.wales). You should be aware that ecological receptors may be already subject to background pressure such that any additional pressure may exceed a critical threshold.

Your cumulative/in combination assessment should include consideration of changes to hydrodynamics, geology, sediments and sediment transport, morphology and morphodynamics from your project and potential changes arising from any other relevant projects or activities (see section 1.1 of this guidance). You need to consider that while some cumulative or in-combination effects are additive, other effects may be non-linear (i.e., the combined effect is greater than the sum of the two individual project impacts). You should be aware that even if the potential change to the environment caused by your project is negligible, you will still need to assess cumulative and in-combination effects because they could prove significant if there is interaction between two or more pressures, activities or developments.

To identify which projects may interact with yours, you should consider whether the physical zones of influence could overlap. For example:

- could a sediment plume caused by your project interact with sediment plumes associated with another project or activity?
- could the addition of cable protection in the nearshore environment interact with coastal defence structures to alter hydrodynamics and sediment transport?

Further information on cumulative effects assessment can be found on the gov.uk website: Nationally significant infrastructure projects: advice on cumulative effects assessment.

6. Decommissioning

You may need to consider decommissioning as part of the relevant consenting process for your project, and it may need to be included within the scope of your EIA. We will advise on decommissioning proposals on a case-by-case basis whilst having regard to any national and international obligations, legislation and guidance, and making use of the best available evidence. You should bear in mind that, for longer term projects, the legislative requirements may change during the course of your project.

Where a decommissioning plan is required for your project, we recommend that it should include the full range of decommissioning options from maintain, through to partial removal and full removal.

Impacts on physical processes arising from decommissioning activities can be similar to those that need to be considered for construction and operational stages of a project. The advice provided in sections 2 and 3 of this guidance is therefore also applicable to assessing the decommissioning stage of your project.

Information used to support assessments of the construction and operational stages of your project can also inform your decommissioning plan. This can include baseline characterisation, modelling, anticipated effects, monitoring, and any adaptive management measures required during operation.

You can find further information on decommissioning at:

- Decommissioning of offshore renewable energy installations under the Energy Act 2004: guidance notes for industry (publishing.service.gov.uk)
- Addendum to decommissioning of offshore renewable energy installations under the Energy Act 2004: guidance notes for industry - Tidal lagoons (publishing.service.gov.uk)

7. Additional guidance and data sources

7.1 Additional NRW guidance

As well as the guidance mentioned previously in this document, there is a wide range of NRW guidance and position statements that may be helpful to you in completing your physical processes assessment:

- For projects involving subsea cabling, guidance on cabling sensitivities is currently being developed and may be available at the time of your project. You should check the NRW website for this.
- It may also be useful to consider the guidance on benthic marine habitat surveys available on our website: Benthic habitat assessments for marine developments. This guidance contains an over-arching guidance note, an introduction and then a series of chapters relating to specific habitats.
- You can find information on marine ecology datasets on our website: Marine ecology datasets for marine developments. The section on benthic data is most likely to be useful for physical processes assessments.
- Projects involving the movement or removal of sediment should pay close attention to our position statement The Sustainable Management of Marine and Coastal Sediment. This provides information on the favoured approaches to sediment management.
- Projects where activities at the coast may lead to coastal squeeze of Special Protected Areas (SPAs) or Special Areas of Conservation (SACs) will need to assess coastal squeeze using the guidance GN062: Assessment of Coastal Squeeze (PDF, 800KB).

- Where coastal structures or assets are being installed or modified, ecological enhancement could be considered. Information about this, and other nature-based solutions can be found at Natural Resources Wales / Nature based solutions for coastal management.

7.2 External guidance

There is also a wide range of external guidance that may be useful, although note that listing here is not necessarily an NRW endorsement of content and at times NRW advice might be contrary to this external guidance:

- The Estuary Guide (website) aims to provide an overview of how to identify and predict geomorphological change within estuaries, as a basis for sound management. It supplements the report on numerical modelling provided here by including other techniques such as historical trends analysis and expert geomorphological assessment. NRW supports consideration of these conceptual techniques where appropriate. Note that The Estuary Guide is undergoing a review at the time of writing.
- The Sand Dune Managers Handbook can be downloaded from https://dynamicdunescapes.co.uk/, this handbook is focused on dune managers, but may be useful if your project is in a sand dune area.
- For cross-border projects, The Severn Estuary: A cross-border marine planning guide (PDF) may be useful.
- Natural England have a range of relevant documents, including a desk study on options for scour and cable protection decommissioning which can be found at Scour and Cable Protection Decommissioning Study - NECR403 (naturalengland.org.uk) and Natural England Offshore Wind Cabling: ten years experience and recommendations (PDF) which provides insight into the experience Natural England has gained in providing advice on the environmental impacts of offshore power cables.
- Natural England have developed offshore wind best practice advice and environmental best practice for subsea cables (jointly with JNCC). These documents are live and undergo regular review to ensure they refer to best available evidence. For access, email NEOffshoreWindStrategicSolutions@naturalengland.org.uk .

7.3 Sources of existing data

Appendix B of Advice on physical processes for small scale marine and coastal projects (PDF) provides a table of links to various data repositories.

Additionally:

- Bathymetric data can be obtained from the Admiralty Seabed Mapping Service website
- Topographic and bathymetric data can be obtained from the Wales Coastal Monitoring Centre
- A wide range of data, including LiDAR data can be searched on DataMapWales
- Topographic, bathymetric and oceanographic data (from English locations) can be accessed at the Coastal Monitoring website.
- Wave data from around the UK can be downloaded from Cefas WaveNet
- A range of data can be found in the Marine Data Exchange

- Information on Shoreline management plans can be found on Natural Resources Wales / Shoreline Management Plans
- Information on flood and coastal erosion risk around Wales can be found on Natural Resources Wales / Check your coastal erosion risk (National Coastal Erosion Risk Management map)

Appendix A: Generic questions on environmental impact

Using your project description and your conceptual understanding of the physical processes within your project's zone of influence, you can define the questions about impact to physical processes that your assessment methodology will need to consider (Section 3.1). This appendix contains generic questions. The questions are split into different types of change. We recommend that you also look at the sector specific questions in Section 5 of [Guidance of Best Practice for Marine and Coastal Physical Processes Baseline Survey and Monitoring Requirements to Inform EIA of Major Development Projects (PDF)]

Sediment disturbance

- Could construction related activities (e.g. foundation installation, bed preparation works, drilling, dredging or disposal) cause a significant increase in suspended sediment concentrations and associated changes in bed levels inside and outside of the project area?
- Could the construction, presence or removal of ancillary infrastructure present during construction (e.g. coffer dams, construction plant etc.) mobilise sediment causing a significant increase in suspended sediment concentrations?
- Will the presence of new infrastructure, or other aspects of your project or activity during operation, cause a significant increase in suspended sediment concentrations and associated changes in bed levels?
- Will sediment disturbed by the construction or operation of your project or activity disperse and how far will it travel? Will it affect sediment transport and what will be the effects on the wider area?
- Will sediment that settles out of the water column alter the sedimentary character of the sea bed (sediment size distributions and morphology) at your project site or around your zone of influence?

Blockage: tidal related impacts

- Will there be changes to water levels inside and outside of your project or activity area caused by your project or activity?
- Will your project or activity cause the magnitude and pattern of current speeds and directions to change (including residual currents) and if so by how much?
- Will the phasing and timing of the tidal cycle (both water levels and currents) be affected within your project or activity area, for example, inside a tidal energy lagoon.
- Will the phasing and timing of the tidal cycle (both water levels and currents) be affected in the near- or far- field environment?
- Will any changes to tidal current speeds result in significant changes in bed shear stresses and changed patterns of intertidal and subtidal erosion and accretion?
- Could any changes to bed shear stress lead to a change in sediment type (grain size) on the sea bed?
- Could there be a change in the effects of wave-current interaction which could change the energy distribution at the bed and/or at the coastline?

- Are there water column features such as tidal mixing fronts within the zone of influence of your project or activity and could these be impacted via a change to hydrodynamic conditions?
- If your project or activity is situated within an estuary, will the normal tidal limit be altered, altering the saline influence and flood risk within the estuary and adjacent rivers?

Blockage: wave-related impacts

- What will be the spatial extent and magnitude of change to wave characteristics as result of any installed offshore infrastructure?
- Could changes to the wave regime extend to the coast and could they influence coastal morphology through modifying rates of erosion, sediment transport (on and offshore) and accretion?
- Could any changes to the wave regime at the coast alter the amount of salt spray to coastal habitats, particularly cliffs and other rocky shores?
- Could seabed morphology and features (especially sandbanks) be altered as a result of changes to wave induced bed shear stress
- If changes to wave climate are anticipated, could the seabed sediment characteristics (grain size distribution and micro-topography, e.g. ripples) in the affected area alter in response to changes to wave regime?
- Could there be a change in the effects of wave-current interaction which could change the energy distribution at the bed and/or at the coastline

Blockage: sediment and morphology related impacts

- How will sediment supply to nearby receptors (including the coast and any nearshore banks) as well as the overall sediment budget be altered?
- Will any completed structures encourage medium to long-term scour of the adjacent sea bed, and/ or interfere with the transport of sediment, alongshore, on/offshore at the bed and/or suspended in the water column?
- Could the construction, presence or removal of principal and/or ancillary infrastructure present during construction (e.g. coffer dams, construction plant etc.) give rise to morphological change (either directly such as through plant transport routes or indirectly, through modification of the wave regime)?
- Will associated infrastructure such as anchor blocks or any seabed penetrating foundations impact the morphology and features of the seabed?
- Will any scour protection be required for any structures associated with your project?
- Will any coastal infrastructure affect wind-blown sand transport?
- What rate of sedimentation can be expected within any impounded areas, and what will the maintenance dredging and disposal requirements be?

Bed level

- How will the wave climate be affected by changes in bathymetry and what will the effect be on adjacent inter-tidal areas and shorelines?
- What are the implications for local water circulation resulting from the removal or creation of topographical features on the seabed?

- How will flood and ebb tidal current speeds and directions be affected in response to dredging, disposal, or other bed level modifications, particularly with respect to changing sediment transport pathways?
- Could modification/ removal of sand waves adversely impact adjacent sand bank systems or other sedimentary environments?

Other questions

- What is the source and storage plan of construction materials and will their extraction/supply or storage affect any physical processes?
- If you are using aggregates, are there sufficient reserves in nearby land or marine sources? If not will additional aggregate extraction be required?
- Are there any designated habitats or important seabed features (e.g. sandbanks) located sufficiently close to your project as to be impacted by changes to waves, hydrodynamics and sediment transport? (Relevant to operation phase);
- Will any operational discharges from your project (e.g. warm cooling water an operational power station) have a significant impact on local hydrodynamics and sediment properties of the water column that could affect sediment transport processes?
- What are the implications of a permanent loss of sediment caused by your project (e.g. aggregate extraction) from the wider sedimentary system (sediment cell or sub-cell)?
- How will the combination of the above changes affect the morphology of the system (including any offshore banks), either in the short or long term?
- How will the natural ongoing morphological evolution of the area around your project be altered by the changes identified above? (This is likely to be a potentially greater effect for an estuarine project)