Stressor-specific Guidance Document: Habitat Change

The guidance documents are intended to be available for regulators and advisors as they carry out their decision-making and for developers and their consultants as they prepare consenting and licensing applications. This stressor-specific document presents an overview of the scientific information that is known for habitat change.[1] *It is not intended to replace any regulatory requirements or prescribe action for a particular risk.*

Introduction to Stressor

Habitats are the natural environments of an organism, comprising the array of physical and biological resources necessary for survival and reproduction, and are the foundation for organisms in the marine environment providing protection, preys to feed on, etc. Structures placed in the marine environment have the potential to alter habitats or impact marine organisms. Habitat alteration, loss, or creation may occur throughout the marine environment, including in benthic (seafloor) or pelagic (water column) environments. Figure 1 shows an abbreviated version of where this stressor fits within the guidance document framework.

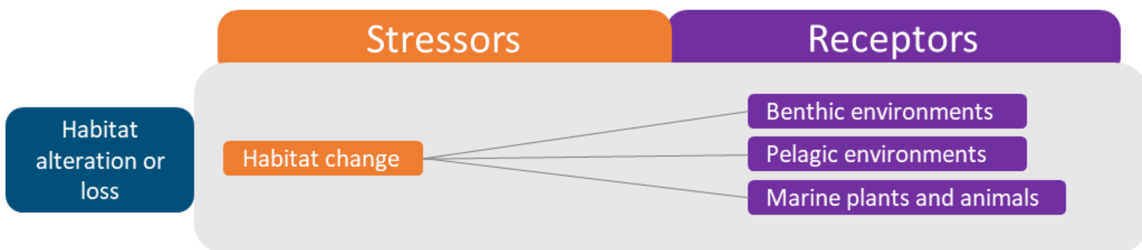

Figure 1. Portion of the guidance document framework depicting habitat change and key receptors, which are relevant under the regulatory category of habitat alterations. The full framework can be found in the background guidance document.[1]

As marine renewable energy (MRE) devices and associated infrastructure are deployed, features of the devices and their associated components may impact marine habitats (Figure 2). MRE devices attached to the seafloor by gravity foundations, pin piles, or anchors, as well as cables and other equipment or infrastructure on the seabed, may alter the benthic habitat; while mooring lines, cables, and the devices themselves placed in the water column may alter the pelagic habitat. Impacts to marine organisms and environments may include negative effects (e.g., loss of habitats), changes that cannot be detected relative to natural variation (e.g., changes in sediment around anchors), or potentially beneficial (e.g., new sources of habitat) or neutral changes, and will depend on a variety of factors. Changes in habitats may occur due to:

- Sediment trenching and digging for cable installation that contributes to localized disturbance; this is limited to a narrow path along cable routes though the site may take months to years to recover depending on the habitat type(s) present (Taormina et al. 2018).
- The hydrodynamic alteration of fast-flowing water and localized turbulence causing sediment removal (i.e., scouring) around artificial structures that contributes to localized disturbance; this may occur around MRE device foundations and anchors and is likely to only impact infauna in the immediate vicinity (Davis et al. 1982).

[1] This stressor-specific document should be read in conjunction with the background guidance document, which can be found on *Tethys*: https://tethys.pnnl.gov/guidance-documents.

- Loss of habitat immediately under foundations, anchors, and cables; proper siting will avoid the loss of critical habitats (Hemery 2020).
- Increased turbulence around the base of devices (i.e., the footprint effect), which can affect epibenthic communities in the immediate vicinity (O'Carroll et al. 2017).
- New hard-substrate habitat that is created by the presence of MRE devices and associated structures; these are likely to be colonized by a diversity of organisms, which is influenced by natural variability and existing nearby biofouling communities (Macleod et al. 2016). Non-native invasive species may use MRE devices and other artificial structures as stepping stones (Adams et al. 2014).
- MRE devices and associated structures that may attract mobile organisms such as crabs and fish and create artificial reef and fish aggregating effects (Kramer et al. 2015; Langhamer 2012).
- Biofouling and artificial reef effects that may cause local biomass to increase; this can lead to seafloor enrichment in the immediate vicinity due to the accumulation of organic matter from litter falls, with potential impacts to local food webs (Raoux et al. 2017; Wilding 2014).
- Areas surrounding MRE devices that may be closed to fishing and other human activities that can lead to marine reserve effect; this has the potential to benefit the entire food web and nearby areas, as well as increase organism biomass both within the area and outside (i.e., spillover) (Alexander et al. 2016).

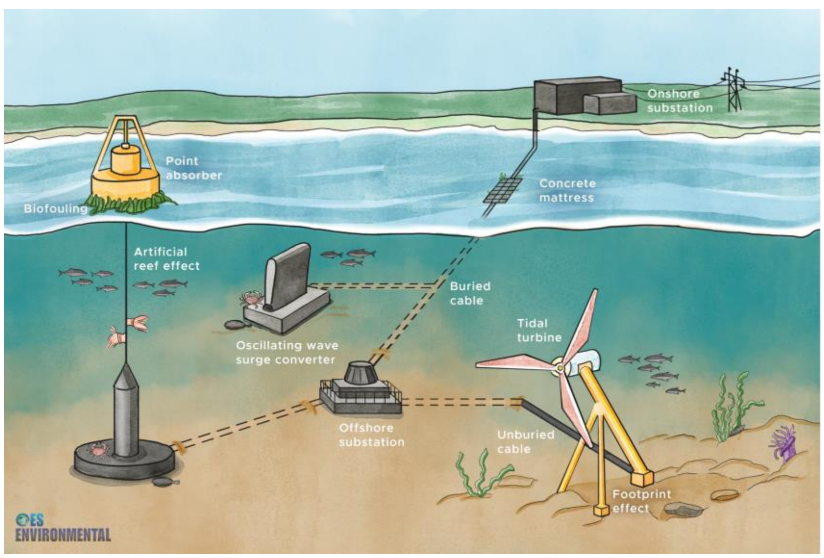

Figure 2. Schematic of various wave and tidal energy devices, and associated infrastructure, and their potential effects on the benthic and pelagic habitats. (Illustration by Rose Perry)

Existing Data and Information

2020 State of the Science

Chapter 6 of the 2020 State of the Science Report (Hemery 2020) covers habitat change in detail. It synthesizes research and findings from current MRE projects to provide a comprehensive look at the status of knowledge for changes in habitats.

Evidence Base

OES-Environmental has developed an evidence base of key research papers and monitoring reports for habitat change that supports the understanding and risk retirement for small numbers of MRE devices[2]. The evidence base has been reviewed by international subject matter experts in workshop settings and can be accessed on *Tethys*[3]: Habitat Change Evidence Base. A limited number of the studies included in the habitat change evidence base are shown at the end of this document in the Additional Information section (Table 1).

Monitoring Datasets Discoverability Matrix

OES-Environmental has also developed the Monitoring Datasets Discoverability Matrix, an interactive tool that allows the user to locate datasets by stressor, receptor, and other specifications for habitat change, as shown in Figure 3. In addition to the research studies and key documents included in the evidence base, from both MRE and analogous industries, the matrix includes baseline and post-installation monitoring reports. These are compiled from OES-Environmental Metadata, which provides links and contacts to existing datasets from MRE projects and research studies. The metadata includes information solicited from developers and researchers on environmental monitoring for MRE, which is updated annually.

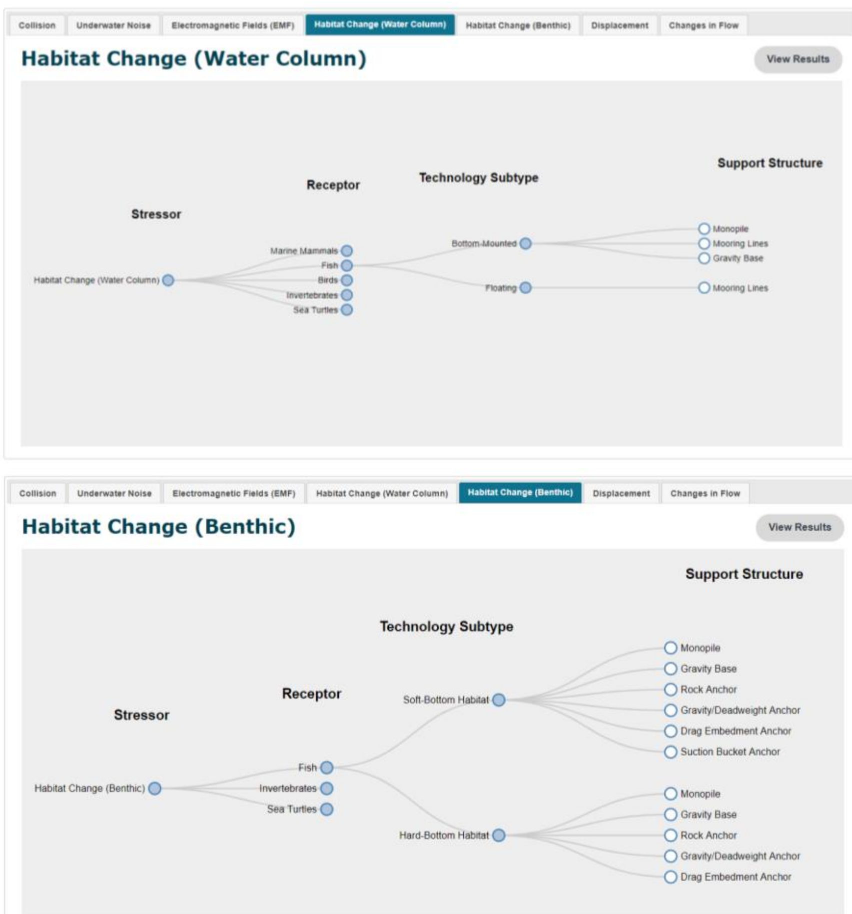

Figure 3. Screenshots of the Monitoring Datasets Discoverability Matrix selections for habitat change on *Tethys*. Water column habitat change is shown in the top picture and benthic habitat change is shown in the bottom picture. Selections under the other receptors are similar to those shown for fish.

[2] For the purposes of risk retirement, small developments have been defined as one to four devices.
[3] *Tethys* is the U.S. Department of Energy's online platform that aims to facilitate the exchange of data and information on the environmental effects of wind and MRE, and serves as a commons for the OES-Environmental initiative. *Tethys* is developed and maintained by the Pacific Northwest National Laboratory.

Management Measures Tool

The Management Measures Tool has been developed by OES-Environmental to show management (or mitigation) measures from past or current MRE projects as a reference to help manage potential risks from future projects. The tool can be filtered by technology (tidal or wave), management measures, project phase, stressor, and/or receptor. An example of management measures returned for habitat change is shown in Figure 4 below.

Filter by Technology: - Any - | Management Measure: - Any - | Project Phase: - Any - | Stressor: Habitat Loss | Receptor: - Any -

Search: | Apply | Reset

Technology	Project Phase	Stressor	Receptor	Management Measure	Implications of Measure	Advantages	Challenges	Project Documents
Wave, Tidal	Installation, Decommissioning	**Habitat Loss** Direct loss of protected or sensitive sub-littoral seabed communities due to the presence of devices and associated moorings or support structures on the seabed.	**Fish** Demersal fish	**Design feature** Site selection to avoid sensitive or protected sub-littoral seabed communities.		This could reduce/remove effects on sensitive habitats.	N/A	**ScottishPower Renewables 2012**
Wave, Tidal	Installation, Decommissioning	**Habitat Loss** Direct loss of protected or sensitive sub-littoral seabed communities due to the presence of devices and associated moorings or support structures on the seabed.	**Fish** Demersal fish	**Design feature** Minimise footprint of anchors / foundations.	This could reduce effects on sensitive habitats, however may impact technical considerations.	This could reduce effects on sensitive habitats	May impact technical considerations.	**Aquatera Ltd 2011, Xodus Group 2019, Federal Energy Regulatory Commission (FERC) 2020**

Figure 4. Screenshot of the Management Measures Tool selections for habitat change, specifically habitat loss.

***Tethys* Knowledge Base**

The *Tethys* Knowledge Base hosts thousands of documents about the environmental effects of MRE. All documents associated with habitat change can be found here.

Pathway to Risk Retirement

The evidence to date suggests that the impacts from habitat change from small-scale MRE developments are limited (Hemery 2020 and references therein). Severe habitat change can be avoided or mitigated through identification and avoidance of fragile, unique, or important habitats during site selection. In addition, impacts would only affect a limited area around the footprint of a device/associated infrastructure, or would dissipate quickly (e.g., sediment scouring) or recover quickly from disturbances (e.g., cable laying). Alternatively, developments may provide new habitats for marine organisms (e.g., colonization of hard surfaces or use of as an artificial reef). Habitat change from operational MRE devices are not likely to cause injury or harm to marine organisms. Overall, there is general consensus that habitat change from small-scale MRE developments does not typically pose a significant risk to habitats and marine plants and organisms when sited properly to avoid critical habitats (Hemery et al. 2021).

Some uncertainties about the effects from habitat change remain, and more studies will be useful to increase understanding. A complete list of remaining uncertainties and research needs is available in Chapter 6 of the 2020 State of the Science Report (Hemery 2020) and in Hemery et al. (2021). Key examples include the need to:

- Define appropriate spatial and temporal scales for environmental assessments and monitoring.
- Continue to increase understanding of community changes over time, including through conducting long-term studies of ecological processes.
- Develop guidelines for the level of biodiversity, assemblages, and scales to be considered.
- Identify thresholds for habitat changes, including loss of habitat, as well as the level of colonization and aggregation.
- Characterize the diversity and ecological characteristics of biofouling and aggregating species.
- Understand the cumulative effects of MRE devices and other activities occurring in the same areas, particularly for artificial reef and aggregating effects, as well as reserve and stepping-stone effects.

Recommendations

Sharing data, information, and findings across the MRE industry and other marine industries will benefit the general understanding of habitat change, including cumulative effects. As the MRE industry progresses, it will be important to continue to consider local conditions, existing sources of habitat impacts, and important species that may be at risk from changes to the habitat, to understand and minimize the risks posed by habitat change. Risk from habitat change for small numbers of devices can be retired, and if an MRE project is sited to avoid important, vulnerable, or unique habitats, studies of habitat at each new proposed project site may not be needed (Hemery et al. 2021). However, any data collected around projects and other developments will continue to inform understanding of cumulative risks and increase the knowledge of spatial and temporal scales of habitat change.

Additional Information

The evidence base for habitat change can be found at: https://tethys.pnnl.gov/habitat-change-evidence-base

Table 1. A selection of studies from the evidence base for habitat change, in chronological order.

Project/Research Study	Location	Device Type	Habitat Change Type	Conclusion
In-Situ Ecological Interactions with a Deployed Tidal Energy Device; An Observational Pilot Study (Broadhurst et al. 2014)	Orkney, Scotland	Tidal	Fish aggregating effect	Fish (pollack) were observed aggregating in shoals temporarily around the device, with abundance significantly associated to the water velocity rate.
Assessment of Benthic Effects of Anchor Presence and Removal (Henkel 2016)	Oregon	Wave	Scour effect	No significant differences in sediment or macrofauna composition were observed between stations on the seabed around anchors and control sites, neither during operation nor after removal of the anchors.
Biofouling Community Composition across a Range of Environmental Conditions and Geographical Locations Suitable for Floating Marine Renewable Energy Generation (Macleod et al. 2016)	Scotland	Buoy	Biofouling	Despite the perceived importance of environmental and temporal factors, geographical location explained the greatest proportion of the observed variation in community composition.
Identifying Relevant Scales of Variability for Monitoring Epifaunal Reef Communities at a Tidal Energy Extraction Site (O'Carroll et al. 2017)	Northern Ireland	Tidal	Footprint effect	Seasonality, rather than the tidal turbine, significantly affected epifaunal community structure and bare rock distributions.
Colonisation of wave power foundations by mobile mega- and macrofauna – a 12-year study (Bender et al. 2020)	Sweden	Wave	Artificial reef effect	The results of this 12-year study show a distinct reef effect on the device foundations, with significant greater species richness and abundance than at control sites.

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