Morlais Project

Fish Ecology Issues
Responses to NRW comments

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Introduction

This document provides the Applicant's responses to Natural Resources Wales (NRW) comments regarding ES Chapter 10 Fish and Shellfish Ecology and associated figures and appendices.

NRW Comment: Particle motion
Particle motion is known to affect non-hearing specialist fish and invertebrates. NRW Advisory is concerned that the construction and operational impacts of this do not appear to have been assessed in the ES. Shellfish can also be affected by particle motion but appear to have been excluded from the noise assessment (paragraph 132)

Potential particle motion effects may arise through the construction and operation of the Project. With respect to construction, potential particle motion effects may arise from drilling of foundations. As way of amendment to the original Chapter 10 (Fish & Shellfish Ecology), please note that following review of Chapter 4 (Project Description), the original figure of up to 3,840 days of drilling should be revised to 3,990. This correction results in no changes to the conclusions of the impact assessment.

Following post-submission consultation with NRW fish specialists, the key focus of any particle motion effects has been clarified as being from operational tidal turbines. The tidal devices are anticipated to produce underwater sound that is low frequency and also low pressure (Lossent *et al.,* 2018). There is a paucity of information on the particle motion component of underwater sound produced by tidal turbines; this is also the case for wind turbines, despite the number of offshore wind farms (OWF) in UK waters (Popper and Hawkins, 2019). Nevertheless, the potential impacts of this pathway on fish and shellfish receptors has been considered here.

Several recent papers have identified the importance of the particle motion component in the detection of underwater sound by fish and invertebrates (e.g. Nedelec *et al.,* 2016; Popper and Hawkins, 2017; 2019). Only through recent advances has it been possible to measure and analyse particle motion, and there are many areas where further research is needed (Nedelec *et al.,* 2016; Hawkins and Popper, 2017). Hawkins and Popper (2017) state that assessment of the impacts of particle motion is difficult due to "*difficulty in measuring and modelling particle motion, the lack of experimental data on the responses of fishes and invertebrates to potentially damaging levels of particle motion, and the absence of guidelines—based on particle motion—that indicate the levels of particle motion that are likely to have adverse effects upon animals*." These limitations greatly restrict the level of detail to which it is possible to assess the impacts of particle motion. This explains why, so far, most studies on underwater sound have only measured sound pressure, without considering water-borne particle motion, or indeed the energy in the seabed (Roberts *et al.,* 2015).

It should be noted that the limited amount of research on particle motion has been focussed on replicating levels of vibration associated with high-impact sources such as pile driving (e.g. Roberts *et al.,* 2015). Pile driving produces a strong vibration radiating outwards from the length of the pile into the seabed and water column (Roberts *et al.,* 2015; 2016). Pile driving foundations and/or other project infrastructure will not be utilised during the Project.

Most fish species have a relatively narrow bandwidth of hearing and are only sensitive to particle motion e.g. *Salmo salar* and *Scomber scombrus* (Popper and Hawkins, 2019). However, the hearing sensitivity of fish species to particle motion is in turn poorly known (Popper and Hawkins, 2019). The behavioural responses of fish to sound pressure vs. responses to particle motion is also not understood (Popper and Hawkins, 2019). It is therefore not possible to exclude the possibility that responses of fish to underwater noise described to date in the ES (Chapter 10), from mortality to auditory injury and behavioural response, is due to the particle motion component of underwater sound, as opposed to the sound pressure. Indeed, Popper and Hastings (2009) suggested that excess particle motion may contribute significantly to hearing loss and/or tissue damage in fish. However, no correlations between observed effects and metrics of particle motion have been developed (Popper and Hastings, 2009). It is currently unknown if particle motion can indeed cause the most severe impacts (though less severe behaviours like startle responses have been described from particle motion only; see Sigray and Andersson, 2011).

The exact sensitivities of non-hearing marine invertebrates to vibration are generally unknown (Roberts *et al.,* 2016). Vibration studies have been limited to crustaceans and bivalves (Roberts *et al.,* 2016). Roberts *et al.* (2015) report that different taxa of bivalve are sensitive to different frequency ranges, but all are more sensitive to lower frequencies (typically <210 Hz).
Mobile invertebrates such as cephalopods and crustaceans are reported to be more sensitive than sessile molluscs (Roberts *et al.,* 2015).

Roberts *et al.* (2015; 2016) investigated the impacts of vibration on blue mussel *Mytilus edulis* and hermit crab *Pagurus bernhardus*. Both species showed negative behavioural and physiological changes to the vibration (Roberts *et al.,* 2015; 2016). The thresholds for effects on these shellfish were shown to be within the levels measured near anthropogenic operations that produce high levels of underwater noise such as pile-driving, which would be detectable to a receptor up to 296 m away from the source (Roberts *et al.,* 2016). However, anthropogenic methods that typically produce low levels of underwater noise such as dredging produce low levels of vibration, below the threshold of detection at all but the higher frequencies, except at small distances from the source (5 m) (Roberts *et al.,* 2016). The sound levels produced by operational tidal turbines are low and more similar to dredging than pile driving (see the underwater noise modelling of tidal turbines for this project; document reference MOR/RHDHV/DOC/0116), therefore the vibration levels are also expected to be lower and only detectable at small distances from the source, with the size of the effect radius even smaller than the radius of detection. In addition, Roberts *et al.* (2015) indicate that both the level of vibration and the strength of receptor response decreases with distance from the source. The radius of effect from vibrations is therefore anticipated to be limited to the immediate vicinity of the tidal devices. This will be applicable to all fish and shellfish receptors.

In summary, particle motion may adversely affect fish and shellfish but the significance of such effects will be determined by the level of noise and proximity of the noise source to the receptor. It is acknowledged that there is no predictable relationship between sound pressure and particle motion, particularly in the near field. However, it is reasonable to assume that the difference in magnitude of sound pressure levels produced by piling and tidal turbine operation, will also be reflected in a similar difference in magnitude of particle motion between the two sources. It can therefore reasonably be anticipated that the radius of effect will be spatially limited to the immediate area around the Project infrastructure and that behavioural responses will not be as severe as those reported for piling. Furthermore, the Project is located in a highly tidal and turbulent area which already has a high background noise levels and so the magnitude of change in particle motion above the baseline is low. It is therefore predicted that any impact from particle motion will be not significant to populations of fish and shellfish in the region.

NRW Comment: Electro-magnetic fields

The ES does not address the latest research on attraction to cables by edible crab and possible impacts. Clarification is required on what impact EMF may have in reducing the area used by crabs if they are attracted to and remain near the cable instead of roaming.

As detailed in Chapter 10 of the ES (Fish & Shellfish Ecology), electromagnetic fields (EMF) can arise in the immediate vicinity of electrical cables. The Project will include a maximum of 248 km of cable around which EMF can arise, with an overall footprint of 43,337 m^2. Most turbines will export grid compliant power at 11 kV, though some may be at 24 kV or 33 kV over the longer term.

A proportion of the seabed cables will be covered with protection systems which will decrease the likelihood of overlap of EMF with fish and shellfish species occurrence. Additionally, EMF levels are also known to dissipate quickly with distance from a cable; a study by Love *et al.* (2015) found that EMF levels around an energised cable dissipates to background levels at a distance of ~1 m.

With respect to potential EMF effects on edible (brown crab), specifically the potential for attraction, we note this and we also recognise the potential for any such attraction to impact on key stages of the edible crab life-cycle, including spawning and over-wintering migrations. However, OSPAR (2009) reported observations that marine species such as edible crab showed no impact on their migratory routes from the presence of subsea cables in the Baltic Sea.
Similarly, Taormina *et al.* (2020) demonstrated that juvenile of another key shellfish species (European lobster), did not exhibit any changes in behaviour when submitted to an artificial magnetic field gradient.

There are a limited number of preliminary laboratory tests that show a level of behavioural changes resulting from EMF on crab species (PTEC, 2014). Scott *et al.* (2018) reported that edible crab showed a clear attraction to an EMF-exposed shelter, and significantly reduced their time spent roaming (by 21%). Some physiological effects were also reported in edible crab exposed to EMF (Scott *et al.,* 2018). Scott *et al.* (2018) selected the low EMF strength of 2.8 mT to reflect the "expected…levels on the surface of a subsea cable". However, this EMF value may be a significant overestimation of the EMF produced by subsea cables. To illustrate, the value of 2.8 mT is ~200 times higher than the EMF modelled for the Vineyard Wind export cable (when buried at a depth of 1 m). Furthermore, the export cable of Vineyard Wind utilised 220 kV, which is significantly higher than the worst-case 33 kV for the proposed Project. Therefore, the response observed by Scott *et al.* (2018) may be significantly greater than what can be expected from a real-world situation, particularly for this specific Project. Scott *et al.* (2018) did not directly assess the distance threshold over which an EMF attraction response could occur. However, as it has been shown that EMF levels dissipate to background levels at a distance of 1 m (Love *et al.,* 2015), it is assumed that the worst-case impact radius for such effects is 1 m from the cable.

Although the evidence detailed so far in this note suggests that any effect on shellfish is unlikely, if an effect is assumed for a distance of 1 m either side of the cable, i.e. a 2 m width of effect, and taking into account the maximum cable length (40.5 km export cable and 204.5 km array cable, 245 km cable total) for the Project, the worst-case area of that effect would be 0.49 km^2. This corresponds to 1.23% of the total Morlais study area (39.76 km^2). Therefore, should EMF effects occur, they would only occur over an extremely low percentage of the site, with the majority of the site unaffected. It is reasonable to conclude that the magnitude of an assumed, non-evidence based and hypothetical EMF effect on crustacean behaviour in this area will be low.

A further piece of important evidence is also available when considering for crustacean behaviour at a population level. For edible crab, it is noted that to date there have been no population-level impacts reported as a result of potential EMF effects from cables associated with the construction of 30+ offshore wind farm projects in UK waters. Whilst it is recognised that cables in OWF areas are often buried to at least 1.0m beneath bed level (OWF projects typically constructed in more sedimentary environments than tidal stream, thus enabling cable burial), there are still many cables associated with OWF projects that are not buried and have the potential to have localised EMF effects.

Another aspect to consider is the relative EMF contribution of this project in the context of total EMF from existing OWF cables in UK waters. Data on the total amount of OWF cables is available for September 2018 (El Mountassir and Moran, 2018). As of September 2018, the UK's operational offshore wind farms are using 62 export cables totalling a length of 1,499 km, and over 1,806 km of inter-array cables, to transport 6,385 MW of electrical generation (El Mountassir and Moran, 2018).

The proposed project will comprise, at full site deployment, a total of 204.5 km of inter-array cables, and 40.5 km export cables. Therefore, at full site deployment, the proposed project will comprise an increase of 2.7% to the total export cables, and an increase of 11% of the total inter-array cables, in UK waters. This does not take into account OWF cables that have been built since September 2018, which would further decrease the relative contribution of the proposed project to the total EMF in UK waters. El Mountassir and Moran (2018) stated that a total of approximately 9.6 GW of OWF capacity would be in or entering operation by 2020. Based on this, the full site deployment for the Project (240 MW) would comprise a 2.4% increase in the total capacity of UK waters. The more recent Round 3 OWF projects are proposed to have a capacity that is almost an order of magnitude greater than the proposed Project (e.g. Norfolk Vanguard and Boreas, both 1.8 GW), therefore there is a clear difference in the magnitude of the effect expected between the Project and recently proposed OWFs.

The sensitivity of shellfish to EMF during the operational phase of the Project is judged to be low. This assessment, coupled with the low magnitude of effect, results in the potential for a **minor adverse** impact upon receptor species.

NRW Comment: Larvae and turbulence

Clarity is sought on the increase in wake from the proposed devices. Increased turbulence can affect larvae of some species via mortality or vertical position changes; this has not been addressed in the ES, especially for protected species. Clarity is sought on what impact, if any, turbulence from the MDZ would have on protected and commercial fish species that are known to spawn in the area, as there is currently no information in the ES to determine this

Turbulence effects, such as rapid changes in velocity and turbulence induced shear stresses at the small, millimetre scale, can impact planktonic larvae. Effects include limited fertilisation, interference with normal development, and damaged larval forms resulting in increased mortality (Mead and Denny, 1995; Jessop, 2007). High levels of mortality may lead to impacts at a population level due to reduced connectivity between populations.

In high tidal flow velocity areas such as the MDZ, there is a high degree of baseline turbulence owing to interaction with irregular bed features and the coastline. The operation of tidal turbines may result in changes in turbulence in the area immediately surrounding the turbines. However, the proposed tidal device technology will not cause acceleration of the water; rather, the devices are instead expected to cause a mild retardation in flow speeds. This is fundamentally opposite to other tidal energy technologies such as barrages and lagoons, which channel and hence accelerate flows through their enclosed turbines. The exact extent and magnitude of the change in turbulence in the immediate near-field area around each TEC is unknown, though it is anticipated to be highly localised. However, the potential for the introduced turbulence to affect the sensitive larvae of gastropods and bivalves cannot be excluded.

Different taxa of planktonic larvae may be impacted by turbulent conditions to different extents. Jessop (2007) reported that the larvae of gastropods and bivalves showed significantly increased mortality (up to a maximum of 60% of the larvae in the sample), whereas the larvae of barnacles, bryozoans and polychaetes were not affected. This is due to the thin shells of gastropod and bivalve veligers, which can be damaged upon collision with suspended particles or hard substrates in turbulent environments (Jessop, 2007).

Mead and Denny (1995) reported impacts to larvae of the purple sea urchin *Strongylocentrotus purpuratus* at high shear stresses of the magnitude found in the surf zone. The high shear stresses were found to decrease fertilisation success, increase abnormal development in fertilise eggs and decrease survival of the eggs.

However, the change in the turbulence regime as a result of the turbines need to be considered within the context of the natural levels found within the Morlais Development Zone (MDZ). The Project is located within a highly tidal environment, experiencing high baseline currents speeds. Togneri *et al.* (2017) described the project area as having highly energetic turbulence when they compared the level of turbulence in the site using in situ measurements and modelling. The authors indicated that the overall turbulence in the site is dominated by wave action, and that wave effects dominated turbulence throughout the upper half of the water column and less frequently affecting the whole water column.

Therefore, any additional turbulence introduced by the tidal turbines is expected to be small in comparison to the natural turbulence arising from the hydrodynamic processes in the study area, to which receptors such as planktonic larvae are already exposed, and which are a component part of the natural mortality of those populations.

The sensitivity assessment of fish and shellfish larvae to the effects of turbulence during operation of the Project is concluded as medium. This is a worst-case scenario for the most sensitive taxa, gastropods and bivalves, which show an increased level but not complete mortality in turbulent environments (i.e. limited tolerance and adaptability), and some recoverability is expected to occur for the population as a whole. This assessment, coupled with the low magnitude of effect (i.e. as a portion of the already existing natural turbulence), results in the potential for a minor adverse impact upon receptor species. This is considered sufficiently precautionary given the lack of knowledge on potential impacts on receptor species. The residual impact is judged to be minor adverse.

NRW Comment: Fish Aggregating Devices
Clarity is sought on whether there would be an impact if the proposed floating structures acted as FADs and increased fish and predators to the area and what impact the turbines could have on the populations of larvae of protected species or larger predators attracted to the FADs, as there is currently no information provided to determine this

ABPmer (2010) indicate that tidal energy devices have low potential to act as a fish aggregating device (FAD). The potential for tidal energy devices to act as FADs has been reviewed by Kramer *et al.* (2015), who found that the potential for infrastructure to act as a FAD applies only to surface and midwater structures, such as mooring lines, buoys, and the tidal devices themselves. The species that may assemble around the devices will likely vary with distance from shore and deployment depth. Kramer *et al.* (2015) also reported that associations with mid-water and surface structures were unlikely for most species (though this is correlated to the specific species in the study area, the west coast US). They also indicated that the devices acting as FADs would not result in negative effects on juvenile species due to increase predation (Kramer *et al.,* 2015).

Čada and Bevelhimer (2011) suggest that tidal energy devices could offer refuge from high speed currents by providing a lower-energy downstream of the turbine and supporting structure. It is therefore possible that fish could aggregate in the wake of turbines, and that these areas could become attractive to predators (VIehman and Zydlewski, 2014). Indeed, Fraser *et al.* (2018) reported an increase in fish school observations around a tidal device, particularly at night and in the wake of the tidal device, which constituted a disruption from normal diurnal behaviour. Both Fraser *et al.* (2018) and Williamson *et al.* (2019) reported the most consistent number of small fish aggregations during lower current velocities (<1 m/s), below the threshold which a turbine would be operational, thereby reducing the overall risk to predators. These authors both report different patterns for peak flows; Fraser *et al.* (2018) indicates avoidance by fish during these times, whereas Williamson *et al.* (2019) indicated the largest schools. The avoidance behaviour reported in Fraser *et al.* (2018) and literature referenced therein, suggests that the devices will not act as an FAD throughout the tidal cycle, and that higher levels of risk to fish and to their predators as a result of increased peak flows would be avoided by both groups. The disagreement with Williamson *et al.* (2019) perhaps reflects a lack of consensus in the literature when considering the reactions of fish to speed of current flow, with such behaviour likely be species specific.

The potential for the tidal device to act as an FAD will depend on many characteristics of the device, such as size, position in the water column, and the environment in which it is deployed (ABPmer, 2010). In areas with high flow rates such as tidal rapids, pelagic fish will be unlikely to aggregate for long periods. Although they may use areas of lower turbulence, e.g. around device columns, as shelter, these are not large enough to allow many fish to gather. Flow rates will also determine the composition of encrusting assemblages on device and hence the potential food supply to fish. The numbers of small pelagic fish gathering may then influence the attractiveness of the device area to larger, predatory fish. With regards to demersal fish, ABPmer (2010) reports that large moorings may provide additional habitat for small demersal fish such as blennies and gobies, and that increases in demersal fish have been observed around the piles of offshore wind farms.

In summary, it is accepted that the tidal devices may act as FADs, and so could increase the density of fish in the vicinity of the turbine, particularly in the wake and at night (Fraser *et al.,* 2018). Any increases in the density of the fish may in turn affect the foraging behaviour of larger predators, however this is currently identified as a research gap (Fraser *et al.,* 2018). As highlighted by NRW, the primary concern is an increased level of collision risk to predators as a result of attraction to elevated prey density close to tidal devices. However, it is our consideration that the scale of any effect to marine predators would be limited.

NRW Comment: Migration Patterns

There is a lack of clarity about migration patterns (i.e. the actual routes fish take when carrying out their migration) and migration periods, which are discussed in Table 10-16. They are very different, and this section appears to try and cover both, but misses out the vital issues about migration patterns (routes) taken by fish

Please see updated **Table 10-16** with additional information on migratory fish that may be found in/around the Morlais project area.

Table 10-16 Additional information on migratory fish

Species	Time spent in freshwater before downstream migration	Timing of downstream migration	Time spent at sea before first return	Timing of upstream migration	Migratory Patterns/Routes
Atlantic Salmon	2-3 years	April- May (Smolt)	1, 2 or 3 years	All year round with peak in late summer early autumn (Adults)	Thought to be distinct components to the homeward migration of adult fish (Hansen et al., 1993). The first oceanic phase is rapid and highly directed, probably involving navigation or orientation using position of sun and reference to the Earth's magnetic field (Hansen & Quinn, 1998). The final phases of up-river migration are thought to use the sense of smell to detect olfactory cues that are remembered from the outward migration (Hasler & Scholz, 1983). Very little is understood of the phase of migration between location by salmon of the home land-mass and identification of the home river. The limited available information on adult swimming depths suggest that they spend most of their time in shallow water (generally 0-40m), although they can dive to substantial depths up to 280m. It has been hypothesised that these dives are related to feeding or predator avoidance. Based on work done by Marine Scotland Science, gut content analysis suggest that adult fish are often still feeding, particularly early in the year. Little is known about the migration pathways of post-smolts. Some research has shown that post-smolts move in schools when heading to deep-sea feeding areas. Some of these fish feed in the Norwegian Sea and the waters off southwest Greenland. Studies in Norway and Canada indicate that post-smolts were always observed to migrate rapidly and actively towards open marine areas after leaving their source rivers.

Species	Time spent in freshwater before downstream migration	Timing of downstream migration	Time spent at sea before first return	Timing of upstream migration	Migratory Patterns/Routes
					They did not appear to closely follow nearby shores, although this may occur where coastal currents are substantial in this area. For the few studies where swimming depth was reported, it appears that post-smolts generally utilise shallow depths (typically 1-3m, but up to 6m). This latter observation is consistent with the effectiveness of sea surface trawls in catching post-smolts (MSS, 2010). Tagged UK (Scottish) Atlantic salmon have been observed at locations extending from Labrador in the west to Faroe in the east. It is assumed that UK (Welsh) salmon will exhibit a similar distribution. Available evidence indicates that the marine origins of the fish are likely to be highly biased towards a range of locations to the north and west of the British Isles. The MDZ is shallow and does not comprise a feeding ground for adult Atlantic salmon. Adults may occur in the MDZ year-round with a peak in late summer/early autumn, coinciding with their upstream migration. There is the potential for the MDZ to be used by post-smolts year-round, though these are likely to be transiting rapidly through the MDZ in order to reach open water. The currents in the MDZ are strong and therefore post-smolts may follow nearby shores, remaining in the upper water column, before migrating to open seas north and west of the British Isles.
Sea trout	2-3 years	Spring/early summer	Usually 1 or 2 years, in coastal areas	April-June	Brown (sea) trout exhibit a wide range of migratory behaviour that is thought to be influenced by genetics and environment. At the extreme, brown trout can migrate to the marine environment where they are known as sea trout. In contrast to salmon, sea trout post-smolts do not migrate rapidly out to sea from inshore coastal areas. Instead they tend to use near shore areas where available.

Species	Time spent in freshwater before downstream migration	Timing of downstream migration	Time spent at sea before first return	Timing of upstream migration	Migratory Patterns/Routes
					There is relatively little information on post-smolt swimming depths although observational data generally suggests shallow swimming depths in the upper 10m or so of the water column. Some post-smolts return to fresh water relatively quickly after migration to sea. There is considerable uncertainty as to the movement of sea trout after the initial few months in the marine environment (MSS, 2010). As the MDZ is nearshore, it may be utilised by sea trout post-smolts for 1-2 years, though there is highly variability in duration at sea and also uncertainty in their marine movements. During their time at sea, the post-smolts are likely to remain in the upper water column.
Sea lamprey	3-4 years	July to September to open sea	18-24 months	April-May spawning in May/June	Metamorphosis to the adult form takes place between July and September. The time of the main migration downstream seems to vary from river to river (Applegate & Brynildson 1952) and relatively little is known about them after they reach the sea, where they have been found in both shallow coastal and deep offshore waters. The spawning migration in Europe usually takes place in April and May when the adults start to migrate back into fresh water (Hardisty 1969). After metamorphosis and the downstream migration to the sea, the adults feed on fish there. They seem to feed on a wide variety of marine and anadromous fishes, including herring, salmon, cod and haddock. There is the possibility that sea lamprey occur in the MDZ as the species has been found in shallow coastal waters. The temporal distribution in the MDZ is unknown. Whilst they are feeding at sea, their distribution is determined by the distribution of their prey, which are known to occur in the MDZ.

Species	Time spent in freshwater before downstream migration	Timing of downstream migration	Time spent at sea before first return	Timing of upstream migration	Migratory Patterns/Routes
River lamprey	5 years or more. Remain in burrows in river silt beds until adults	July to September to feed in estuaries	2 years spent in estuaries	Winter and spring when temps are <10oC. Migrate at night	Mature river lamprey, having spent one to two years mainly in estuaries, stop feeding in the autumn and move upstream into medium to large rivers, usually migrating into fresh water from October to December. During winter and early spring they continue to migrate upstream at night when conditions are suitable. After metamorphosis (July–September) at three to five years of age, the young adults migrate downstream during darkness to estuaries. The marine distribution of river lamprey is restricted to estuaries. As the MDZ does not lie within an estuary, it is unlikely that the species will occur in the MDZ in any notable numbers.
European eel	Males 7-20 years Females 9-50 years	Late spring (as silver eels)	Many do not return to fresh water	January to June (as juvenile glass eels)	It is thought that both juvenile and adult eel migrations have a seasonal component, but in each case the season is probably quite protracted. It is thought that juvenile glass eels destined for UK rivers must remain in coastal regions until April or May before river temperatures rise sufficiently for them to enter fresh water. Both juvenile and adult eels can be found in all levels of the water column (at least in depths of less than 300m), and the depth selected can vary with time of day and state of tide. Negative phototaxis is pronounced in eels of all stages and they are unlikely to be found within a few metres of the surface during daylight, or even bright moonlight, if deeper water is available. Glass eels travel in near-shore areas may be facilitated by moving to the sea bed in ebb tides and up into the water column in flood tides. The use of

Species	Time spent in freshwater before downstream migration	Timing of downstream migration	Time spent at sea before first return	Timing of upstream migration	Migratory Patterns/Routes
					similar tactics by adult eels in open water has been observed but does not appear to be widespread (MSS, 2010). European eels can occur over a range of water depths and distances from the coast, and so may be present in the MDZ. There may be a peak in juvenile eels in the MDZ in the late spring, during which they wait in coastal waters before migrating upriver. European eels may be found throughout the water column except for the first few metres from the surface.
Allis and Twaite Shad	Short period few months (Juveniles)	April/May (Juveniles)	3-4 years Estuarine areas	April to May spawning in freshwater	The requirements of shads at sea are very poorly understood, but they appear to be mainly coastal and pelagic in habit. Allis shad have been reported from depths of 10–150 m, and twaite from depths of 10–110 m, with a preference for water 10–20 m deep (Taverny 1991) although Roule (1925) recorded them at depths of 200–300 m. A suitable estuarine habitat is likely to be very important for shad, both for passage of adults and as a nursery ground for juveniles. Little can be inferred about the presence of shad in the MDZ, except that they may show a preference for the shallower water depths (10-20 m) found in the MDZ.

NRW Comment: Freshwater Pearl Mussel (FWPM)
Not mentioned in this section but *Salmo salar* and, to a greater extent, *S. trutta* are both hosts to a part of the FWPM life cycle. Therefore, NRW Advisory considers that FWPM should be scoped into the ES.

It is noted that freshwater pearl mussels *Margaritifera margaritifera* are reliant on salmonids (salmon or trout). A critical part of their lifecycle involves spat settlement on the gills of salmonids, where they harmlessly live for the first year of their lives. Therefore, connectivity with salmonids exists for successful juvenile recruitment and population sustainability of freshwater pearl mussel. Therefore, this response considers the potential significance of impacts to freshwater pearl mussel, in parallel with the potential significance of impacts to Atlantic salmon and *Salmo trutta*.

As minor adverse effects are predicted for Atlantic salmon and *Salmo trutta,* then it is expected that effects on freshwater pearl mussel will not exceed minor adverse. This has been determined for freshwater pearl mussel both as an environmental receptor and as a designated feature of SACs in the region.

NRW Comment: Collision Risk
This section contains some generalisations in the absence of available information on the subject. NRW Advisory is concerned about how impacts to individual *Salmo salar* can be quantified in the absence of available information on the movements of this species when returning to their natal rivers. Species such as *S. salar* are expected to travel in shoals, therefore if one individual is exposed to an outside impact it can be presumed that all the individuals in that shoal are likely to be exposed. NRW Advisory therefore cannot agree with the finding of this section until further clarification is provided as to how the conclusion has been reached in the context of impacts occurring to individuals.

We note that NRW acknowledge an absence of available information related to collision risk between operational tidal turbines and migrating salmonids in the marine environment. Following an initial call on this issue on 02/03/2020 between Menter Mon, MarineSpace (EIA consultants) and NRW fish technical officers, this lack of empirical data to better define this potential impact was noted and discussed further. The issue is potentially an important one, especially in the context of ever decreasing populations of migratory salmonids in many Welsh rivers.

It is recognised that some desk-based collision risk estimates were produced in support of the MeyGen tidal energy project in the Pentland Firth, Scotland. Key aspects of this work, including comments from a Marine Scotland Science Review are summarised below. This summary is intended to highlight the potential inputs and assumptions that may be of relevance to any similar, future work required on salmonid collision risk for the Morlais project.

However, it is important to recognise that based on a lack of available, relevant data on salmonid migration around the Welsh coastline, including the MDZ, it is not currently possible to undertake any robust, evidence-based collision risk modelling. It is also argued that due to the fact that the proposed project will not create a permanent barrier to migration, and the majority of the water column in and around the MDZ will still be available for fish to move through unhindered, the need for such detailed collision risk modelling is currently limited.

Summary of Desk-Based Assessment of Potential Salmon Collision Risk at MeyGen (Pentland Firth, Scotland)

- Only salmon were considered;
- Both salmon smolts and returning adults are considered;
- Estimates of number of 1 sea winter (SW) and multi-sea winter (MSW) fish returning to Scottish waters were used as the basis of the assessment;
- These numbers were taken from the Report of the ICES Working Group on North Atlantic Salmon (2015);
- Additional information on migratory routes and pathways was taken from MSS (2010);
- Assumptions were made with respect to proportion of adult vs smolts via a process of apportioning. This itself relied on review of population structures from individual rivers;
- Assumptions were also factored in with respect to Number of blades; Maximum blade width; Blade pitch at blade tip; Blade profile; Rotation speed; % time not operational; and Mean current speed
- It was assumed that any migrating fish were uniformly distributed across the cross-sectional area of the study area (Pentland Firth);
- Marine Scotland Science (MSS) concentrated their review of this work on adult salmon. They judged that the small size of smolts should reduce the likelihood that smolts which would be expected to collide with the turbine blades would get injured or be killed;
- The Collision Risk Modelling (CRM) work concluded that, assuming 95% avoidance, up to 32 salmon (1SW + MSW) and 211 smolts would potentially collide with the maximum development scenario of 200 turbines per year. This represents 0.007% of the annual number of grilse and adult fish passing through the Pentland Firth and 0.003% of the smolts;
- MSS challenged some of the assumptions presented in the original and adopted more precautionary values. However, they still concluded that impacts via collision risk were acceptable, albeit noting the high level of uncertainty about the values. A Marine Licence was subsequently issued for this project which is now operational.

From the above, it can be noted that scope does exist for some form of review of collision risk. However, any such assessment would require a coordinated, approach between developer and NRW in order to collate relevant information on populations of migratory fish in the marine environment and migration pathways. These are key, fundamental topics that relate to overall management of these fisheries which we note is the remit of NRW. This highlights the need for some form of coordinate, strategic approach to this issue for tidal stream projects in Welsh waters. Menter Mon would, in principle, be happy to work in collaboration with NRW and other organisations, i.e. the ORJIP Ocean Energy Secretariat (which has identified collision risk between fish and tidal turbines as a key focus of research) to further develop ideas as to how best explore this issue.

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