FLOATGEN

Environmental comparison of the design against traditional foundation types (Draft)

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Project full title: Demonstration of a floating wind turbine system for power generation in Mediterranean deep waters

SEVENTH FRAMEWORK PROGRAMME

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1. EXECUTIVE SUMMARY

The Executive Summary will be completed in the Final version of Deliverable D7.8, this draft of D7.8 contains few differences from D7.6.

2. ACRONYMS

dB	Decibel
dB re 1	Sound level in decibels at a distance of 1m from the source using a standard reference sound pressure of 1 microPascal (used in underwater acoustics)
EEDI	Energy Efficiency Design Index
MarLIN	Marine Life Information Network
MARPOL 73/78	International Convention for the Prevention of Pollution from Ships 1973, as modified by the Protocol of 1978
SEEMP	Ship Energy Efficiency Management Plan

3. INTRODUCTION

Deliverable D7.8 provides an update of the comparisons between the FloatGen wind turbine and other offshore wind turbines which utilise conventional foundations (and some other Floater devices). The updates reflect the revisions to the Questionnaires (see D7.7) based on the knowledge gained from the installation of the device and a short operational period. Updated Questionnaires have been completed for several conventional wind farms and some other floating projects and will be included as Appendices to the Final version of D7.8.

This deliverable is effectively an update of D7.6 which was issued before the installation of the Floater, hence in this draft of D7.8 (issued ahead of the reporting deadline for the FloatGen project, and ahead of installation) is very similar to the final version of D7.6.

The objective of the FloatGen project is to demonstrate the technical and economic viability of floating-wind turbines, in order to expand the development potential of offshore renewable energy into windier and deeper waters that are not currently considered commercially viable.

The purpose of this document is to collate and compare the differences in environmental impacts associated with fixed foundations and floating mooring systems for offshore wind turbines.

Section 4 provides an outline of the types of impact that can be caused by the installation and operation of offshore wind turbines and a summary of how these do and do not differ between fixed and floating wind turbines. Section 5 presents the questionnaire that was developed to enable some comparison of conventional fixed and floating wind turbine foundation systems. The extensive knowledge base of interactions between fixed wind turbines, wave and tidal technologies and marine environmental receptors has been used to identify the criteria selected and included in the Questionnaire. In turn issues relating to floating turbines are also now emerging and need to be addressed. Several industry wide workshops and initiatives are underway to ensure this happens in a timely manner as demonstration projects move towards commercialisation and associated impacts also scale up. As there have been such developments and activities in this sector since the FloatGen project commenced some reference has also been made to the environmental and consenting barriers to developing floating wind warms, including innovative solutions workshop outputs produced by Offshore Renewable Energy (ORE) Catapult in 2016[1]. It is intended to incorporate the outputs of the workshop 2018 to the final version of this report (D7.8).

It is assumed that the aerial parts of the turbines (including the tower above the water line, the nacelle and the turbine blades) would have the same impacts whether they are supported on fixed or floating foundations, hence information has not been included in this report for above-water elements.

[1] https://s3-eu-west-1.amazonaws.com/media.ore.catapult/wp-content/uploads/2017/03/17113725/Floating-Wind-Farms-Workshop-Dec-2016.pdf

4. ENVIRONMENTAL IMPACTS CONSIDERED

The environmental parameters considered within the criteria assessment and the questionnaire are:

- Physical environment
- Ecology
- Navigation
- Water quality
- Underwater noise and vibration
- Fishing
- Greenhouse gas emissions
- Waste
- Archaeology.

These parameters have been considered in terms of the construction, operation and decommissioning phases.

A baseline summary of the environmental features present at the SEM-REV test site is provided in deliverable D7.1.

4.1 PHYSICAL ENVIRONMENT

The physical environment includes bathymetry, shallow geology, seafloor sediments, and oceanography. Potential impacts of offshore wind farm installation include:

- disturbance and changes to seabed morphology from foundation installation, presence of rock placement/ mattressing around the foundations
- increase in suspended sediment levels and re-deposition from installation of turbine foundations, including seabed preparation if gravity based solutions selected
- change to the pattern of erosion, accretion and deposition around turbines from scour effects
- changes to the hydrodynamics (current/ tidal patterns) as a result of the installation and presence of turbine foundations.

The type of foundation or anchoring system used will determine the scale of the impacts both in terms of duration of installation works and spatial extent of foundations during operation.

Geophysical and geotechnical surveys were carried out by the project developer at all sites reviewed using the questionnaire, including SEM- REV for FloatGen to determine baseline conditions at the offshore array sites. Data is used to inform selection of the most appropriate foundation or anchor design and installation solution, as well as to identify any locations where scour protection may be required.

The installation of floating turbines is often associated with shallow seabed penetration depths for anchors, whereas traditional monopiles can penetrate the seabed to depths of >30m and are generally cut off below the sea bed and left *in situ* at decommissioning rather than removed. The six 15 tonnes drag-embedment anchors proposed at FloatGen will be removed at time of decommissioning.

It is not possible to compare the effects of an array of fixed turbines with a single floating foundation in relation to impacts on waves and currents. While the interaction between turbine foundation infrastructure and marine physical processes (sediment movement patterns, currents etc.) will vary due to the presence of anchored mooring systems rather than large, fixed foundations such variations will be location and project specific and require on-going monitoring and wider research efforts to assess.

The mandatory monitoring that will be undertaken for FloatGen under the SEM-REV Environmental Management Plan (EMP) includes: tracking in XYZ position (3D movements) of the electrical cable and its protective mattresses, and the complementary monitoring includes: hydro-sedimentary dynamics and sediment quality.

4.2 ECOLOGY

4.2.1 BENTHIC

Effects on benthic species and communities tend to arise from direct loss of seabed area (e.g. within direct footprint of foundations), physical displacement during the installation process and smothering due to re-deposition of suspended sediments as result of seabed works. When assessing the impact to benthic habitats and species, consideration has to be given to the following criteria:

- Magnitude: the spatial extent of an impact e.g. the area of the seabed directly or indirectly impacted, and the contextual significance of this extent for the receptors present.

- Duration: The duration of an impact may exceed the duration of the activity causing it for example a sensitive benthic community will take longer to recover to pre-construction baseline conditions than a benthic community in an area of high natural change and disturbance.
- Reversibility: to what extent an impact is irreversible (permanent) or reversible (temporary).
- Frequency: whether the impact is a one off, or is repeated.
- Timing: will it occur during seasonally sensitive periods for receptors present.

The sensitivity of different benthic habitats also has to be considered. Sensitivity is based on two aspects:

- The importance of the habitat in terms of its nature conservation value, i.e. whether it has a protected status.
- The expert assessment from the Marine Life Information Network (MarLIN, 2010) which classifies biotopes and habitats according to their tolerance to, and recoverability from, certain impacts e.g. smothering.

Impacts on benthic species and habitats occur with both fixed and floating wind turbines during both construction and operation. FloatGen will not require the presence of jack-up barges as there is no piling involved with the installation of the device, this means that the construction footprint will be smaller than for fixed turbines which reduces loss and disturbance to benthic habitats and species.

While the direct footprint of the anchoring system of FloatGen is smaller than that for fixed monopile foundations, reducing the operational footprint, there will still be direct benthic habitat loss. There is also still potential for scouring of seabed due to the movement of chains / catenary of anchor systems associated with floating turbines; however these impacts vary with different technologies deployed. While colonisation by encrusting species may still occur, varying with antifouling approaches and frequency of maintenance, colonisation potential and the artificial reef effect are both likely to be reduced on floating installations such as FloatGen than fixed foundations.

FloatGen also compares well against the environmental impacts associated with some other anchoring/mooring solutions for floating devices which require drilling (which also produces cuttings that require disposal) or piling, and there is no need to use grout.

The mandatory monitoring that will be undertaken for FloatGen under the SEM-REV EMP includes: benthic habitats and communities alongside the electrical cable and on the test site.

4.2.2 FISH AND SHELLFISH

When assessing the impact to fish and shellfish (such as impacts to habitat, or normal distribution and behaviour), consideration has to be given to the following criteria:

- Magnitude: the spatial extent of an impact – such as the area of sea impacted by subsea noise or change in area of seabed habitat available to shellfish.
- Duration: The duration of an impact may exceed the duration of the activity causing it for example the immediate avoidance reaction of certain fish in response to subsea noise, compared to the time taken to return to the area affected.
- Reversibility: to what extent an impact is irreversible (permanent) or reversible (temporary).
- Frequency: whether the impact is a one off, or is repeated.
- Timing: will it occur during seasonally sensitive periods for receptors present.

Loss of seabed habitat, discussed in detail under section 4.2.1, also impacts fish and shellfish. During construction underwater noise associated with installation works particularly pile driving of fixed foundations, vessels and plant can disturb, displace and potentially injury or kill fish species present. Sources of underwater noise and vibration are discussed further in relation to marine mammals in section 4.2.3.

In fixed wind turbines the inter-array and export cables are generally buried in the seabed, however the power cable is exposed to the water column below a floating device. The potential effects of electro-magnetic fields (EMF) on fish, especially elasmobranchs, requires further consideration and research. Both fixed and floating turbines have the potential to attract and aggregate fish, and in some cases may also create the artificial reef effect. In addition to which the potential exclusion of fisheries from within the immediate vicinity of turbines, or in some cases arrays, may also improve fish abundance in the proximity of both floating and fixed turbines.

The mandatory monitoring that will be undertaken for FloatGen under the SEM-REV EMP includes: EMF, and the complementary monitoring includes: fish and pelagic invertebrates and biofouling.

4.2.3 MARINE MAMMALS

Underwater noise and vibration during installation has the potential to impact on marine fauna including seals, cetaceans, pinnipeds, fish and basking sharks. There is also the potential for cumulative impacts from multiple noise sources audible to marine mammals and fish during installation and increased vessel disturbance.

Detailed modelling is required to predict the impact of underwater noise on fish and marine mammals. There are different types of model available, with the emphasis being on the frequency range within which the species hears, and the typical noise threshold level at which the species hears sound at any of the frequencies (decibel hearing threshold). Based on measured and anticipated noise levels from the likely source (for instance percussion piling) assumptions can be made about the noise levels above the threshold at which disturbance, physical injury and lethality could ensue.

It is generally understood that lethal effects may occur where peak to peak noise levels exceed 240dB re 1µPa. In addition, physical injury (e.g. rupturing of swim bladders) may occur where peak-to-peak noise levels exceed 220dB re 1µPa. Such physical injury may indirectly lead to death, for example through reduced ability to swim or control buoyancy.

Piled foundations are a significant source of underwater noise and vibration associated with offshore wind farm construction. This impact can occur over several years on larger projects and there is also high potential for cumulative underwater noise impacts both within and between other offshore wind farm projects, particularly in areas such as the North Sea with high densities of large offshore wind farms. A major advantage of many floating turbine technologies, such as FloatGen, is that piling is not required which significantly reduces potential impacts on marine mammals. However some floating technologies do require pin piling / helical technologies, while the underwater noise associated with their installation is not comparable to piling monopiles or jackets it is something that should be considered further at test sites containing floating demonstrators. Operational noise for both fixed and floating wind turbine remains largely unknown, for the former this was studied for some of the Round 1 UK projects but data is not widely available especially for more recent deployments. Vibration, twisting and snapping noises associated with mooring lines from floating devices may be an issue for some species depending on hearing sensitivities of the species present[1].

Marine mammals are also at risk of entanglement with mooring ropes, lines and cables associated with floating turbines, particularly if there is fishing gear also entangled, this may result in injury or even death.

The mandatory monitoring that will be undertaken for FloatGen under the SEM-REV EMP includes: the generation of noise, and the complementary monitoring includes: marine megafauna.

4.3 NAVIGATION

The assessment of effects on navigation needs to consider the impact on other maritime vessels in the vicinity of the wind farm development. This includes search and rescue vessels including coastguards and lifeboats, and recreational users. The impact could also lead to a reduction in the safety of navigation and an increase in the risk of collision by other marine users with turbine structures and installation/ maintenance vehicles. The magnitude of the impact is dependent upon how busy the area is for shipping.

The effects upon navigation within the area are reversible upon decommissioning.

Both fixed and floating turbines require clearly defined navigational markers, search and rescue access routes to be clearly delineated and for spacing and layout to accommodate routine and emergency marine traffic movements. However there may be a need to consider what may happen should an anchoring mechanism fail resulting in the unplanned movement of a floating device[1].

The complementary monitoring that will be undertaken for FloatGen under the SEM-REV EMP includes: sea usage and safety / security and marine traffic.

4.4 WATER QUALITY

The water quality of the local environment may be impacted, dependent on the methods / materials used during the construction process. Materials required during the operation and decommissioning phases will also need to be taken into account. This may be in the form of:

- Drilling muds
- Sediment disruption
- Chemicals and oils e.g. grouting and maintenance
- Ballast water.

During the construction process disturbance to contaminated sediments could also affect the water quality e.g. if the foundations were constructed in an area which had previously been used as a disposal site (dredge spoil or munitions dump). Some foundation types can also create high levels of suspended sediment during installation, which also affects water quality.

Vessels involved in the construction, maintenance and decommissioning phases will be required to treat discharges in accordance with MARPOL 73/78 ('black water' (i.e. sewage from toilets and urinals) will be treated by a sewage treatment unit and food waste will be ground in a macerator prior to discharge to sea).

As discussed under section 4.1 the installation of floating turbines, such as FloatGen, is often associated with very shallow seabed penetration depths for anchors, compared with traditional monopiles. This can reduce the seabed preparation requirements and in turn the volumes of suspended sediments generated during construction activities. There is scope for water quality impacts to comparatively reduce as result of smaller volumes of suspended sediment concentrations (SCC) being released, which in turn can reduce risk of resuspension of contaminants that may be present in sediments.

The onshore prefabrication of devices like FloatGen can simplify and speed up the offshore construction period, meaning fewer vessels may need to be present in the construction areas for less time. This in turn may reduce vessel emissions and potential for spills and unplanned releases, noting all offshore wind farm construction is undertaken using internationally recognised best practice for pollution control and prevention. Prefabrication can also remove the need to use many of the substances and chemicals involved while at sea, meaning they can instead be used in controlled dockside environments. The proposed anchoring system for FloatGen does not require drilling muds or grout to be used.

The mandatory monitoring that will be undertaken for FloatGen under the SEM-REV EMP includes the record keeping of every product and materials used, and the complementary monitoring includes: sacrificial anodes dissolution and water temperature increase.

4.5 FISHING

Potential impacts on commercial fishing from construction, operation and decommissioning of wind farms are:

- a complete loss, or restricted access to, traditional fishing grounds
- safety issues for fishing vessels
- increased steaming times to fishing grounds
- interference with fishing activities
- presence of seabed obstacles post construction
- adverse impacts on commercially exploited species.

Both fixed and floating wind turbines have potential to impact on fishing activity especially when deployed in large arrays. The significance of the above impacts will vary with geographic location, fleet size and structure, species targeted and gears used. There is a need to incorporate socio-economic datasets into marine planning processes and for project developers to undertake early and extensive consultations with the commercial fisheries sector. Novel technologies can pose different safety issues for fishing vessels than more established installations like fixed wind turbines which is a further reason for the need for extensive consultation in relation to arrays. However this is not of relevance to the FloatGen project due to it being within the SEM-REM test site where fishing vessels are prohibited.

4.6 GREENHOUSE GAS EMISSIONS

Emissions to atmosphere from the vessels that will be used to construct, operate, maintain, inspect and decommission the offshore elements of a wind farm are governed by the International Convention for the Prevention of Pollution from Ships 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78). In particular, Annex VI sets limits on emissions of nitrogen oxides and sulphur dioxide that have been tightened via revisions as technology has improved. In July 2011, measures were adopted that added a new Chapter 4 to MARPOL Annex VI entitled “Regulations on energy efficiency for ships”, making mandatory the Energy Efficiency Design Index (EEDI) for new ships and the Ship Energy Efficiency Management Plan (SEEMP) for all ships. These regulations, which aim to reduce the carbon intensity of transport by sea (and apply to all ships over 400 gross tonnage), entered into force on 1 January 2013.

As discussed under section 4.4 onshore prefabrication of devices like FloatGen can shorten the offshore construction period, reducing vessel number and presence which may in turn reduce vessel emissions. The publically available data often only provides estimates of vessel number and movements associated with construction and operation, therefore the value of comparisons based on the Questionnaires is considered to be somewhat limited.

Consideration also needs to be given to the embodied carbon of the materials used in the construction of the foundations. This includes the energy required to manufacture the raw materials in the foundations as well as the energy associated with the manufacture of the foundation units.

This level of information relating to materials is not readily available from public documentation preventing comparisons relating to this parameter based on the Questionnaires.

4.7 WASTE

Wastes will be generated during the fabrication, installation, operation and decommissioning process. The scale and type of waste will be dependent on the type of foundation and installation methodology used - will foundations be pre fabricated onshore? How and where will dredged material be deposited? Will there be any waste generated as a consequence of the maintenance programme, and if so, how will it be disposed of? Consideration of the waste generated from the decommissioning process will also be required.

All projects will comply with waste handling, management and disposal legislation and policy regardless of the foundation type used. Very little project specific information is available publically to respond to the questions posed above.

4.8 ARCHAEOLOGY

The marine heritage value of the wind farm site would be assessed before any construction work progressed. The value of the site would be assessed in terms of:

- Records of wrecks and obstructions, known wrecks, documented losses and archaeological finds
- Records of protected wrecks
- Historic records held by onshore and offshore agencies, e.g. coastguard
- Geophysical survey records.

The potential impact of the wind farm foundation on the heritage assets assessment would consider the area of the seabed required for development and the location and importance of the known marine heritage assets. Very often adverse effects on known archaeological features can be avoided through careful siting of seabed equipment.

There were no clear additional advantages noted for archaeological receptors beyond those associated with physical and benthic receptors as discussed in sections 4.1 and 4.2.1.

4.9 EMERGENCY RESPONSE

In the event of the construction, operation and decommissioning processes not going to plan, emergency response processes need to be in place to manage and minimise the environmental impact of such an event.

This will include details of how any predicted incidents will be managed, responsibility for managing the incident response, communicating accurate information to the regulatory authorities and emergency services. Both fixed and floating turbines require clearly defined navigational markers, search and rescue access routes to be clearly delineated and for spacing and layout to accommodate routine and emergency marine traffic movements. However there may be a need to consider what may happen should an anchoring mechanism fail resulting in the unplanned movement of a floating device[1].

The complementary monitoring that will be undertaken for FloatGen under the SEM-REV EMP includes: sea usage and safety / security and marine traffic.

4.10 DECOMMISSIONING

The environmental impact of decommissioning will be across all environmental parameters. The degree of the impact to each receptor will be dependent on the foundation design and the way in which it is installed and subsequently decommissioned.

The detailed decommissioning plan for FloatGen is not yet confirmed. However it is expected that all project infrastructure (wind turbine tower, nacelle and blades, dynamic cable, anchor mooring lines, anchors) will be removed from the SEM- REV site. It is possible that the export cable will remain *in situ* to be used for a subsequent project if agreed by all project partners.

5. ENVIRONMENTAL COMPARISON CRITERIA

The following questions were used to collect information to define the differences between floating and fixed offshore wind turbine foundations in terms of their environmental impacts.

A. Physical environment	
Construction	
A1. Will extensive pre-construction surveys (such as geotechnical survey) be required?	
Choose an item.	If yes please add details: Click here to enter text.
A2. Will the installation of the foundation require a jack-up barge or other equipment that needs to be in contact with the seabed?	
Choose an item.	If yes please add details: Click here to enter text.
A3. What area of seabed will be affected during construction?	
Area in m^2: Click here to enter text.	
A4. Will the seabed require preparation (e.g. levelling) prior to installation?	
Choose an item.	
A5. If yes, how would seabed preparation be undertaken?	
Click here to enter text.	
A6. Where would dredged materials be deposited?	
Choose an item.	Please provide details? Click here to enter text.
A7. What will be the direct footprint of the foundation on the seabed?	
Please insert area in m^2: Click here to enter text.	
Operation#	
A8. How much of the foundation will protrude above the seabed?	
Please insert height in metres: Click here to enter text.	
A9. How much rock armouring will be required per foundation?	
Click here to enter text.	
A10. Will there be movement of the foundation type that could result in disturbance of the seabed (e.g. anchors and chains) during operation? If so, what area of seabed would be affected?	
Choose an	If yes please insert area in m^2: Click here to enter text.

item.	
A11. Is scour likely? How will this be avoided, or otherwise mitigated?	
Choose an item.	If yes please add details: Click here to enter text.
A12. What are the likely effects of the foundation on sediment movement? Will there be general accretion or erosion?	
Click here to enter text.	
Decommissioning	
A13. What is the approximate duration of the decommissioning period?	
Please insert time frame in months Click here to enter text.	
A14. Would the entire foundation be removed from the seabed during decommissioning?	
Click here to enter text.	
B. Ecology	
Construction	
B1. What area of seabed will be directly affected during construction?	
Insert area in m^2 Click here to enter text.	
B2. Will it be possible to commence noisy installation operations in a "slow start / soft start" mode to enable mobile species to avoid the area?	
Click here to enter text.	
B3. Are specialist construction vessels from distant locations required (that could introduce risk of alien invasive species)?	
Choose an item.	If yes please add details: Click here to enter text.
B4. How will the foundations be constructed and attached to the seabed?	
Click here to enter text.	
B5. Will piling or drilling be required, and if so by what method?	
Choose an item.	If yes please add details: Click here to enter text.
B6. For piling, what is the maximum source noise level?	
Click here to enter text.	

B7. For piling, what is the maximum duration of a single piling event?	
Click here to enter text.	
B8. For piling, what is the maximum number of events per turbine?	
Click here to enter text.	
B9. For piling, what is the total piling time per turbine?	
Click here to enter text.	
B10. For drilling, what is the maximum sound pressure level at the source?	
Click here to enter text.	
B11. For drilling, what is the maximum drilling time per turbine?	
Click here to enter text.	
Operation	
B12. What area of seabed will be taken up by the foundation?	
Insert area in m^2 Click here to enter text.	
B13. Will anti-fouling paint be used?	
Click here to enter text.	
B14. Could the foundation act as a nursery ground or act as an artificial reef or fish aggregation device?	
Choose an item.	
B15. Will the option create an acoustic signal during operation? If so, how is this likely to manifest itself in the water column?	
Choose an item.	If yes please add details: Click here to enter text.
B16. Is marine species entanglement a known issue for the foundation type i.e. mooring cables?	
Choose an item.	If yes please add details: Click here to enter text.
B17. Do you utilise any specific management practices to reduce the risk of marine species entanglement?	
Choose an item.	If yes please add details: Click here to enter text.

Decommissioning	
B16. Would surveys be undertaken to determine the extent of species using the structure?	
Choose an item.	If yes please add details: Click here to enter text.
B17. How will the foundations be decommissioned and removed from the seabed?	
Click here to enter text.	
B18. Will the decommissioning methodology require operations likely to generate underwater noise and vibration?	
Click here to enter text.	
B19. If yes, How long will each event last for?	
Click here to enter text.	
C. Navigation	
Construction#	
C1. What size of exclusion area will be required during the construction phase?	
Insert area in m^2 Click here to enter text.	
C2. What is the size of a typical construction vessel for this option? How many support vessels would be required?	
Insert size in metres Click here to enter text. Insert number of vessels Click here to enter text.	
C3. How many construction vessel movements will be required per installed foundation?	
Insert number of vessel movements Click here to enter text.	
Operation#	
C4. Will the foundation designs require restricted navigation in their vicinity?	
Choose an item.	
C5. How often will general maintenance operations be required, and how many vessel movements will be required?	
Click here to enter text.	
Decommissioning	
C6. What size of exclusion area will be required during decommissioning?	
Insert area in m^2 Click here to enter text.	

C7. How many vessel movements are predicted to be required for the decommissioning per installed foundation?	
Insert number of vessels Click here to enter text.	
D. Water quality	
Construction#	
D1. Will the foundations be pre-fabricated onshore or assembled on-site? If on-site, what activities will be involved?	
Choose an item.	If onshore please provide details? Click here to enter text.
D2. Will installation of the foundation create sediment disturbance? What sized area would be affected?	
Choose an item.	If yes please provide area: Click here to enter text.
D3. Will drilling muds be required?	
Choose an item.	If yes please add details: Click here to enter text.
D4. How will drilling muds be controlled?	
Click here to enter text.	
D5. How long will the installation of each foundation take?	
Please insert time frame Click here to enter text.	
D6. Will chemicals be required (e.g. grouting chemicals)	
Choose an item.	If yes please add details: Click here to enter text.
D7. Will construction require the discharge of ballast water?	
Choose an item.	If yes please add details: Click here to enter text.
Operation#	
D8. How will the foundation be protected against corrosion? Will sacrificial anodes be required as part of a cathodic protection system?	
Click here to enter text.	

Decommissioning	
D8.Will decommissioning of the foundation create sediment disturbance? What sized area would be affected?	
Choose an item.	If yes please add details: Click here to enter text.
D9. How long will the removal of each foundation take?	
Click here to enter text.	
D10. Will chemicals be required?	
Choose an item.	If yes please add details: Click here to enter text.
D11. Will decommissioning require the discharge of ballast water?	
Choose an item.	If yes please add details: Click here to enter text.
E. Fishing	
Construction	
E1. How long will any exclusion zone apply to the area of construction?	
Click here to enter text.	
E2. What area would be required for exclusion for each foundation?	
Insert area in m^2 Click here to enter text.	
Operation	
E3. From what seabed area would fishing be excluded for each foundation?	
Insert area in m^2 Click here to enter text.	
E4. Can trawling still take place between foundations?	
Choose an item.	
E5. Will the new hard substrate created by the foundation be suitable for local colonization by commercial species (i.e. scallops)?	
Choose an item.	If yes please add details: Click here to enter text.
Decommissioning	
E1. How long will any exclusion zone apply to the area of decommissioning?	
Click here to enter text.	

E2. What area would be required for exclusion for each foundation?	
Click here to enter text.	
F. Greenhouse gas emissions	
Construction	
F1. From what materials will the foundation type be manufactured?	
Click here to enter text.	
F2. Please provide quantities of the main components used in the manufacture of the foundations?	
Click here to enter text.	
F3. Has an assessment of the energy used in the manufacture of the foundations been undertaken?	
Choose an item.	If yes please add details: Click here to enter text.
F4. How will the foundations be transported to site and how long will an individual installation take?	
Click here to enter text.#	
F5. What type of vessel(s) will be required?	
Click here to enter text.	
F6. Can this type of vessel be sourced locally to the site (is a specialist vessel required)?	
Choose an item.	
Operation	
F7. How frequently are maintenance vessels planned to visit the site?	
Click here to enter text.	
F7. What type of vessel(s) will be required?	
Click here to enter text.	
F8. Can this type of vessel be sourced locally to the site (is a specialist vessel required)?	
Choose an item.	

Decommissioning	
F9. How will foundations and any associated structures be removed from the site?	
Click here to enter text.	
F10. What type of vessel(s) will be required?	
Click here to enter text.	
F11. Can this type of vessel be sourced locally to the site (is a specialist vessel required)?	
Click here to enter text.	
F12. Is the number of vessel movements to complete the decommissioning process known?	
Choose an item.	If yes please add details: Click here to enter text.
G. Waste	
Construction	
G1. Will a Site Waste Management Plan be developed for the construction phase?	
Choose an item.	
G2. Have the waste types expected to be generated been identified in terms of waste types (EWC Code) and estimated quantity?	
Choose an item.	If yes please add details of waste types: Click here to enter text.
G3. Have waste management options been identified for the above waste types?	
Choose an item.	
OPERATION	
G4. Have the waste types expected to be generated during operation been identified in terms of waste types (EWC Code) and estimated quantity?	
Choose an item.	If yes please add details of waste types: Click here to enter text.
G5. Have waste management options been identified for the above waste types?	
Choose an item.	
DECOMMISSIONING	
G6. Have the waste types expected to be generated been identified in terms of waste types (EWC Code) and estimated quantity?	
Choose an	If yes please add details of waste types: Click here to enter text.

item.	
G7. Have waste management options been identified for the above waste types?	
Choose an item.	
H. Archaeology	
Construction	
H1. Has a marine heritage asset study been undertaken?	
Choose an item.	If yes please add details: Click here to enter text.
I. Emergency Response	
I1. Have emergency response plans been developed to cover the construction, operation and decommissioning processes?	
Choose an item.	If yes please add details: Click here to enter text.
I2. What are the key environmental risks associated with the foundation design?	
Choose an item.	
J. Decommissioning	
J1. Has consideration been given at the design stage of the materials used to ensure that at decommissioning they are potentially suitable for reuse or can be managed as a waste?	
Choose an item.	If yes please add details: Click here to enter text.
J2. Is there a Decommissioning Management Plan?	
Choose an item.	If yes please add details: Click here to enter text.