| **Fish Species** | **Applicant modelled ‘population level’ output (ADZ behavioural model used)** | **Applicant Impact level from the Environmental Statement framework and turbine impact value (see Environmental Statement Matrices below)** | **Alterations to Parameters within the applicant’s submitted ADZ model based upon consultation responses.**  | **ADZ Model output undertaken by Cefas in sensitivity testing of the altered parameters**  | **Impact level from the Environmental Statement Framework utilising the ADZ modelled output from Cefas** | **NRW (Permitting Service) Consideration of impacts for ongoing determination based upon available evidence of turbine impacts[[1]](#footnote-1)** | **NRW (Permitting Service) Consideration of impacts for ongoing determination from the Environmental Statement Framework (utilising modelled impacts due to turbine strike alone) based upon current available evidence (see Environmental Statement Matrices below)** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Atlantic Salmon | 5.915% | Medium turbine impactSignificance “Moderate adverse effect” | Population Area: Half of Swansea BayThe applicants modelling assume a random distribution of salmon throughout the Swansea Bay area. Advice received in response to the Further Information consultation states that salmon are more likely to be concentrated towards the river mouth/spend more time within that area. It is acknowledged that this cannot be accommodated directly within the model however Cefas advise that halving the population area to half of Swansea Bay would be expected to have approximately the same effect as assuming a linear decline in the density of fish, or time spent by fish, from the river mouth to the edge of the Bay. Migration Cut off: 1st November for returning adults and migration window for smolts of 1st April – 1st June*1st November Cut off:* The data from the Panteg trap indicates that about 94% of Salmon were caught before 1st November and well over 99% by 1st December. Cefas advise that in view of the fact that fish exiting the lagoon would still have to be attracted into the river and negotiate the barrage and lower reaches before reaching Panteg Trap it is considered adult salmon would need to escape the lagoon no later than 1st November. Therefore, the applicants proposed cut-off date of 1st December is too late and should be moved to 1st November for modelling purposes. *Migration window 1st April – 1st June for Salmon Smolts*Cefas advise that salmon smolts normally emigrate during April and May in the southern part of UK and that the limited evidence available indicates that they move rapidly offshore, migrating northwards towards the Norwegian Sea. Surveys in the Norwegian Sea (>68° N) have shown that salmon post-smolts originating from rivers around the Irish Sea have reached that area by July (ref: EU-SALSEA-Merge project). As a result, it would be a major concern if smolts were delayed in the lagoon until that time. It is possible that even a short delay will have an adverse effect, and so the cut-off date should be set at 1st June at the very latest.Data from the River Afan shows that Salmon Smolts have been seen to run between mid-March to mid-June, with the majority running between April in May. Noting the majority arrive in April, the arrival date has been moved from 1st May to the 1st April.*Parameter alteration not taken forward: Retention Time* It is considered that there is a potential that salmon may be retained in the lagoon for a period of time. However, Cefas advise that there is insufficient information on the likely effects of retention in the lagoon to determine whether a maximum retention time (MRT) should be applied and, if so, what value to use.  There is some evidence (e.g. from studies of sea trout in the River Glaslyn and salmon tracking studies in SW England) that if fish are prevented from migrating for a period, they may be deterred from continuing their normal migratory behaviour, but there is currently no clear basis for setting a specific MRT for any life stage of salmon.  Inclusion of any MRT will increase the impact estimates, and the shorter the MRT the greater will be the increase.Cefas provided the results of sensitivity analysis in which if an arbitrary MRT is set at 5 days then the impact level would double. Given the lack of available evidence to set the MRT parameter Cefas highlight that they do not advise that the impact assessments should be doubled for salmon.  The NRW (Permitting Service) note the arbitrary nature of the 5 days provided in the Cefas sensitivity analysis and as such have not included MRT parameter in the impacts levels for determination. However this uncertainty is acknowledged and the NRW (Permitting Service) notes the impact levels are potentially higher that the 20 %. | 21% | High turbine impact“Major Adverse effect” | Minimum of 21%  | High turbine impact“ Major Adverse effect[[2]](#endnote-1)” |
| Sea Trout | 10.15% | High Turbine Impact“Major Adverse Effect” | Population Area: Half of Swansea Bay for Migratory Stages The applicants modelling assumes a random distribution of sea trout throughout the Swansea Bay area. Advice received in response to the Further Information consultation states that sea trout are more likely to be concentrated towards the river mouth/spend more time within that area. It is acknowledged that this cannot be accommodated directly within the model however Cefas advise that halving the population area to Half of Swansea Bay would be expected to have approximately the same effect as assuming a linear decline in the density of fish, or time spent by fish, from the river mouth to the edge of the Bay. Migration Cut-off date: 1st November for Returning AdultsThe data from the Panteg trap indicates that 95% of adult sea trout were caught before the beginning of November. Cefas advise that in view of the fact that fish exiting the lagoon would still have to be attracted into the river and negotiate the barrage and lower reaches before reaching Panteg Trap it is considered adult sea trout would need to escape the lagoon no later than 1st November. Therefore, the applicants proposed cut-off date of 1st December is too late and the cut-off date should be set at 1st November. Whitling Kelt (0 Sea Winter)NRW (TE) and Cefas advise that the Sea Trout life stage Whitling Kelt has not been included in the model noting that within the “survival and impacts calculations” worksheet the 0 Sea Winter fish is omitted for some age groups. This has been included within the Cefas model outputs. *Parameter alteration not taken forward due to lack of available evidence: Retention Time* It is considered that there is a potential that Sea Trout may be retained in the lagoon for a period of time. However, Cefas advise that there is insufficient information on the likely effects of retention in the lagoon to allow the NRW (Permitting Service) to determine whether a maximum retention time (MRT) should be applied and, if so, what value to use.  There is some evidence (e.g. from studies of sea trout in the River Glaslyn and salmon tracking studies in SW England) that if fish are prevented from migrating for a period, they may be deterred from continuing their normal migratory behaviour, but there is currently no clear basis for setting a specific MRT for any life stage of salmon.  Inclusion of any MRT will increase the impact estimates, and the shorter the MRT the greater will be the increase.Cefas provided the results of sensitivity analysis in which if an arbitrary MRT is set at 5 days then the impact level would double. Given the lack of available evidence to set the MRT parameter Cefas highlight that they do not advise that the impact assessments should be doubled for sea trout.  The NRW (Permitting Service) note the arbitrary nature of the 5 days provided in the Cefas sensitivity analysis and as such have not included MRT parameter in the impacts levels for determination. However this uncertainty is acknowledged and the NRW (Permitting Service) notes the impact levels are potentially higher that the 20 %. | 25.3% | High Turbine impact“Major adverse effect” | Minimum of 25 % | High Turbine impact“Major adverse effect” |
| European Eel | 0.15 | Negligible Turbine impact “Minor adverse effect” | Population Area: Western Wales River Basin DistrictCefas and NRW (TE) advise that in accordance with the Eels (England and Wales) Regulation 2009 the Management Units for which stock assessment should be conducted are River Basin District and that anthropogenic impacts should be assessed in these units. It is therefore appropriate that the relevant River Basin District the Western Wales River Basin District is utilised as the population area for all life stages of eel. Diurnal Behaviour factor: Alteration of the correction for diurnal behaviour to allow assessment for the 15% of the population to be active in the day Cefas advise that there is evidence that eel do exhibit diurnal behaviour in freshwater and estuaries being less active during the day than at night, and whilst there is less information available on the behaviour of eel at sea it is believed that marine fisheries catch eel at night. While Cefas advise that it is appropriate to apply a correction factor to take account of diurnal behaviour tracking studies which show that eel are not totally inactive during the day with 10-20% of movements occurring in daylight (e.g. Walker *et al.* 2013). Therefore the diurnal correction factor has been adjusted to take into account 15% of day time activity.  | 5.5% | Medium Turbine Impact“Major Adverse effect “ | Approximately 6% | Medium Turbine Impact“Major Adverse effect”  |
| Shad (Allis and Twaite)  | 1.57 | Low turbine impact“Moderate adverse effect “ | Diurnal Behaviour factor : RemovedIn the encounter models, the applicant has assumed that shad are only active during the day and they have therefore applied a correction factor of 0.5093 to the impact estimate for the resident stage. However, the Fish Species Datasheet for shad indicates that the diurnal behaviour relates to migration through estuaries and does not provide evidence of diurnal behaviour in the sea. On the basis of no evidence provided to support that shad are only active in the day the correction factor for diurnal behaviour has been removed in the Cefas ADZ model outputs. *Parameter not altered due to lack of evidence/data*The applicants submitted Alternative Fish Impact Assessment Results (Table 6.7) indicate that the age structure of Twaite Shad is estimated by providing an annual mortality of 0.67. However elsewhere in the submitted documentation the applicant states that shad have a maximum age of at least 10 years. This maximum age has not been taken account of in the applicants’ model outputs.Based on the immediately available data Cefas advise that it is not possible to conduct a full assessment based upon a maximum age of 10 years upon the age structure of shad and the STRIKER mortality rates for the age classes (sizes) passing through the turbines. Given the availability of data this has not been investigated further. The NRW (Permitting Service) acknowledge the further uncertainty associated with the chosen model output figures. | 2-4% | Medium Turbine Impact“Major Adverse effect “ | 2-4 % However the uncertainty of the potential impact of age structure the impact may be higher | Medium Turbine Impact “Major Adverse effect” |
| River Lamprey | 1.47 | Low turbine impact“Minor adverse effect” | Population Area: Bristol Channel The applicant in the submitted model utilises an assumption that 75% of population is assumed to adopt a behaviour of remaining in the Bristol Channel. Cefas advise that there is little evidence to support that 75% of River Lamprey stay within the Bristol Channel Population area and 25% move off to the Celtic Sea. Therefore, given the level of available evidence this parameter has been set at the smaller Bristol Channel level for all life stages. Diurnal behaviour factor: RemovedIn the encounter models, TLSB has assumed that river lamprey are only active during the night and therefore applied a correction factor of 0.4907 to the impact estimate for the resident stage. However, the Fish Species Datasheet for River Lamprey indicates that the diurnal behaviour relates to migration through estuaries and does not provide evidence of nocturnal behaviour in the sea. On the basis of no evidence provided to support River Lamprey are only active at night the correction factor for diurnal behaviour has been removed in the Cefas ADZ model outputs.  | 2.85% | Medium Turbine Impact“Major Adverse effect “ | Approximately 3 % | Medium Turbine Impact“Major Adverse effect “ |
| Sea Lamprey | 2.80 | Medium turbine impact category“Major adverse effect”  | Population Area: Bristol Channel for Resident phaseThe applicants’ submitted ADZ model provides annual impacts of emigrating sea lamprey transformers with the population area as Swansea Bay and for returning adults and residents with a population area as the Bristol Channel. The total impact on the population is assumes that sea lamprey remain at sea for 3 years before spawning once but the resident stage is split between the Bristol Channel and the Celtic Sea. The evidence provided for these assumptions is unclearThe parameter for the resident phase has therefore been set at the Bristol Channel. Diurnal behaviour factor: RemovedIn the encounter models, the applicant has assumed that sea lamprey are only active during the night and they have therefore applied a correction factor. However, the Fish Species Datasheet for sea lamprey indicates that the diurnal behaviour relates to migration through estuaries and does not provide evidence of nocturnal behaviour in the sea. On the basis on no evidence provided to support sea lamprey are only active at night the correction factor for diurnal behaviour has been removed in the Cefas ADZ model outputs | 4-7% | Medium Turbine Impact“Major Adverse effect “ | Approximately 4-7% | Medium Turbine Impact “Major Adverse effect” |
| Herring | 1.18 | Low turbine impact category“Minor adverse effect” | No alterations  | 1.18 | Low turbine impact“Minor adverse effect” | Approximately 1 % | Low turbine “Minor Adverse effect” |
| Common Sole (juvenile)  | 0.0018 |  | No alterations made*Parameter alteration not taken forward:* Impact to Adults not further investigatedThe applicant’s submitted model output provides values for juvenile Common Sole only. However, given the low impact to juveniles. It is not considered that this should be further assessed.  | N/A | N/A | Approximately 0.0018%  | Negligible turbine impact“Insignificant effect” |
| Sandeel | 1.39 | Low turbine impact category“Minor adverse effect” | Population present throughout the yearThe applicants submitted ADZ model included an assumption that 1/12 of the population of Sandeel are present each month throughout the year. As Sandeel are not migratory this parameter has been adjusted so that all the population are present throughout the year.Population area: Swansea Bay or Bristol ChannelPopulation area utilised with the applicant’s ADZ model sets the population area as Bristol Channel. Cefas advise that Sandeel are demonstrate a high site fidelity to a specific substrate. There is suitable substrate found within Swansea Bay. If the Sandeel population present within Swansea Bay completely mix with those within the Bristol Channel and that the population present throughout the year, the output of the model would be 15%. However, if the Sandeel within Swansea Bay form a discrete population and do not mix with the Bristol Channel the model outputs would be 100%. The extent of the mixing between the Swansea Bay population and Bristol Channel population is unknown, therefore it is not possible to further refine the model output to a single value.  | 15-100%  | High turbine impact“Moderate Adverse effect” | 15- 100% | High turbine impact “Moderate Adverse Effect” |
| Cod/whiting | 2.26 | Medium turbine impact“Moderate adverse effect” | No parameter alterations  | 2.26 | Medium turbine impact“Moderate adverse effect” | Approximately 2 % | Medium Turbine Impact“Moderate adverse effect” |
| Plaice | 0.03 | Negligible turbine impact “Insignificant Effect” | No parameter alterations  | N/A | N/A | Approximately 0.03 % | Negligible Turbine Impact “Insignificant Effect” |
| Bass | 0.96 | Low turbine impact category“Minor adverse effect” | No parameter alterations  | 0.96 | Low turbine impact category“Minor adverse effect” | Approximately 0.96 % | Negligible Turbine Impact“Insignificant Effect” |

**ENVIRONMENTAL STATEMENT MATRICES**

**Criteria used to classify the magnitude of impacts on fish and shellfish (From Environmental Statement Table 9.5, updated in further information submission of 14th July 2016 “Fisheries matters not agreed requiring clarification”)**

|  |  |
| --- | --- |
|  **Impact Magnitude** | **Annual Mortality Rate Due to Turbine Passage only** |
| High | >10% |
| Medium | >2.0 - ≤ 10% |
| Low | >1% - ≤2.0% |
| Negligible | ≤ 1% |

**Fish and Shellfish Valued Ecological Receptors (VER) within the Swansea Bay Tidal Lagoon study area and their relative geographical importance. (From Environmental Statement, Table 9.2, updated following 27th January 2016 Meeting between the applicant, NRW TE, NRW PS and Cefas)**

|  |  |
| --- | --- |
| **VER** | **Value** |
| **Migratory fish species** |
| European eel, allis shad, twaite shad, sea lamprey | International importance |
| Other diadromous fish (atlantic salmon, river lamprey and sea trout) | National importance |
| **Other fish and shellfish** |
| Common Sole | National importance |
| Herring  | Regional importance |
| Sandeel | Regional importance |
| Other demersal and pelagic species | Regional importance |
| Commercial Shellfish | Regional importance |

**Significance of an impact resulting from the combination of receptor sensitivity/value**

**and the magnitude of the effect upon it (From Environmental Statement, Table 9.4 provided by applicant updated in Further information submission of 14th July 2016 “Fisheries matters not agreed requiring clarification”)**

|  |  |
| --- | --- |
| **Value/importance** | **Magnitude (Positive/Adverse)** |
| **Neutral** | **Negligible** | **Low** | **Medium** | **High** |
| **Very High/International** | No impact | Minor | Moderate | Major | Major |
| **High/National** | No impact | Insignificant | Minor | Moderate | Major |
| **Medium/regional** | No impact | Insignificant | Minor | Moderate | Moderate |
| **Low/local** | No impact | Insignificant | Insignificant | Minor | Moderate |

**Permitting Service determination of the appropriate model methodology**

The Applicants “Further Information submission” of the 8th July 2016 (and revised for clarity and resubmitted on 14th July 2016) provides modelled outputs for turbine impact utilising the STRIKER model (to model turbine injury rate) and either Individual Behaviour Model (IBM), Draw Zone model or Alternative Draw Zone model.

Based upon the current available evidence the NRW (Permitting Service) consider that the model combination of the STRIKER and Alternative Draw Zone model is consider to provide the best available potential impact values, the reasoning for this is provided below. The NRW (Permitting Service) acknowledge the uncertainties associated with the STRIKER and Alternative Draw Zone models and as such considers that an “uncertain” confidence level is assigned to the figures (as per 9.3.4.7 of the applicant’s Environmental Statement).

STRIKER model: The STRIKER model is utilised to assess turbine strike mortality rates. Whilst many of the previous applications of the STRIKER model has predominately been utilised in the freshwater environment, Cefas advise that as the model largely depends on the physical properties of the turbines and the size of the fish Cefas a broadly content with the of STRIKER model. The NRW (Permitting Service) therefore consider that based upon the information available that the STRIKER model is the best available tool for assessing turbine injury rate.

Individual Behaviour Model (IBM): Advice received from NRW (TE) and Cefas state that the model does not taking into account key life cycle stages (for example residency) for most fish species and there are concerns with a number of parameters such as regards to the navigational rules. The NRW (Permitting Service) therefore consider that based upon the available evidence the IBM model cannot be considered to provide reliable estimates for the potential impacts.

Draw Zone Model (DZ) and Alternative Draw Zone Model (ADZ): The applicant’s submission provides the results of two alternative modelling scenarios to the IBM, the Draw Zone model and the Alternative Draw Zone Model. As the draw zone model is based upon Hammar *et al*. which was developed primarily to estimate encounters with tidal stream turbines, Cefas advise that the DZ model is not ideal for the assessing potential impacts of lagoon turbines. The alternative draw zone method was developed as a variation to the DZ method but applies a probability for fish, within a certain distance of the DZ, entering the DZ as a proportion of direction choices a fish could make. The values from the ADZ model are on average 10% greater than the Draw Zone model with the same parameter values. Therefore, the Permitting Service consider that the more precautionary ADZ values are utilised.

1. The NRW (Permitting Service) highlight this this value is calculated based upon the outputs of the ADZ model and does not take account of none turbine related impacts or any mitigation. [↑](#footnote-ref-1)
2. The term “Adverse effect” is taken from the Environmental Statement and does not imply that the NRW (Permitting Service) consider that there will be an adverse effect upon European Sites in the context of the Conservation of Habitats and Species Regulations (2010) or as risk of deterioration of Waterbodies classified under [The Water Environment (Water Framework Directive) (England and Wales) Regulations 2003](http://www.opsi.gov.uk/si/si2003/20033242.htm). The assessment of the impact levels under this legislation will be undertaken by the NRW (Permitting Service) in due course. [↑](#endnote-ref-1)