Appendix 9.4

Fish Turbine Passage Modelling

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Swansea Tidal Lagoon

STRIKER v4 Fish Turbine Passage Modelling

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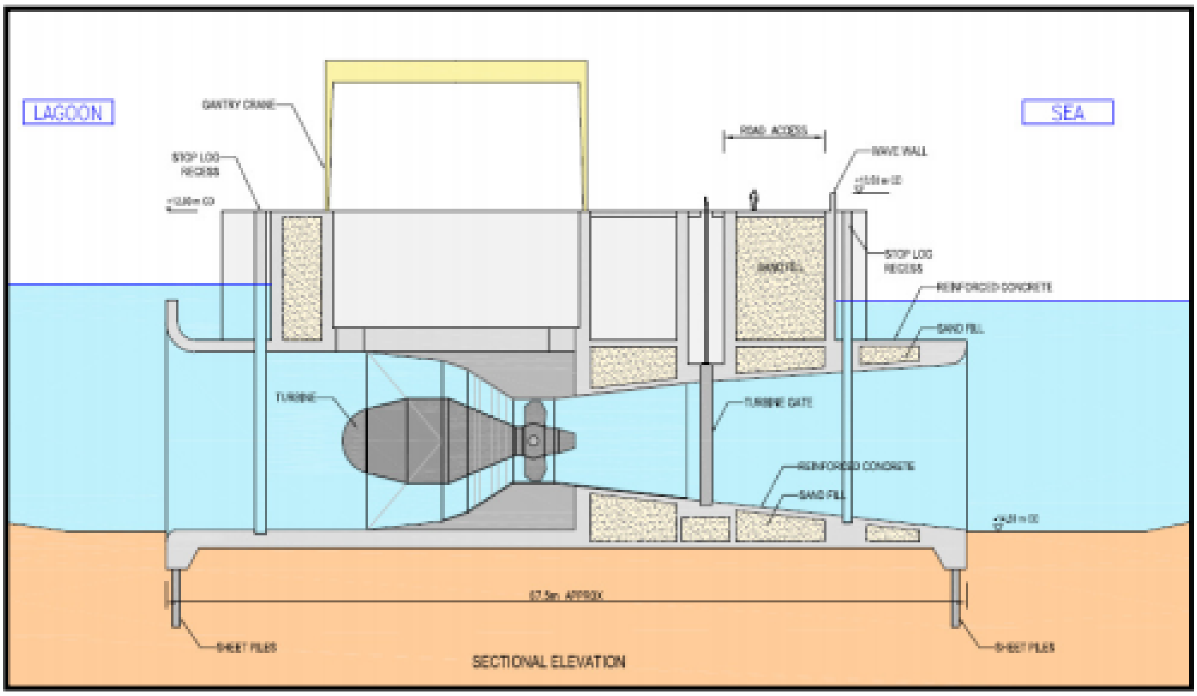

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Swansea Tidal Lagoon: STRIKER v4 Fish Turbine Passage Modelling

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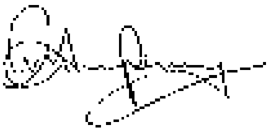


Turnpenny Horsfield Associates Ltd

Swansea Tidal Lagoon: STRIKER v4 Fish Turbine Passage Modelling

Contents

1.0 Introduction

1.0.0.1 Tidal Lagoon Swansea Bay (TLSB) Ltd propose to develop a tidal lagoon for the purpose of generating energy in Swansea Bay, Wales. The scheme design presently uses up to 16 hydroelectric turbines, which will generate power by extraction of potential energy as water moves from the high to low tidal water levels across the lagoon wall. The turbines will be orientated for maximum power extraction efficiency on the ebb tide (as the tidal lagoon empties) but will also generate power, albeit at a slightly lower efficiency, on the flood tide as the lagoon refills. The overall flux of water into and out of the lagoon will be augmented by opening up to ten large sluices around the high and low water periods to maximise the hydraulic head for the next generation period.

1.0.0.2 Fish and other swimming organisms (nekton) present in the tidal volume tend to follow the water flow and will enter and exit the lagoon from time to time. The tendency of fish to enter and leave the lagoon will differ according to the habits of each species, but may be related to such factors as lifestage redistribution requirements, seasonal, diurnal and tidal feeding movements and spawning migrations. Since fish can only enter or leave the lagoon via either the turbines or the sluices (the greater proportion of flow will be exchanged via the turbines), a proportion of those passing via the turbines will risk injury as a result of contact with the rotating blades (known as "runners") and other stresses associated with turbine passage. The quantification of fish injury risk during turbine passage is the subject of the present report using the STRIKER v.4 turbine fish passage injury model. The smaller risk of fish injury during passage via the sluices is considered in the Environmental Statement Volume 1.

1.0.0.3 A separate Fish Behaviour Modelling Study has been undertaken for the TLSB project (Appendix 9.3 of the Environmental Statement) to estimate the extent and frequency of such movements and is used in conjunction with the outputs from the present fish turbine passage modelling study to quantify the overall risk of fish being injured as a result of turbine passage.

2.0 Description of Proposed Turbines

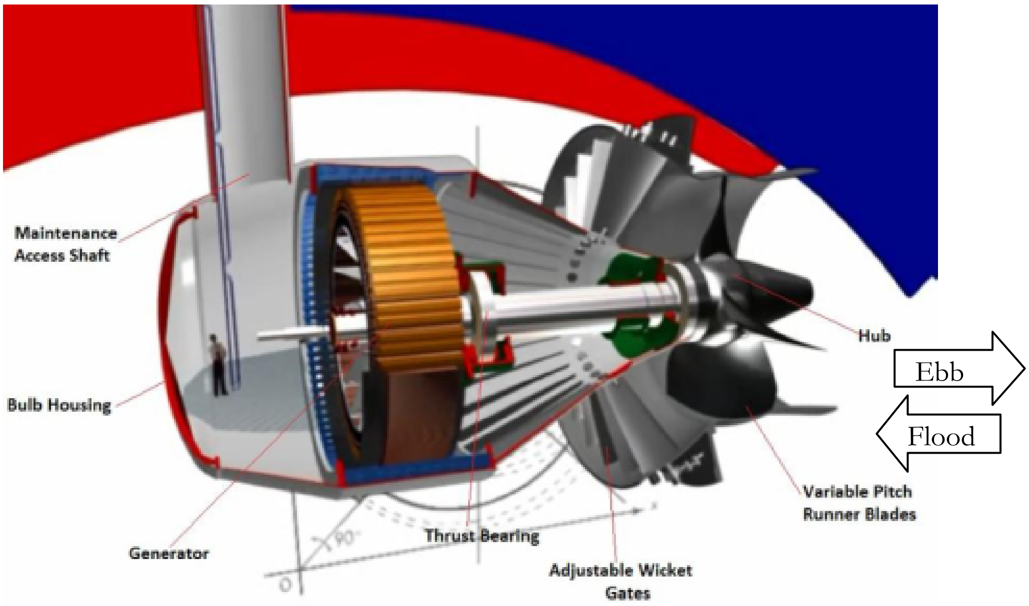


Figure 1 Illustration of axial flow turbine showing the main elements. White arrows show flow direction on ebb and flood tides.

2.0.0.1 The TLSB project will use up to sixteen hydroelectric turbines (worst case) with the following characteristics (provisional):

i.	Turbine type..	axial-flow bulb turbine
ii.	Attitude..	horizontal axis
iii.	Runner diameter..	7.0 m
iv.	Hub diameter...	2.31 m
v.	Number of blades...	3
vi.	Rotation rate (fixed)...	67 rpm (maximum)
vii.	Regulation...	double-regulated
viii.	Fish-friendly features..	minimum gap runner
ix.	Draft tube submergence.......................................	-7m chart datum

2.0.0.2 The turbines will be operated in three modes:

i. Ebb tide generation, in which flow passes through the turbine in the optimum direction: guide vanes=> runner=> draft tube (Figure 1). Turbine efficiency is within the range 80-90% over most of the operating range.

ii. Flood tide generation, in which flow passes through the turbine in the reverse direction: draft tube => runner=> guide vanes (Figure 1). Turbine efficiency is lower under this condition (~70-80%).

iii. Sluicing. During periods around high and low tides when the sluices are opened to fill or drain the tidal lagoon, water will also be allowed to sluice through the turbines. Under this condition the guide vanes will be fully open and the runners will free-wheel.

3.0 Fish Stress and Injury Types and Mechanisms in Hydraulic Turbines

3.0.0.1 This section provides the technical background to the STRIKER v.4 model used in the study to predict fish injury rates.

3.0.0.2 Most work in this field derives from studies of non-tidal hydropower schemes but the general principles are applicable to tidal power if differences such as operating head and bi-directional flow are taken into consideration. In addition to specific references identified in later sections, key works on this subject, and fish-friendly turbine design concepts in general, include: Von Raben (1957), Monten (1985), Čada *et al.* (1997, 2001), Odeh (1999, 2000), Turnpenny *et al.* (2000); a useful review is also given in Eicher *et al.* (1987). Relevant studies dealing specifically with fish passage in relation to tidal (barrage) power include Solomon (1988), Turnpenny *et al.* (1992), Turnpenny (1997) and Turnpenny and Everard (1999). There have been more recent studies dealing with fish injury risk in relation to hydrokinetic (tidal stream) turbines but these are not relevant to potential-energy tidal lagoon generation and are not therefore discussed here.

3.1.1 Mechanical Injury

3.1.1.1 Biological factors, such as the species, length and mass of entrained fish influence the injury rates due to mechanical causes. In addition, mechanical damage is dependent on flow and velocity, number of turbine blades and spacing between them, the geometry of the flow passages and whether the turbines have adjustable guide vanes and runner blades.

Strike

3.1.1.2 Strike injuries can occur when a fish collides with the fixed elements of the turbine water passages, including guide vanes (wicket gates), stay vanes or with the rotating turbine runner blades, at sufficient velocity. Strike injuries may include scale and mucous loss, bruising, eye injury, spinal fracture and internal bleeding. The likelihood and extent of injuries depends on the velocities involved and the shape of the blade's leading edge (Turnpenny *et al.*, 1992).

3.1.1.3 The variables affecting the probability of a fish striking a runner blade were identified by Von Raben (1957), who developed one of the first equations for predicting probability of strike. Important physical variables identified were the length of the fish, the geometry and number of blades in the turbine runner, the rotational speed of the runner and the discharge through the runner. Later work by Monten (1982) considered the effect of velocity of impact on risk of fish injury, which is related to the relative velocity of the runner blade to that of the fish. The relative impact velocity is also a function of the location along the blade where impact occurs, with impact velocity increasing as radial distance along runner blades increases from a runner blade's hub to its tip. Turnpenny (1998) also showed by experiment that the fish's surface area to mass ratio partly determines whether a fish will strike the blade or be swept around it, introducing the further variable of fish mass, although this can be substituted by linear dimensions of the fish such as length. In a more recent investigation, Kibel *et al.* (2009) have come up with a critical impact pressure of 2.5 kg/cm^2, above which fish injury will usually occur. Impact pressures with turbine components other than the runner blade are normally low enough to discount injuries arising from contact with them, as impact velocities are lower and profiles are generally more rounded (thicker).

3.1.1.4 Ploskey and Carlson (2004) reviewed four papers describing variants on blade-strike models (Von Raben, 1957; Bell 1991; Turnpenny, 2000; and Pavlov *et al.* 2002) and found that they were all essentially mathematically the same; therefore it is not necessary to consider the merits of alternative models.

3.1.1.5 The estimation of runner strike injury is discussed at length by Turnpenny (1998). If we were to regard a fish as a rigid object behaving like a stick, then the probability of a fish being struck by the blade is primarily dependent on fish length, the number of runner blades, their speed of rotation and the rate at which water passes through the blades. To avoid a strike, the 'stick' must pass through after the passage of one blade and before the arrival of the next. The quicker it passes through, the less likely the strike, so both axial water velocity and the relative motion of the fish through swimming will affect this. Von Raben (1957) coined the term "Water Length", which is defined as the axial length of water that passes the runner between the blade-passes at any point. For our theoretical 'stick', assuming it is aligned axially to the runner, its length must be less than or equal to the water length for it to pass undamaged and if it is the same length as the Water Length it must be perfectly positioned between the blades to pass without blade contact; if it is longer than the water length, it will definitely be struck by the runner, while if it is shorter than the water length, the probability of a strike declines with decreasing size. This is a simple, deterministic model of chance. Von Raben (1957) presented this mathematically as follows:

$$\text{Injury Rate} = \boldsymbol{L} * \boldsymbol{M}/\boldsymbol{W} \qquad (1),$$

where L is the water-length, calculated as:

$$\boldsymbol{W} = \underline{\boldsymbol{U}_{axial}}/\cos \boldsymbol{\alpha}\, (\boldsymbol{n} * \boldsymbol{s}/60) \qquad (2),$$

3.1.1.6 and $\boldsymbol{n}$ is the number of runner blades, $\boldsymbol{s}$ the rotational speed in rpm, and $\boldsymbol{U}_{axial}$ is the axial water velocity, calculated as discharge /runner swept area. The angle a is that formed between the streamlines and the axis of the turbine at runner's leading edge. The term $\boldsymbol{M}$ is known as the "Mutilation Ratio" and is a factor that takes account of the fact that, at some points on the fish's body, the contact will be glancing (e.g. the tail flexes out of the way) and the fish will not be injured. For eels, Von Raben (1957) estimated $\boldsymbol{M}$=0.43. This removes the assumption that a fish behaves like a stick (for which $\boldsymbol{M}$ would equal unity).

3.1.1.7 Broadening this concept, Turnpenny (1998) showed by experiment that $\boldsymbol{M}$ is a variable, dependent on fish mass and hence, when moving in a flow, its momentum. Essentially, the fish's probability of blade contact is a contest between its momentum, which tends to make it continue towards the blade, and the drag force of the water, which tends to pull it around the blade. A small fish has a relatively high surface area to mass ratio and the drag force wins; large fish, vice versa. A newly hatched larva, as an extreme example, will not be affected by blade strike.

3.1.1.8 The above description assumes that fish approach the runner with their long axis aligned with the flow streamlines, which represents the worst possible case: any deviation from this alignment would effectively reduce the 'apparent' length of the fish relative to the Water Length (Solomon, 1988), reducing strike probability. The papers listed above contain much debate on the likely orientation of migratory fish as they enter a hydroelectric turbine. Coutant and Whitney (2002) concluded that this behaviour is highly variable, depending species, lifestage and other factors. Dheng *et al.* (2011) found that fish strike models gave the best fit when any possible orientation of fish was assumed. Assuming random orientation is therefore the reasonable course. The assumption of random orientation allows the average 'apparent' length to be used. This is calculated as the average sine of the fish length, $\boldsymbol{L}$ for angles from 0 to 90 degrees (Turnpenny *et al.*, 1992), which equates to a factor of 0.67. When estimating fish blade-strike probability, the fish length is first multiplied by this factor.

3.1.1.9 Observations of turbine-passed fish reported in a review by Eicher (1987) indicate that strike-related injuries in Kaplan turbines increased with impact velocity; minimal mortality was seen at impact velocities of less than 12 ms^{-1} and observations indicated that impact velocities of 6 ms^{-1} or less would eliminate strike-related mortality. Experimental studies reported by Turnpenny *et al.* (1992) showed that collision velocities of less than 7 ms^{-1} with near-hub blade profiles in a bulb turbine would be unlikely to harm fish. Also working with salmonids, Alden Laboratories in the USA have developed relationships between survival and the fish length ($\boldsymbol{L}$) and blade thickness ($\boldsymbol{t}$) versus strike speed (Figure 2). These show an effect similar to that described by Kibel *et al.* (2009), except that in this case fish size is represented as length rather than body mass.

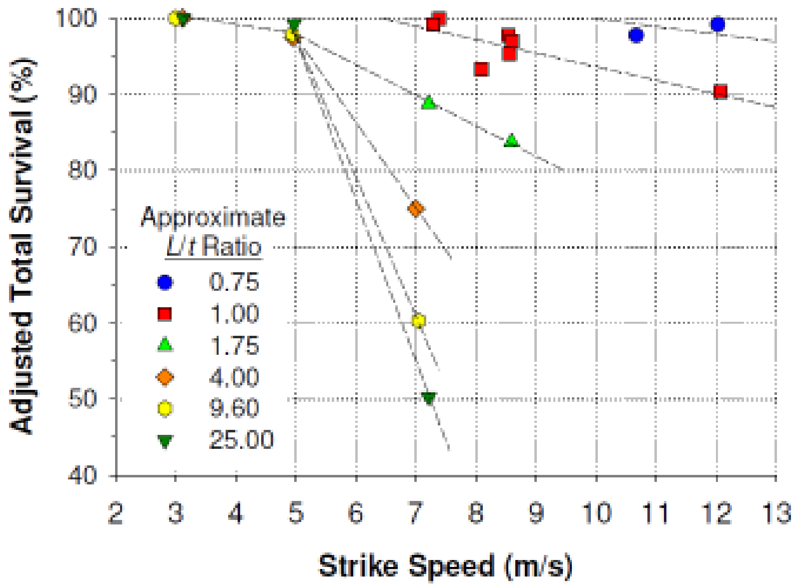


Figure 2 **Blade strike survival rates of rainbow trout tested at various fish length to leading edge thickness ratios (*L*/*t*) over a range of strike velocities (Alden Labs, undated).**

3.1.1.10 Turnpenny (1998) showed that fish up to 200g had around a 75% chance of colliding with the runner when their centre of gravity aligns with the leading edge, increasing to 100% for fish of greater mass than this. Most fish will not be precisely aligned in this way and Turnpenny *et al.* (2000) developed a regression equation for estimating the risk of blade strike using the following formula:

$$\boldsymbol{M} = 0.1533 \log_e \boldsymbol{L} + 0.0125 \quad (3).$$

3.1.1.11 $\boldsymbol{M}$ in this expression is equivalent to Von Raben's Mutilation Ratio but here it becomes applicable to a wider range of fish by making it a fish-length-dependent variable.

Abrasion

3.1.1.12 Abrasion is the ***rubbing*** action of a fish against a fixed turbine component, typically the stay vanes, guide vanes and penstock and draft tube walls. This is not expected to contribute significantly to overall injury frequency (Solomon, 1988) and is not considered further here.

Grinding

3.1.1.13 Grinding injury can occur when a fish is drawn into small clearances (gaps of sizes close to that of the fish). Flow tends to pass more easily through these areas of lower resistance, drawing fish with it. Where unregulated ***turbines*** are used, very small engineering clearances can be achieved, effectively eliminating injury risk from this source. Double-regulated bulb turbines of the type proposed for Swansea use adjustable runner blades and guide vanes and traditional non-fish-friendly designs leave gaps between the rotating blades and vanes and the flow housings within which they operate. There is no existing method for predicting injury risk of this type. However, newer fish-friendly designs recognise and virtually eliminate this risk by ensuring that discharge rings around the blade have a spherical profile in which a minimal clearance is maintained at all runner and guide vane settings, and similar measures are used to avoid gaps at other points. In order to minimize fish mortality in the Swansea turbines, gaps between the blades and the shroud as well as between the blades and the hub will be kept to a minimum throughout the blade stroke. This is achieved by having a spherical shroud centred on the runner (this way the blade outer edge follows the shroud throughout its stroke) and by optimizing the hub shape. Incorporation of minimum gap designs makes it unnecessary to include this aspect in fish injury risk modelling. Gaps on a conventional Kaplan turbine between the blade tip and discharge ring and between the blade and the hub are reduced in the minimum gap runner by changing the shape to a more spherical profile (Figure 1 and Figure 3).

Figure 3 Comparison of (a) normal Kaplan runner and (b) minimum gap runner concept at two tilt angles (Čada, 2001).

3.1.2 Pressure Change

3.1.2.1 Fish are subjected to a sequence of pressure changes as they pass through a tidal power turbine. The typical pattern is illustrated in Figure 4, calculated for the larger tidal range (up to 15 m) for the earlier Severn Barrage scheme (Turnpenny *et al.*, 1992). Note that a 1.0 bar change in pressure is equivalent to a 10 m change in immersion depth. Depending upon its starting level in the water column, a fish may be initially drawn down towards the turbine entrance, which increases the hydrostatic pressure (phase 1). As it crosses from the upstream to downstream side of the turbine runner (phase 2), it experiences a hydrostatic pressure drop equivalent to the head difference across the turbine. However, additional pressure change effects in phase 2 arise from (a) the rotation of the water as it passes through the turbine (swirl) and (b) hydrodynamic changes associated with fluid flow across the guide and stay vanes and turbine runner blade.

3.1.2.2 Swirl is deliberately imparted to the flow by the guide vanes to achieve the optimum flow direction approaching the runner. For a fish entering the turbine at the top of the turbine in the 12 o'clock position, a flow rotation of ≥180 degrees in a 7 m diameter turbine would imply a pressure change of 7 m or 0.7 bar from this cause alone. This factor is added to the centre line hydrostatic profile (following the theoretical line of pressure through the centre of the turbine); depending on the radial position where fish enter the turbine, swirl may increase or decrease the pressure flux experienced by the fish.

3.1.2.3 Hydrodynamic pressure changes occur as a result of low-pressure areas that develop in the wake of guide and stay vanes and the runner blade. Fish passing close to the blades or structures may enter these zones and experience sudden severe pressure drops.

3.1.2.4 Phase 3 represents passage through the draft tube and return to the water body on the downstream side of the turbine. Pressure changes here result from a combination of swirl, large scale water turbulence and exiting of fish into the free water column.

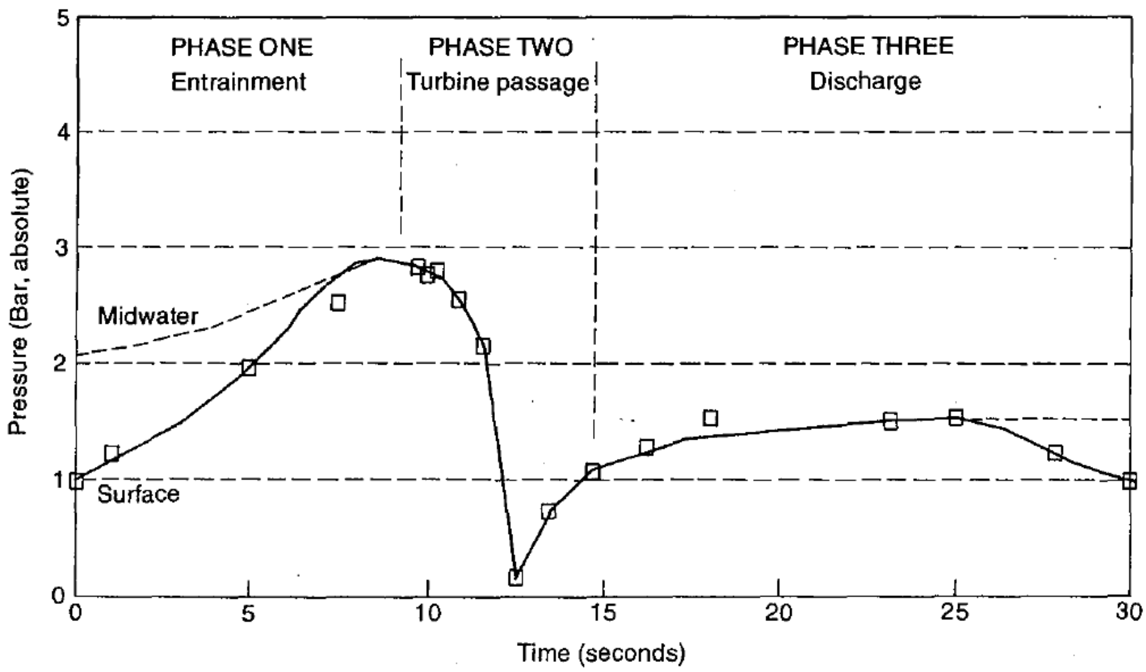


Figure 4 Typical pressure time-series representing passage of a fish through a tidal-power turbine. This is known as the 'meanline curve' (Turnpenny, 1998).

3.1.2.5 Over a tidal cycle, the operating hydraulic head across the turbine changes continuously. The range of heads over which the Swansea turbines will operate is from 1.45 m to 5.5 m (Figure 15). Figure 5 shows how pressure changes experienced by fish might vary according to tidal changes in operating head, and the range of possible values caused by the various factors described above. The example was calculated for a 9 m turbine but will be broadly similar in pattern for the 7 m turbine, allowing for reduced swirl radius The pressure range will be slightly reduced owing to the lower range of operating heads at Swansea compared with the earlier Severn Barrage proposal discussed by Turnpenny *et al.* (1992).

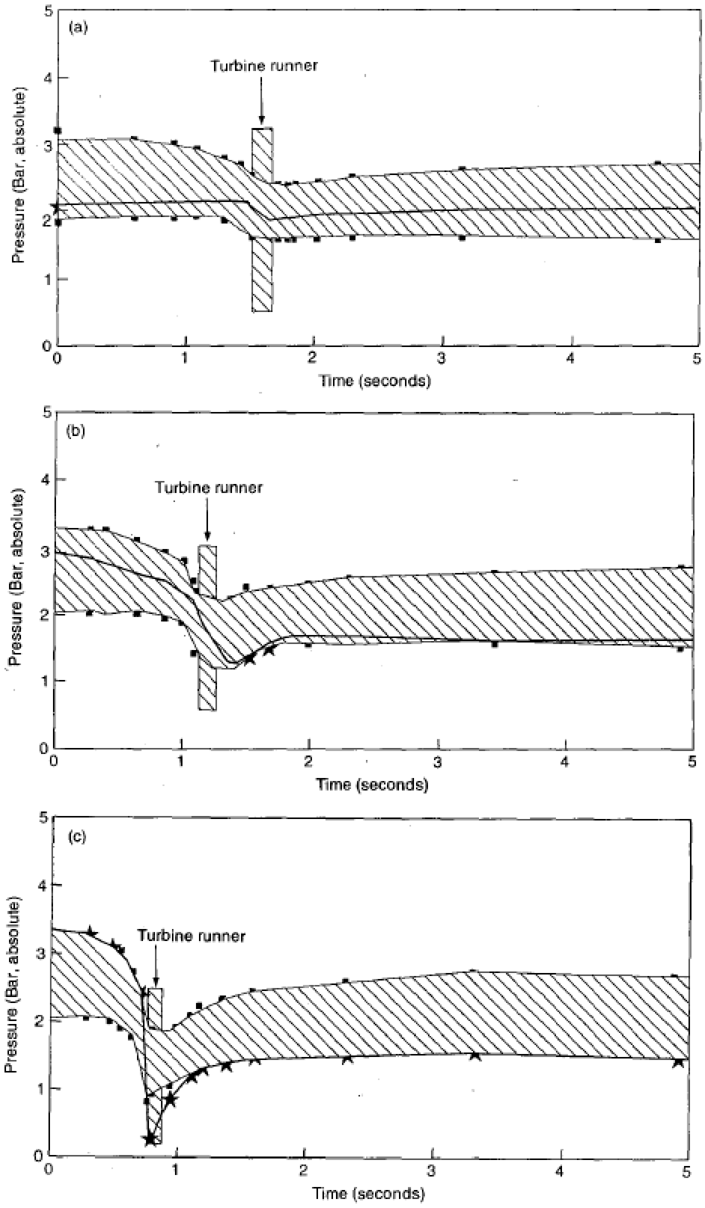


Figure 5 **Pressure flux trajectories for a 9 m axial flow tidal power bulb turbine at three different operating heads: (a) 3 m head, (b) 5 m head (c) 6 m head. Shaded area is range envelope and solids lines are mean fish exposures (Turnpenny, 1998). Note that entry pressures to the left of the plot are based on a 10 m invert on the turbine intake, but this value will vary in different installations.**

3.1.2.6 The examples from top to bottom in Figure 5 illustrate best case to worst case pressure change occurring within the turbine structure. Any individual fish may follows any trajectory within the envelope shown. CFD modelling (McCewan & Scobie, 1992) is used to estimate the probabilities of fish experiencing different values within the range.

3.1.2.7 The rapid pressure increases and decreases experienced by an entrained fish can be reliably simulated in the laboratory, and as a result more is known about this stress than any other. Figure 6 shows the apparatus used by Turnpenny *et al.* (1992) in pressure flux experiments on UK marine and estuarine fish species as part of an earlier tidal power programme. In these trials, pressure changes experienced by a fish are reported relative to the fish's acclimation pressure prior to entering the turbine system.

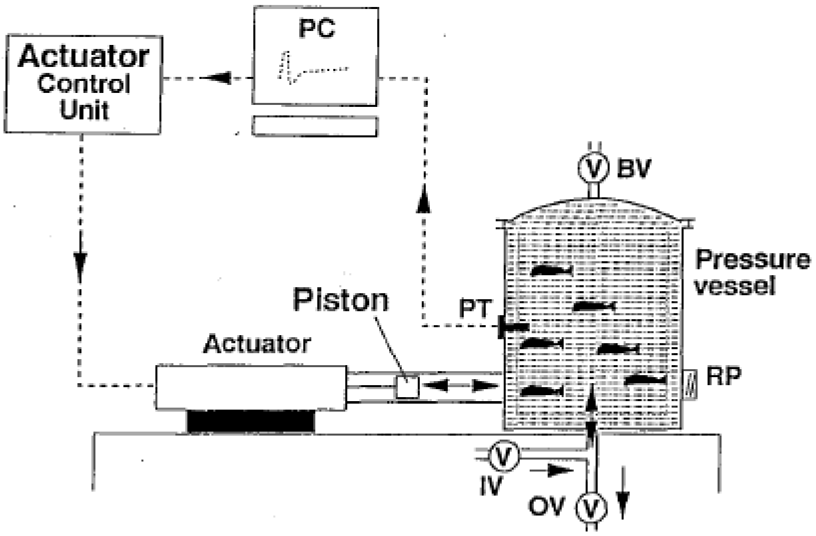


Figure 6 Laboratory pressure flux apparatus used by Turnpenny *et al.* (1992)

3.1.2.8 Pressure changes exert their effect on fish either through causing changes in the volume of the gas-filled swimbladder, or through causing outgassing of body fluids to cause gas bubble trauma, or 'embolisms'. The formation of embolisms can occur in body fluids in any part of the fish's body and can be observed to form e.g. in between fin rays, but is most damaging when they block blood vessels (similar to 'the bends' in divers) or form within the eye capsule (Abernethy *et al.*, 2001). Pressure increases do not appear to cause direct damage to entrained fish, although compression of the swimbladder may affect buoyancy control. Thus effects of concern are a consequence of exposure to reduced external pressure.

3.1.2.9 Considering pressure reduction effects on swimbladders, fish can be divided into the following categories:

i) Fish without swimbladders (e.g. elasmobranchs, lampreys, mackerel) or with non-functional vestigial swimbladders (e.g. flatfishes).

ii) Fish that regulate swimbladder volume by gulping air at the water surface or venting excess volume to the atmosphere via the gut (physostomes: e.g. herring, shad).

iii) Fish that regulate swimbladder volume through vascular exchange (physoclists: e.g. cod, whiting, bib).

iv) Fish with a hybrid vascular and venting system (physoclistostomes: e.g. eel).

3.1.2.10 Category (i) fish are exempt from swimbladder-related effects but can suffer from gas embolisms in the bloodstream, eyes and other organs. Fish in all other categories are subject to the effects of Boyle's law, i.e. a halving of external pressure will cause the swimbladder to double in volume. Taking e.g. the moderate case shown in Figure 5(b), a fish starting on the left of the time sequence at an acclimation pressure of 3 bar absolute (2 bar relative to atmospheric) and experiencing a pressure minimum of around 1.2 bar absolute (0.2 bar relative to atmospheric) the swimbladder would expand to more than twice its initial volume, which the fish can usually withstand without injury. In the worst case shown in Figure 5(c), the expansion factor would be around 32, which would almost certainly cause the swimbladder to rupture. Fortunately, such extreme conditions are rare and can be estimated by computational fluid dynamics (CFD) modelling of 3-dimensional flow within the turbine.

3.1.2.11 For information on passage pressure effects on fish, the work by Turnpenny *et al.* (1992) remains the most relevant, since it deals with the same type of tidal power turbine and examined biological effects on UK fish species relevant to the Severn Estuary and Swansea Bay. Key findings are shown in Table 1 and may be summarised as follows:

i. If the decrease to sub-atmospheric pressures is large and virtually instantaneous (Worst Case, Figure 5c), the swimbladder, particularly in physoclistous fish such as bass, whiting and sand smelt, may rupture. Haemorrhaging of eyes and internal bleeding was not uncommon under these conditions.

ii. If pressure decrease is less rapid (e.g. Moderate Case, Figure 5b), swimbladder rupture is unlikely but haemorrhaging of eyes and internal bleeding can occur (notably in the gadoid, whiting). These symptoms are related to outgassing and formation of gas emboli.

iii. No effects were evident under the Best Case (Figure 5a) scenario.

3.1.2.12 Čada *et al.* (1997) reviewed data on responses of physostomes and physoclists to rapid pressure change and this database was expanded by Turnpenny *et al.* (2000) using further data from Turnpenny *et* al., (1992) to develop the following formulae to predict mortality rates (M) which are used within the STRIKER v.4 model:

Physoclists $M (\%) = -38.83 \ln (x) + 1.756$ (equation 1)

Physostomes $M (\%) = -3.997 \ln (x)+1.571$ (equation 2),

where x= exposure pressure (Pe) /acclimation pressure (Pa).

Table 1 Summary of fish responses to pressure changes associated with simulated tidal turbine passage (adapted from Turnpenny *et al.*, 1992).

Species	Best Case **(Figure 5a)**	Moderate Case **(Figure 5b)**	Worst Case **(Figure 5c)**
Salmonids *Salmo salar, Salmo trutta*	No effect	No effect	20-30% swimbladder rupture
Eel *Anguilla anguilla*	No effect	No effect	No effect
Whiting *Merlangius merlangius*	No effect	5-10% eye haemorrhaging	10% swimbladder rupture 5-10% eye haemorrhaging
Clupeids *Clupea harengus, Alosa*	No effect	No effect	No effect

fallax			
Sand smelt *Atherina presbyter/ boyeri*	No effect	No effect	83% swimbladder rupture
Bass *Dicentrarchus labrax*	No effect	No effect	10% swimbladder rupture 23-24% eye haemorrhaging
Sole *Solea solea*	No effect	No effect	No effect

3.1.3 Shear Stress and Turbulence

3.1.3.1 Shear stress occurs in fluids across a velocity gradient. A fish that enters such an area is exposed to shearing forces across its body, which can lead to various forms of trauma, including scale and mucus loss from the body surface, injuries to exposed delicate organs, principally the eyes and gills (Turnpenny *et al.*, 1992; Čada *et al.*, 2007). Since turbulence results in the formation of vortices across which there may be strong velocity gradients, shear stress and turbulence are closely linked.

3.1.3.2 Turbulence occurs on different scales and these are important to the fish as illustrated in Figure 7. Small-scale turbulence (a) acts on particular delicate body parts such as skin and scales, eyes or gills; intermediate scale turbulence can cause bending and torsion injuries; large-scale turbulence can displace and disorientate the fish.

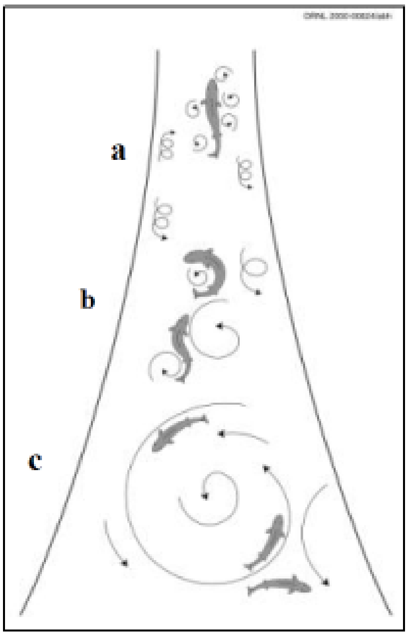


Figure 7 Different scales of turbulence and their effects in relation to fish size (Odeh *et al.*, 2002)

3.1.3.3 Shear stress, like pressure, is a force per unit area, and has the same units, Newtons per square metre (Nm^{-2}); but whereas a pressure is directed perpendicular to a surface, shear stress acts parallel to the surface. In some studies, this effect is represented by another metric, the strain rate, defined as the mean change in water velocity over distance (e.g. Neitzel *et al.*, 2000), as this quantity is more readily extracted from some computational programs. The present study considers shear stress rather than strain rate, as the most relevant biological response data for fish species occurring in Swansea Bay area are again those reported using this metric by Turnpenny *et al.* (1992).

3.1.3.4 Within a turbine, shear stress results from two effects: small-scale turbulence near the runner and small-to-large-scale turbulence in the section downstream of the runner (Čada *et al.*, 1997). Generally the highest shear stresses occur where the relative velocity of water to turbine components is maximal, i.e. close to the runner. As relative velocities in the order of 20-30 ms^{-1} are typical in flows near the blade tips, and the velocity at the blade surface is zero, the strongest gradients and most damaging shear stresses occur in these regions, with high levels in close proximity to the blades (Figure 8). Fish entering this high-shear-stress envelope around the blades are therefore at most risk of injury, the greatest concern here being from small-scale turbulence creating localised but intense shear stress pockets that cause the kinds of trauma listed above. This may be regarded also as the 'near-miss' zone for strike injury. As it only occupies a small proportion of the overall water passage through the turbine available for fish to pass (at least during high efficiency ebb flow generation), the probability of exposure to damaging shear stresses while passing the runner is correspondingly small. It can be computed using probabilistic statistics relative to a defined shear stress injury threshold.

3.1.3.5 When the turbine is operating in (sub-optimal) flood-generation mode, the volume around the runner in which high shear stress levels occur is likely to be higher owing to the poorer hydraulics, but the risk of shear-stress-related injuries will not necessarily be higher, as lower relative velocities between blade and water tends to limit the occurrence of more extreme shear stress values (McEwan and Scobie, 1992).

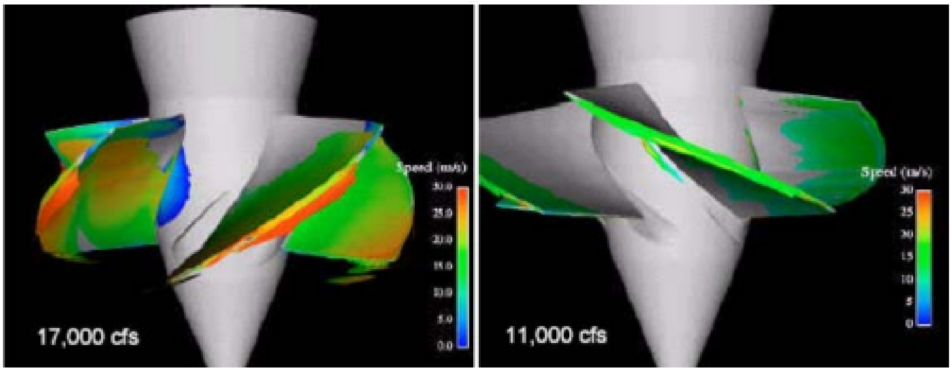


Figure 8 Damaging shear zones in Kaplan turbines (Garrison *et al.*, 2002)

3.1.3.6 The second area of potentially high shear stress is downstream of the blades, where turbulent wakes are generated. It is here that the larger scales of turbulence occur that can disorientate fish or cause torsion-related injuries such as spinal fracture in more extreme conditions (Čada *et al.*, 1997). For the ebb-tide case turbulent wake formation occurs within the draft tube, and for the flood-tide case within the turbine's normal intake section. Again, as the turbine will be operating more efficiently in the ebb-tide case, downstream flow will be less chaotic than in the flood-tide case.

3.1.3.7 Shear stresses will also be generated at other points in the turbine, around the guide and stay vanes and in proximity to the casing walls. However, as these components are static, the shear stress values will be much lower than those around the blades. Shear stress values around the blades during turbine sluicing will also be relatively low, as the hydraulic head during sluicing phases will limit water velocities through the turbines.

3.1.3.8 Biological responses to shear stress have been studied by a number of investigators using high-speed water jets injected into a still body of water to generate locally high shear stress levels, using variations on an apparatus originally described by Groves (1972). This creates intense, small-scale shear stress levels that can be used to simulate the damaging small-scale shear stresses occurring in turbines. The method was adopted in more than ten years of study in the US Department of Energy's (USDOE) "environmentally friendly" turbine programme, which established a shear stress fish injury threshold of of 1600 Nm^{-2}, a value used as a guideline in fish-friendly turbine design in the USA (Čada *et al.*, 2007*)*. These authors calculated that only 0.6% of fish passing through a large Kaplan turbine (the example given is Wapanum on the Columbia River, having a runner diameter of ~7 m, similar to proposed turbines for Swansea) would be harmed by shear stress. It should be noted that the damage criterion was derived only from research on juvenile Chinook salmon (*Oncorhynchus tshawytscha*). The findings most relevant to Swansea Bay are those reported by Turnpenny *et al.* (1992), who examined effects on a number of UK marine and estuarine fish species of shear stress levels ranging from zero to 3410 Nm^{-2}. From this, the USDOE criterion 1600 Nm^{-2} appears to be appropriate for species other than clupeids. Shad and herring, on the other hand, are easily injured by shear stress levels as low as 206 Nm^{-2}.

Table 2 Effects of shear stress levels on fish in laboratory experiments reported by Turnpenny *et al.*, (1992). Note: mortality data corrected against Control (zero shear stress) vales.

Fish Species	Shear Stress Level Nm^{-2}			
	206	774	1920	3410
Salmonids: Atlantic salmon, age 2-gp smolts	No detectable effect	No detectable effect	Slight mucous and scale loss. 28% of fish with eye injury. 4% mortality after 7 d	Slight mucous and scale loss. 32% of fish with eye injury. 8% mortality after 7 d
Salmonids: Brown trout, age 1-2 gp	No detectable effect	No detectable effect	Slight mucous and scale loss. 10% of fish with eye injury. 20% mortality after 7 d	Slight mucous and scale loss. 10% of fish with eye injury. 10% mortality after 7 d
Clupeids: Herring, age 0-group	Light mucous and scale loss. 100% mortality within 1 h	>20% mucous and scale loss per fish. Eye haemorrhage in 60%.100% mortality within 1 h	Average 58% mucous and scale loss per fish. 60% eye injury. 40% with torn jaws/operculum.100% mortality within 1 h	Average 90% mucous and scale loss per fish. 40-60% eye injury. 20% with torn jaws/operculum.100% mortality within 1 h
Clupeids: Twaite shad	Not tested	Not tested	Not tested	Average 90% mucous and scale loss per fish. 40% eye injury. 20% with torn jaws/operculum.100% mortality within 1 h

Flatfish: Sole	Not tested	No detectable effect	Heavy loss of mucous. 65% mortality within 7 d	Heavy loss of mucous. 75% mortality within 7 d
European eel	No detectable effect	No detectable effect	Some mucous loss. 7-d survival not affected	Some mucous loss. 7-d survival not affected
Percids: Bass	Not tested	Not tested	Average 9% mucous and scale loss per fish. 13% with gill injury. 7% bleeding into body cavity. No survival data	Average 10% mucous and scale loss per fish. 8% with gill injury. No survival data
Gadids: Whiting	Not tested	Not tested	Average 5% mucous and scale loss per fish. 20% with eye injury. 20% with torn jaws/operculum.100% mortality within 1 h	Average 5% mucous and scale loss per fish. 28% with eye injury.

3.1.3.9 Within the natural environment, fish are exposed to shear stresses associated with fast flowing water and bed features, turbulence around waterfalls, etc. Čada and Odeh (2001) reviewed records of naturally occurring shear-stress levels, which in streams and rivers appear to seldom exceed a few tens of Nm^{-2} and only exceeded 2000 Nm^{-2} in the most extreme flash flood events in small basins. It is therefore unsurprising that most fish appear to be well adapted to cope with values of a few hundred Nm^{-2}. A notable exception are the clupeids, which experiments have shown are susceptible to injury when exposed to even relatively low levels of shear stress of ~200 Nm^{-2}. The pelagic habit of clupeid fishes such as shads and herrings ensures that they normally avoid contact with the bed and other solid structures and therefore scale loss is avoided. An exception in their lifecycle is when they deposit their eggs on gravel spawning beds, immediately after which mortality in these fish is naturally very high[1].

3.1.4 Cavitation

3.1.4.1 Cavitation is the rapid vaporisation and condensation process in a liquid. In turbines it can occur mainly in the wake of the runner blades where local areas of reduced pressure arise near the blades, and in cavitating vortices shed by the blades (Solomon, 1988). The collapse of vapour bubbles can sometimes be violent and cause noise, vibrations and pressure fluctuations. As this can cause pitting in the runner blades, turbine designers strive to ensure that cavitation does not occur. This is achieved by good hydraulic design, minimising areas of reduced pressure, and by submerging the turbine deep enough to maintain adequate hydrostatic pressure in the draft tube. Čada *et al.* (1997) state that "turbine designs that minimise pressure reductions to no more than 60 per cent of ambient will not cavitate, and cavitation related injury to fish will not occur". In the Swansea scheme the turbines will be

[1] http://www.wyeuskfoundation.org/isac/shad.php

set at a level of -7m below Chart Datum to prevent cavitation and it is not expected that cavitation will be a significant source of fish injury.

3.1.5 Post-Passage Effects

3.1.5.1 The trials reported by Turnpenny *et al.* (1992) examined survival of simulated turbine-passage stresses over a period of up to seven days post exposure. The extended monitoring period allowed delayed mortalities to be assessed, and recovery from injury. Some types of trauma, for example swimbladder rupture, will heal with time as evidenced by scar tissue on fish subjected to pathological examination after this period. Nonetheless, it has generally been assumed for environmental assessment purposes that any fish injured during turbine passage will be sufficiently disadvantaged in predator confrontations to count them as dead.

3.1.5.2 The question of whether uninjured fish that have passed through a turbine are also put at a disadvantage in such confrontations has also been investigated. Odeh *et al.* (2002) exposed a variety of salmonids and percid fish species to turbulence levels typical of turbine passage, then subjected them to the silhouette of an avian predator (61 cm wingspan cormorant). While some reduced startle response was evident, no statistically significant response could be demonstrated. Subsequently, Čada *et al.* (2003) developed a technique to measure the 'C-start' escape response in fish subjected to sublethal stresses. Čada *et al.* (2006) applied this technique at the Wapanum hydroelectric site, to fish that had passed through the ~7 m runner-diameter turbines. They measured the C-start response at 1, 5 and 15 min after collection, and compared these to non-turbine-passed controls and were unable to detect differences between test and control groups. Both groups of authors offer cautions in the interpretation of their findings on the basis of sample sizes and handling techniques employed.

4.0 The STRIKER v.4 Turbine Fish Passage Model

4.1 Model Description

4.1.0.1 STRIKER ™ is a computer model for estimating fish injury/mortality rates during passage through hydroelectric turbines. The original version (STRIKER v.1) was developed by Fawley Aquatic Research Laboratories (Turnpenny *et al.*, 2000) on behalf of the UK Department of Trade and Industry's Energy Technology Support Unit (ETSU) and dealt specifically with salmonid passage through small (runner diameter typically <2 m) Francis and Kaplan/propeller turbines in low-head run-of-river applications. However it relies upon principles originally developed in the Severn Tidal Power Group programme (Turnpenny *et al.,* 1992; McEwan and Scobie, 1992; Turnpenny, 1988) and on biological data from the same source. Later versions (STRIKER v.2, v.3) were developed for site-specific applications while STRIKER v.4 is designed for tidal head (i.e. not hydrokinetic) power schemes. STRIKER v.4 has the following additional features:

i. Supports multiple fish species (for which species-specific biological response data must be available).

ii. Calculates Von Raben $\boldsymbol{M}$ by species according to species-specific fish shape (length divided by maximum body diameter, known as 'fineness ratio'), as well as length values, as per Turnpenny (1998) and Turnpenny *et al.* (2000).

iii. Allows the orientation (degrees relative to flow angle at runner), or random orientation and swimming speed of the fish (body lengths per second) as they enter the runner section to be specified as per Turnpenny *et al.* (1992).

iv. Computes probability of blade strike resulting in injury according to position along the blade (requires input of blade profile data), collision velocity and size and fineness ratio of the fish.

v. Allows the sinuosity factor of the fish to be input where this might affect the apparent length of the fish for strike probability computation (normally set to 0.9 for eel and lamprey as per Solomon, 1988, p.29 and 1.0 for other species).

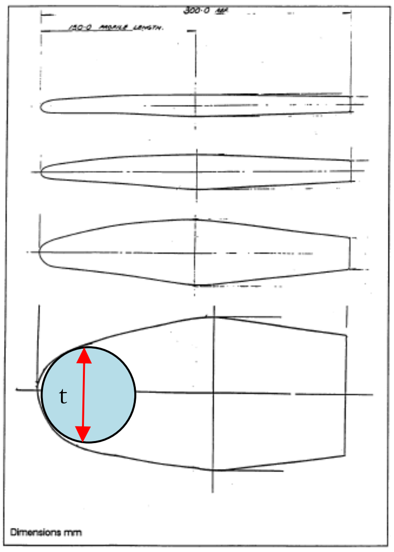
vi. Includes effect of turbulence/shear stress data for on- and off-design turbine operating conditions as per McEwan and Scobie (1992) to enable use for turbine operation when well away from the design point, or in reverse-flow generation. Off-design data were derived from CFD analysis with a blunt rectangular runner blade section, as opposed to the hydraulically streamlined profile used to represent the on-design condition.

4.2 Input Data for Swansea

4.2.1 Fixed Turbine Parameters

4.2.1.1 Fixed turbine parameters are a function of turbine design rather than operation and include runner and hub diameter, number of blades and rotation rate. Values of these parameters for the Swansea turbines are as follows:

FIXED TURBINE PARAMETERS (all dimensions in mm except where stated)	
Rotation rate (rpm)	60
Turbine hub diameter	2310
Turbine runner diameter	7000
Number of blades	3
Guide vanes present (1=yes, 0=no)	1



Position	*t*, mm
Tip	15.3
	15.6
	21.0
Hub	86.3

Figure 9 Runner blade profiles for 9 m reference turbine, from tip (top) to hub (bottom) (Turnpenny *et al.*, 1992). Blade thickness, *t*, is measured as the diameter of the circle (shown in blue) best fitting the tip profile. Values of *t* are shown the table alongside.

4.2.2 Turbine Operating Parameters

4.2.2.1 A number of turbine parameters vary according to operation, notably as a result of tidal state. Shown below is the input table for variable parameters. Below that, Table 3 shows the allowable values estimated by the turbine designers for the Swansea scheme.

4.2.2.2 STRIKER v.4 requires inputs on the flow rate, net operating head and whether operating in ebb or flood generation mode. In flood generation mode it uses CFD data on shear stress derived from the 'blunt' (rectangular section) blade profile to mimic the off-design condition (see section 4.2.3).

VARIABLE TURBINE PARAMETERS	
Flow rate (cumecs) - set as appropriate for nett operating head (below)	297
Ebb (set as 1) or flood tide (set as 0)	1
Nett operating head (m)	6.5

Table 3 Allowable flow, guide vane angle and net head values for Swansea Axial Flow turbines, when operating in ebb or flood generation modes.

	Ebb		Flood	
Net Head (m)	Flow (m3/s)	Guide Vane Angle (°)	Flow (m3/s)	Guide Vane Angle (°)
6.5	297	62	345	95
5.3	375	73	375	95
5.25	375	73	375	95
4.75	375	75	375	95
4.25	375	77	375	95
4	375	78	375	95
3.75	370	79	370	95
3.25	360	80	360	95
2.75	350	81	350	95
2.5	344	82	344	95
2.25	360	82	360	95
1.75	300	83	300	95
1.7	294	83	295	95
1.25	280	84	280	95

4.2.3 Turbine CFD Data

4.2.3.1 Turbine CFD analysis provides data on the probabilities of occurrence of potential fish-stressing conditions with the turbines under different operational regimes. This can be in the form presented in Figure 5 but for STRIKER are entered as probability tables such as that in Table 4, which is that given by McEwan and Scobie (1992) for the STPG 9 m axial flow reference turbine. The 9 m turbine data have been used for the present as they are expected to hold good for a 7 m turbine. On- and off-design values are used in the Swansea scheme to represent ebb generation and flood generation respectively.

Table 4 Pressure and shear stress distributions representing passage exposure risk for a fish passing through a 9m axial flow tidal turbine (adapted from McEwan and Scobie, 1992).

Pressure Distribution		Shear Stress Distribution		
			On-Design	Off-Design
Bar abs.	Probability within Turbine, %	Nm^{-2}	Probability within Turbine, %	Probability within Turbine, %
0-0.5	8.4	50-100	52.1	56.89
0.5-1.0	0.4	100-500	31.14	28.14
1.0-1.5	9.1	500-1000	9.21	6.21
1.5-2.0	31.9	1000-2000	3.89	2.99
2.0-2.5	36.9	2000-3000	2.1	2.4
2.5-3.0	8.7	3000-4000	1.5	1.2
3.0-3.5	0.8	4000-5000	0	2.1
3.5-4.0	3.7			

4.3 Biological Data

4.3.1 Stress Response Data

4.3.1.1 The biological response data for pressure flux and shear stress used to predict fish injury/mortality rates from the physical data are taken from Turnpenny *et al.* (1992) as summarised in s.3 above.

4.3.2 Fish Species Data

Fish Species /Group	Swimbladder Type	Reason for Selection as Indicator Species
Atlantic salmon & sea trout smolt	Physostome	Important migratory species in regional and local context
Atlantic salmon & sea trout adult		
Atlantic salmon & sea trout kelt		
Shad adults	Physostome	Important migratory species in national and regional (Seven Estuary) context
Glass eel /elver	Physoclistostome	Important migratory species in national and regional (Seven Estuary) context
Silver eel	Physoclistostome	
Gadoids (cod, whiting, bib, hake etc.)	Physoclistostome	Commercial important species regionally and locally
Bass	Physoclist	Commercial important species regionally and locally
Flatfish (plaice, sole, dab, rays)	Non-functional or no swimbladder	Commercial important species regionally and locally
Lamprey	No swimbladder	Important migratory species in national and regional (Seven Estuary) context

4.3.3 Fish Length Distributions

4.3.3.1 Length distributions of fish used for modelling purposes were informed as far as possible by quarterly Swansea Tidal Lagoon Project (STLP) fish surveys, supplemented where necessary by published data. The turbine-passage mortality rates generated by the model are integrated across the length-frequency distributions.

Salmon:

4.3.3.2 No salmon (either smolts or adults) were recorded in surveys. However, parr/smolts were frequently entrained in power station intakes in the Severn Estuary and Bristol Channel in the range 83-164mm in a study by Claridge *et al.* (1986). Returning adults are generally in the range 400-750mm with some multi sea winter fish >1000mm (Maitland & Herdson, 2009; Davies *et al.*, 2004). Environment Agency fish survey and catch return data give no indication of the size of smolts or returning adults for the rivers discharging into Swansea Bay.

Sea trout:

4.3.3.3 No sea trout (either smolts or adults) were recorded in STLP surveys. However, parr/smolts as well as returning/foraging adults were frequently entrained in power station intakes in the Severn Estuary and Bristol Channel in the range 42-400mm in a study by Claridge *et al.* (1986). Returning adults vary greatly in size from 500g (Davies *et al.*, 2004) (roughly 300mm+) to over 1000mm but most are in the range 350-450mm. Environment Agency fish survey and catch return data give no indication of the size of smolts or returning adults for the rivers discharging into Swansea Bay.

Shad:

4.3.3.4 Claridge *et al.* (1986) found that twaite and allis shad sampled in four power station intakes in the Severn Estuary and Bristol Channel consisted fish in the range 24-357mm and 300-400mm respectively. The 0+ shad found in these intake studies are not found in Swansea Bay and migrating adults are likely to be in the range 300-450mm for twaite and 350-450mm for allis shad (Maitland & Herdson, 2009).

Herring:

4.3.3.5 Herring are to be separated in terms of juveniles (i.e. 0+ post larvae) and spawning adults. Claridge *et al.* (1986) found that herring sampled in four power station (PS) intakes in the Severn Estuary and Bristol Channel consisted fish in the range 25-118mm. 0+ fish at Oldbury-on-Severn PS were in the range 25-85mm. STLP Q2 survey conducted in late May shows a clear 0+ cohort likely to be associated with an early spring inshore spawning (see Fig. 1) in the range 40-70mm. However, smaller herring like those found at Oldbury PS are likely to be present in Swansea Bay in the preceding weeks.

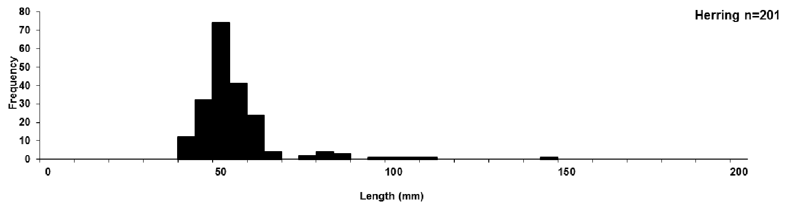


Figure 10. Herring recorded in Q2 (end of May) STLP surveys

4.3.3.6 When the herring data from Q1, Q2 and Q3 are combined there is an obvious 0+ cohort but the upper size limit is hard to define (see Fig. 2). It is likely that the situation is confused by the fact that there are both spring and autumn spawning herring populations in the Bristol Channel. However, the majority of these 0+ herring are in the range 30-90mm, and this 90mm upper limit is in line with the 85mm limit given by Claridge *et al.* (1986).

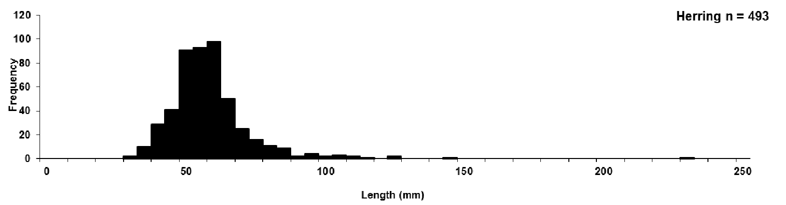


Figure 11. Herring recorded in all STLP surveys

4.3.3.7 It is therefore considered that the 0+ range should be given as 25-90 mm for herring.

4.3.3.8 The size range for spawning adults is harder to ascertain. Only one mature herring (232mm) was recorded in surveys and the power station intake datasets are not as useful in this instance as they do not tend to intercept the adult herring spawning migrations. Given that herring in the southern North Sea tend to mature at 3-4 years and the (exceptional) upper size limit is given as 400mm (Lythgoe & Lythgoe, 1975) and 450mm (Maitland & Herdson, 2009) a likely range is 200-350mm.

Silver eel:

4.3.3.9 Only the Q2 surveys recorded eel, however, these fish were yellow eel of 433 and 582mm rather than migrating silver eel. The point at which yellow eel transform into silver eel is variable and females are generally considerably larger. A study by Vøllestad, 1992 found the mean length at metamorphosis to be 406mm for males and 603mm for females. The maximum size attained (i.e. the silver eel stage) is given as 500mm for males and 1000mm for females (Wheeler, 1978). Claridge *et al.* (1986) found that eel including elver, yellow and silver lifestages sampled in four power station (PS) intakes in the Severn Estuary and Bristol Channel consisted fish in the range 65 - >1000mm in length.

Bass:

4.3.3.10 STLP Q1, Q2 and Q3 surveys found bass in the range 14-505mm (see Fig. 3) and this is confirmed by Claridge et al (1986) who gave a 26-480mm range from power station studies in the Severn Estuary and Bristol Channel. 0+ individual recent post-larvae had just arrived in Q3 surveys (July) and can be seen in Fig. 3 along with clear 1 and 2+ cohorts.

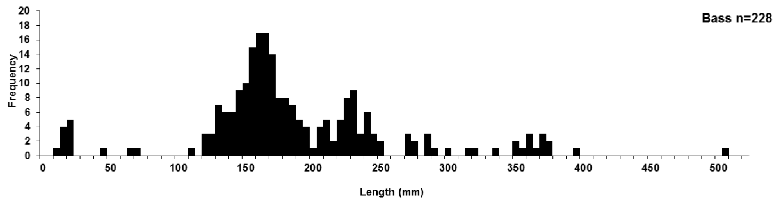


Figure 12. Bass recorded in all surveys

Plaice:

4.3.3.11 STLP surveys found plaice in the range 24-441mm (see Fig. 4) and this is confirmed to some extent by power station studies reported by Claridge *et al.* (1986) where a 28-160mm range was recorded.

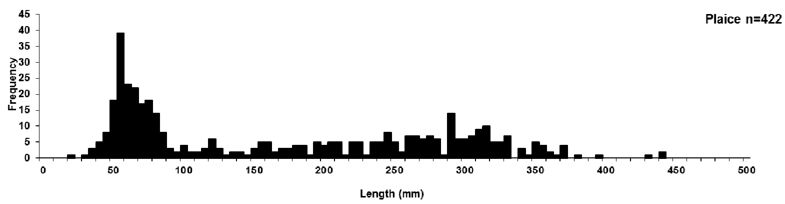


Figure 13. Plaice recorded in all surveys

Whiting:

4.3.3.12 STLP Q1, Q2 and Q3 surveys found whiting in the range 51-352mm (see Fig. 5) and this is confirmed by Claridge *et al.* (1986) who gave a 38-321mm range from power station studies in the Severn Estuary and Bristol Channel.

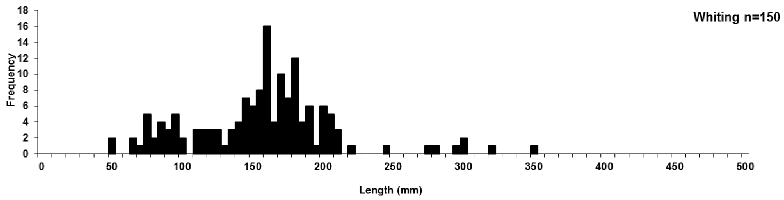


Figure 14 Whiting recorded in all the surveys

Cod:

4.3.3.13 STLP surveys have found one juvenile cod (104mm) only. However, Claridge *et al.* (1986) give a range of 55-561mm and this is likely to be consistent across shallower areas of the Bristol Channel.

River & Sea Lamprey:

4.3.3.14 River and sea lamprey have not been recorded in STLP surveys. However, the species have frequently been taken on power station intake screens in the Severn Estuary and Bristol Channel in the range 83-405mm and 560-915mm respectively (Claridge *et al.*, 1986). The size ranges for migrating adults are fairly well documented; river lamprey are on average 300-400mm with individuals up to 500mm, whilst sea lamprey are on average 600mm with individuals up to 900mm and exceptionally 1000mm (Maitland & Herdson, 2009; Davies *et al.*, 2004; Wheeler, 1978; Lythgoe & Lythgoe, 1975). The size range of emigrating juveniles of both species in this locale is harder to ascertain. Bird et al (1994) found sea lamprey in the upper Severn Estuary that had recently transformed into the parasitic marine phase in the range 155-218mm with a mean of 182mm. This corresponds to the literature which suggests that river and sea lamprey larvae grow to a maximum length of 130mm and 150mm respectively prior to transforming (Maitland & Herdson, 2009; Davies *et al.*, 2004; Wheeler, 1978; Lythgoe & Lythgoe, 1975).

4.3.4 Fish Behaviour

4.3.4.1 Model inputs for fish behaviour are shown in the data entry segment below. Solomon (1988) discusses the relevance of these parameters. For the Swansea project, random orientation of fish at the runner entry position was assumed. Swimming speed was set at zero (i.e. no upstream or downstream swimming bias). For eel and lamprey, a sinuousity factor of 0.9 was used, and 1.0 for other species.

ASSUMED FISH BEHAVIOUR	
1=random orientation, 2=drift aligned with flow, 3=swim upstream aligned with flow	1
Swimming speed, body lengths per second (use +ve values for against current, -ve for with, 0 for drift)	0
Sinuosity factor (for species other than eel and lamprey, usually set to 1.0 for most other species	1.0

4.4 STRIKER v.4 Outputs for Swansea

4.4.1.1 Each run of STRIKER v.4 generates fish passage injury rate estimates (taken here as worst case to be mortality rates) for the fish species and life stages listed in s.0 and the length distributions described in s.4.3.3.

4.4.1.2 STRIKER™ computes the Compound Injury Rate ($P_{compound}$) as:

$$P_{compound} = (1-P_{pressure}) * (1-P_{shear}) * (1-P_{strike}) \quad (3),$$

where:

$P_{pressure}$ is the probability of injury due to pressure flux,
P_{shear} that due to shear stress and
P_{strike} that due to runner strike.

4.4.1.3 Outputs are for a single combination of turbine flow, operating head and guide vane opening, using allowable combinations set out in Table 3. To obtain average mortality rates across all turbine usage, the forecast frequency distribution of net head during operation shown in Figure 15 was used. The model was run for each of these operating heads (mid-class values) with their associated flow values and guide vane settings.

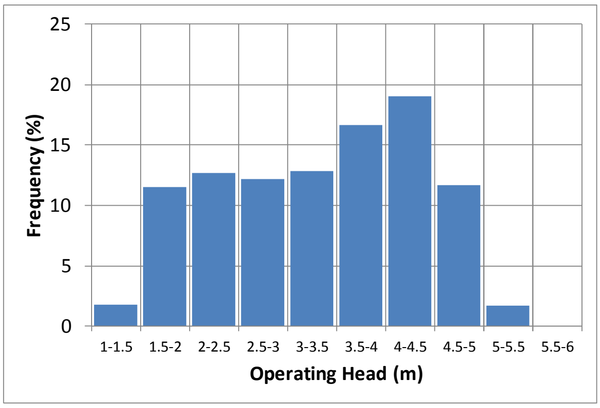


Figure 15 Frequency distribution of turbine operating head expected for the Swansea turbines

4.4.1.4 Full output tables for each species and operating head are attached in Appendix 2 of this report. An example is shown in Figure 16. These include details of fish size distributions used in each case, the predicted injury rates due to 'strike', 'shear' and 'pressure' respectively and the resultant compound value for fish of a given size.

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine				Atlantic salmon & sea trout smolt	
Fish species:			Atlantic salmon & sea trout smolt				Length-weighted mortality rate	
Operating Condition:			Flood Tide	Net head=		1.25 m		
Discharge =			280.00	cumecs	Off design			
Fish swimming condition:	1		Fish swimming speed			0 bl/s		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length (cm)	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.37	0.8%	1.71%	0.33%	2.8%	10.0%	0.3%
15	10	0.43	1.4%	1.71%	0.33%	3.4%	70.0%	2.4%
20	13	0.47	2.2%	1.71%	0.33%	4.2%	15.0%	0.6%
25	17	0.51	2.9%	1.71%	0.33%	4.9%	5.0%	0.2%
					Atlantic salmon & sea trout smolt			3.6%

Figure 16 Example of STRIKER v.4 output table for a single species/lifestage and operating condition (in this flood tide generation at a net operating head of 1.25 m)

4.4.1.5 The final output from these tables is a compound mortality rate weighted for fish size distribution. Tables in Appendix 3 & 4 of this report then give predicted fish injury rates across different operating heads, and a frequency-weighted average value. A summary of data from these tables is given in Conclusions.

4.4.1.6 The STRIKER v.4 modelling presented here provides indicative estimates of fish injury rates during a single pass of the turbine for a selection of the key species of conservation, commercial and recreational interest in the locality. The model brings together more comprehensive biological response data than has previously been deployed in such models. The STRIKER model outputs are not intended to be used in isolation but in conjunction with fish turbine encounter rate estimates derived from modelling studies. By combining encounter rates with turbine passage injury rates, estimates of population attrition rates associated with turbine operation can be made.

4.4.1.7 Table 5 and Table 6 respectively give single-pass injury rates for ebb and flood generation. These are the final outputs that are applied in the Swansea Tidal Lagoon environmental impact assessment. Within the IBM fish encounter model used to make the overall mortality estimates, each individual fish carries its complete set of attributes with it as it moves within the model. If it passes through a turbine, its probability of injury is calculated, depending on its species, size and the tidal state/turbine operating state at the time.

5.0 Conclusions

5.0.0.1 The STRIKER v.4 modelling presented here provides indicative estimates of fish injury rates during a single pass of the turbine for a selection of the key species of conservation, commercial and recreational interest in the locality. The model brings together more comprehensive biological response data than has previously been deployed in such models. The STRIKER model outputs are not intended to be used in isolation but in conjunction with fish turbine encounter rate estimates derived from modelling studies. By combining encounter rates with turbine passage injury rates, estimates of population attrition rates associated with turbine operation can be made.

Table 5 Predicted Percentage Fish Injury Rates Over Operating Head Range, Ebb Tide Generation

Species/Lifestage	**Tidal Condition: Ebb**									
	Net Operating Head (m)									
	1.25	1.75	2.25	2.75	3.25	3.75	4.25	4.75	5.25	**Full Tidal Range**
Atlantic salmon & sea trout smolt	3.3%	3.2%	2.9%	2.9%	2.9%	2.8%	2.8%	2.8%	2.9%	**2.90%**
Atlantic salmon adult	11.2%	10.6%	9.1%	9.3%	9.1%	8.9%	8.9%	8.9%	9.0%	**9.23%**
Sea trout adult	7.7%	7.3%	6.3%	6.5%	6.4%	6.2%	6.2%	6.3%	6.3%	**6.44%**
Shad adult	51.1%	50.9%	50.4%	50.5%	50.4%	50.4%	50.3%	50.4%	50.4%	**50.46%**
Herring	49.8%	49.7%	49.4%	49.5%	49.4%	49.4%	49.4%	49.4%	49.4%	**49.47%**
Glass eel/elver	0.7%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	**0.60%**
Silver eel	7.0%	6.6%	5.6%	5.7%	5.6%	5.5%	5.4%	5.5%	5.5%	**5.67%**
Gadoids	9.8%	9.5%	8.9%	9.1%	9.0%	8.9%	8.8%	8.9%	8.9%	**9.00%**
Bass	5.2%	5.0%	4.7%	4.8%	4.7%	4.9%	4.7%	4.7%	4.7%	**4.78%**
Flatfish	2.2%	2.1%	1.8%	1.9%	1.8%	1.8%	1.8%	1.8%	1.8%	**1.86%**
Lamprey	7.3%	6.8%	5.7%	5.9%	5.8%	5.6%	5.6%	5.7%	5.7%	**5.86%**

Table 6 Predicted Percentage Fish Injury Rates Over Operating Head Range, Flood Tide Generation

Species/Lifestage	Tidal Condition: Flood									
	Net Operating Head (m)									
	1.25	1.75	2.25	2.75	3.25	3.75	4.25	4.75	5.25	**Full Tidal Range**
Atlantic salmon & sea trout smolt	3.9%	3.8%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	**3.52%**
Atlantic salmon adult	11.8%	11.1%	9.6%	9.9%	9.7%	9.5%	9.5%	9.5%	9.6%	**9.81%**
Sea trout adult	8.3%	7.9%	6.9%	7.1%	7.0%	6.8%	6.8%	6.8%	6.9%	**7.04%**
Shad adult	46.6%	46.4%	45.8%	45.9%	45.9%	45.8%	45.8%	45.8%	45.8%	**45.90%**
Herring	45.2%	45.1%	44.8%	44.8%	44.8%	44.8%	44.7%	44.8%	44.8%	**44.82%**
Glass eel/elver	0.7%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	**0.60%**
Silver eel	7.0%	6.6%	5.6%	5.7%	5.6%	5.5%	5.4%	5.5%	5.5%	**5.67%**
Gadoids	11.3%	11.0%	10.4%	10.5%	10.5%	10.4%	10.3%	10.4%	10.4%	**10.50%**
Bass	5.2%	5.0%	4.7%	4.8%	4.7%	4.9%	4.7%	4.7%	4.7%	**4.79%**
Flatfish	2.2%	2.1%	1.8%	1.9%	1.8%	1.8%	1.8%	1.8%	1.8%	**1.86%**
Lamprey	7.3%	6.8%	5.7%	5.9%	5.8%	5.6%	5.6%	5.7%	5.7%	**5.86%**

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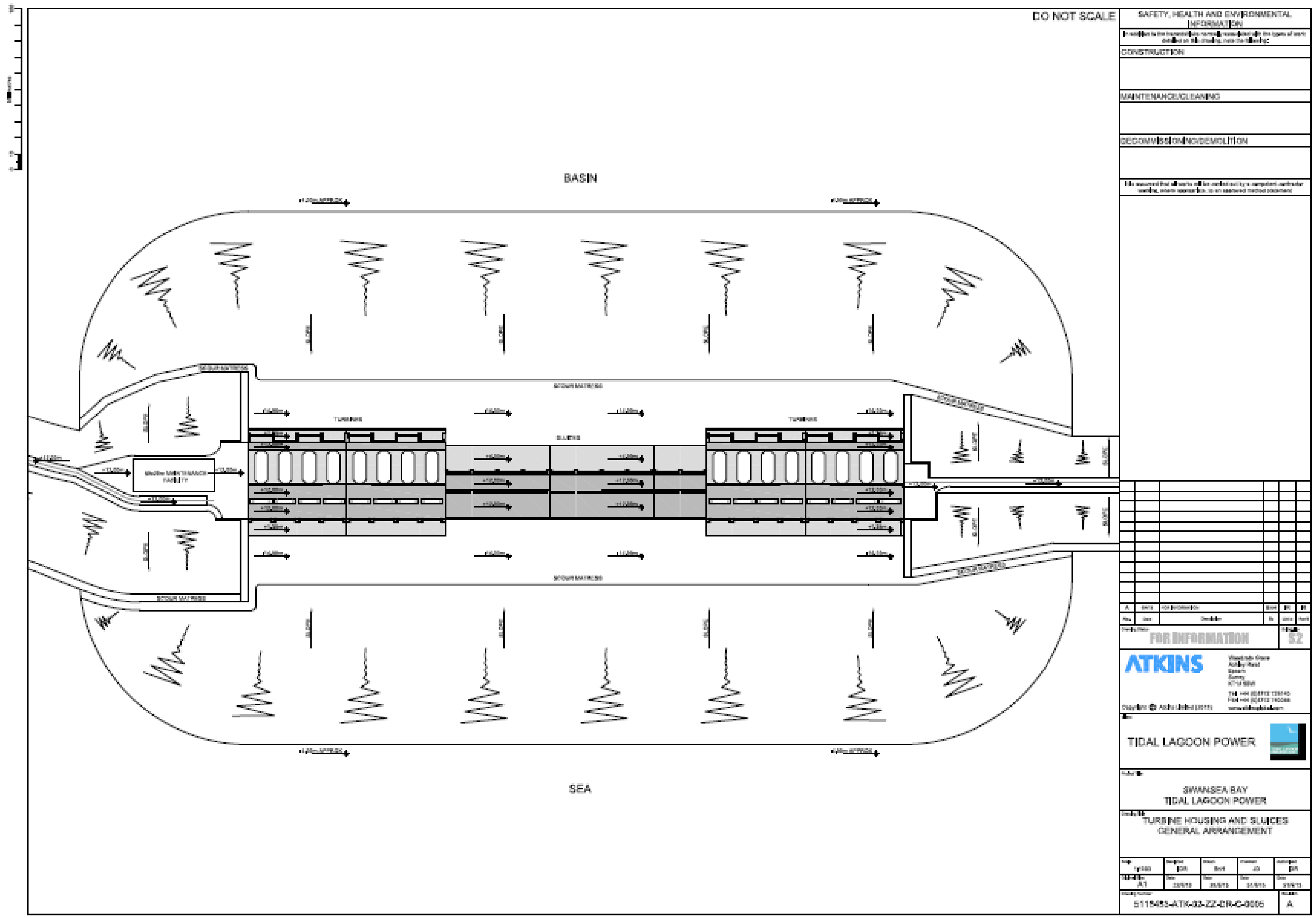
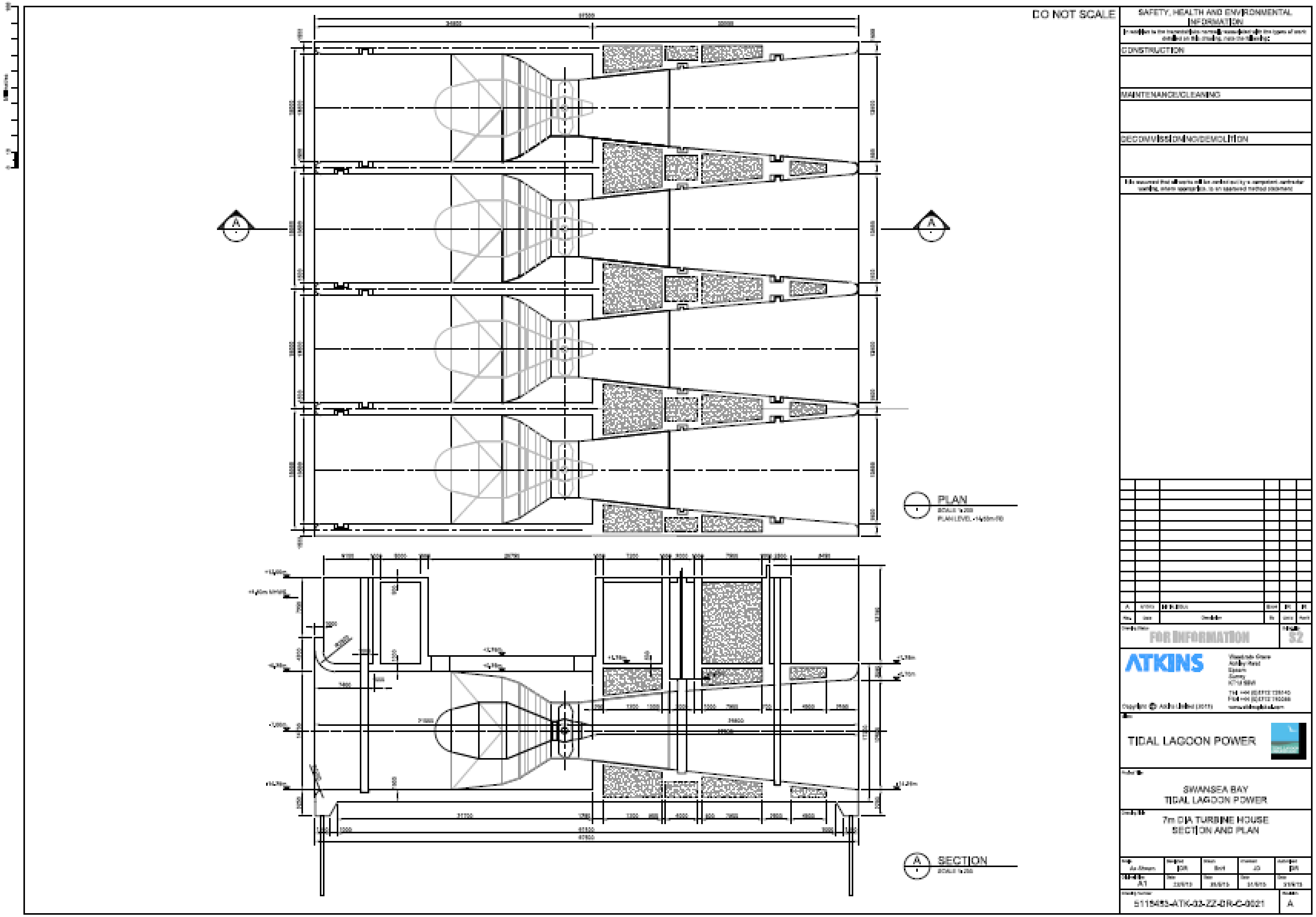
Appendix 1 Drawings

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DECOMMISSIONING/DEMOLITION
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ATKINS
TIDAL LAGOON POWER
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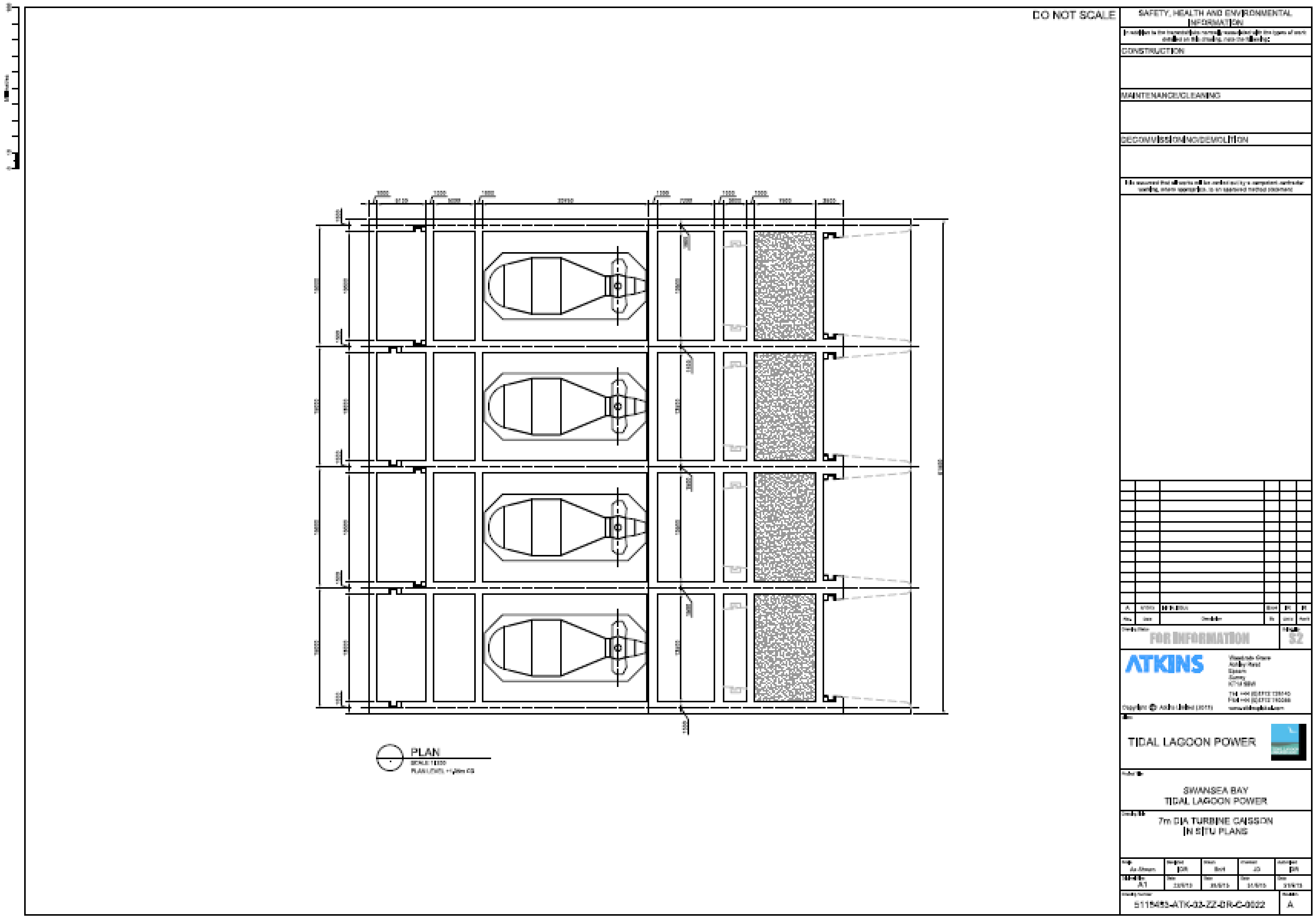
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Appendix 2 STRIKER v.4 Output tables showing predicted injury (mortality) rates for selected species and lifestages and operating heads.

Table A2.1: Operating Head: 1.25 m, Ebb and Flood Generation

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**				**Atlantic salmon & sea trout smolt Length-weighted mortality rate**	
Fish species:			**Atlantic salmon & sea trout smolt**					
Operating Condition:			**Ebb Tide**	**Net head=**		**1.25 m**		
Discharge =			**280.00**	**cumecs**	**On design**			
Fish swimming condition:	**1**		**Fish swimming speed**			**0 bl/s**		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length (cm)	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.37	0.9%	1.08%	0.33%	2.3%	10.0%	0.2%
15	10	0.43	1.6%	1.08%	0.33%	3.0%	70.0%	2.1%
20	13	0.47	2.4%	1.08%	0.33%	3.8%	15.0%	0.6%
25	17	0.51	3.3%	1.08%	0.33%	4.7%	5.0%	0.2%
					Atlantic salmon & sea trout smolt			3.1%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**				**Atlantic salmon adult Length-weighted mortality rate**	
Fish species:			**Atlantic salmon adult**					
Operating Condition:			**Ebb Tide**	**Net head=**		**1.25 m**		
Discharge =			**280.00**	**cumecs**	**On design**			
Fish swimming condition:	**1**		**Fish swimming speed**			**0 bl/s**		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
40	27	0.58	6.2%	1.08%	0.33%	7.5%	5.0%	0.4%
50	34	0.61	8.4%	1.08%	0.33%	9.7%	35.0%	3.4%
60	40	0.64	10.6%	1.08%	0.33%	11.9%	50.0%	5.9%
70	47	0.66	12.8%	1.08%	0.33%	14.1%	7.5%	1.1%
80	54	0.68	15.1%	1.08%	0.33%	16.3%	2.0%	0.3%
90	60	0.70	17.5%	1.08%	0.33%	18.6%	0.5%	0.1%
					Atlantic salmon adult			11.2%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**				**Sea trout adult Length-weighted mortality rate**	
Fish species:			**Sea trout adult**					
Operating Condition:			**Ebb Tide**	**Net head=**		**1.25 m**		
Discharge =			**280.00**	**cumecs**	**On design**			
Fish swimming condition:	**1**		**Fish swimming speed**			**0 bl/s**		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.53	4.2%	1.08%	0.33%	5.6%	5.0%	0.3%
35	23	0.56	5.2%	1.08%	0.33%	6.5%	10.0%	0.7%
40	27	0.58	6.2%	1.08%	0.33%	7.5%	70.0%	5.3%
45	30	0.60	7.3%	1.08%	0.33%	8.6%	10.0%	0.9%
50	34	0.61	8.4%	1.08%	0.33%	9.7%	5.0%	0.5%
55	37	0.63	9.5%	1.08%	0.33%	10.7%	0.0%	0.0%
					Sea trout adult			7.6%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**				**Shad adult Length-weighted mortality rate**	
Fish species:			**Shad adults**					
Operating Condition:			**Ebb Tide**	**Net head=**		**1.25 m**		
Discharge =			**280.00**	**cumecs**	**On design**			
Fish swimming condition:	**1**		**Fish swimming speed**			**0 bl/s**		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
25	17	0.51	3.3%	47.84%	0.33%	49.7%	0.0%	0.0%
30	20	0.53	4.2%	47.84%	0.33%	50.2%	20.0%	10.0%
35	23	0.56	5.2%	47.84%	0.33%	50.7%	30.0%	15.2%
40	27	0.58	6.2%	47.84%	0.33%	51.3%	30.0%	15.4%
45	30	0.60	7.3%	47.84%	0.33%	51.8%	20.0%	10.4%
50	34	0.61	8.4%	47.84%	0.33%	52.4%	0.0%	0.0%
					Shad adult			51.0%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine				Herring	
Fish species:			Herring				Length-weighted mortality rate	
Operating Condition:			Ebb Tide	Net head=	1.25 m			
Discharge =			280.00	cumecs	On design			
Fish swimming condition:	1		Fish swimming speed		0 bl/s			
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.26	0.3%	47.84%	0.33%	48.2%	0.0%	0.0%
10	7	0.37	0.9%	47.84%	0.33%	48.5%	0.0%	0.0%
15	10	0.43	1.6%	47.84%	0.33%	48.9%	0.0%	0.0%
20	13	0.47	2.4%	47.84%	0.33%	49.3%	25.0%	12.3%
25	17	0.51	3.3%	47.84%	0.33%	49.7%	50.0%	24.9%
30	20	0.53	4.2%	47.84%	0.33%	50.2%	25.0%	12.6%
					Herring			49.7%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine				Glass eel/elver	
Fish species:			Glass eel /elver				Length-weighted mortality rate	
Operating Condition:			Ebb Tide	Net head=	1.25 m			
Discharge =			280.00	cumecs	On design			
Fish swimming condition:	1		Fish swimming speed		0 bl/s			
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
6	4	0.12	0.1%	0.00%	0.33%	0.5%	30.0%	0.1%
8	5	0.16	0.3%	0.00%	0.33%	0.6%	30.0%	0.2%
10	7	0.20	0.4%	0.00%	0.33%	0.7%	20.0%	0.1%
12	8	0.23	0.6%	0.00%	0.33%	0.9%	10.0%	0.1%
14	9	0.25	0.7%	0.00%	0.33%	1.1%	5.0%	0.1%
16	11	0.27	0.9%	0.00%	0.33%	1.2%	5.0%	0.1%
					Glass eel/elver			0.7%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine				Silver eel	
Fish species:			Silver eel				Length-weighted mortality rate	
Operating Condition:			Ebb Tide	Net head=	1.25 m			
Discharge =			280.00	cumecs	On design			
Fish swimming condition:	1		Fish swimming speed		0 bl/s			
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.37	2.4%	0.00%	0.33%	2.7%	5.0%	0.1%
40	27	0.41	3.7%	0.00%	0.33%	4.0%	15.0%	0.6%
50	34	0.44	5.1%	0.00%	0.33%	5.4%	20.0%	1.1%
60	40	0.47	6.6%	0.00%	0.33%	6.9%	30.0%	2.1%
70	47	0.50	8.1%	0.00%	0.33%	8.4%	20.0%	1.7%
80	54	0.52	9.8%	0.00%	0.33%	10.1%	10.0%	1.0%
					Silver eel			6.6%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine				Gadoids	
Fish species:			Gadoids				Length-weighted mortality rate	
Operating Condition:			Ebb Tide	Net head=	1.25 m			
Discharge =			280.00	cumecs	On design			
Fish swimming condition:	1		Fish swimming speed		0 bl/s			
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.38	0.9%	2.74%	2.50%	6.1%	10.0%	0.6%
20	13	0.80	4.2%	2.74%	2.50%	9.1%	70.0%	6.4%
30	20	0.87	6.9%	2.74%	2.50%	11.7%	10.0%	1.2%
40	27	0.91	9.9%	2.74%	2.50%	14.5%	10.0%	1.5%
50	34	0.94	13.0%	2.74%	2.50%	17.5%	0.0%	0.0%
60	40	0.97	16.1%	2.74%	2.50%	20.5%	0.0%	0.0%
					Gadoids			9.6%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Bass				Bass Length-weighted mortality rate	
Operating Condition:			Ebb Tide	Net head=	1.25 m			
Discharge =			280.00	cumecs	On design			
Fish swimming condition:	1		Fish swimming speed		0 bl/s			
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.29	0.3%	0.03%	2.50%	2.9%	5.0%	0.1%
10	7	0.40	1.0%	0.03%	2.50%	3.5%	25.0%	0.9%
20	13	0.51	2.6%	0.03%	2.50%	5.1%	50.0%	2.6%
30	20	0.57	4.6%	0.03%	2.50%	7.0%	17.0%	1.2%
40	27	0.61	6.7%	0.03%	2.50%	9.1%	2.5%	0.2%
50	34	0.65	8.9%	0.03%	2.50%	11.2%	0.5%	0.1%
					Bass			5.0%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Flatfish				Flatfish Length-weighted mortality rate	
Operating Condition:			Ebb Tide	Net head=	1.25 m			
Discharge =			280.00	cumecs	On design			
Fish swimming condition:	1		Fish swimming speed		0 bl/s			
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.40	0.5%	0.00%	0.33%	0.8%	50.0%	0.4%
10	7	0.51	1.2%	0.00%	0.33%	1.6%	20.0%	0.3%
15	10	0.57	2.2%	0.00%	0.33%	2.5%	5.0%	0.1%
20	13	0.61	3.2%	0.00%	0.33%	3.5%	10.0%	0.3%
30	20	0.67	5.4%	0.00%	0.33%	5.7%	10.0%	0.6%
40	27	0.72	7.7%	0.00%	0.33%	8.0%	5.0%	0.4%
					Flatfish			2.2%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Lamprey				Lamprey Length-weighted mortality rate	
Operating Condition:			Ebb Tide	Net head=	1.25 m			
Discharge =			280.00	cumecs	On design			
Fish swimming condition:	1		Fish swimming speed		0 bl/s			
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	20	0.37	2.4%	0.00%	0.33%	2.7%	10.0%	0.3%
20	27	0.41	3.7%	0.00%	0.33%	4.0%	10.0%	0.4%
30	34	0.44	5.1%	0.00%	0.33%	5.4%	20.0%	1.1%
40	40	0.47	6.6%	0.00%	0.33%	6.9%	20.0%	1.4%
50	47	0.50	8.1%	0.00%	0.33%	8.4%	20.0%	1.7%
60	54	0.52	9.8%	0.00%	0.33%	10.1%	20.0%	2.0%
					Lamprey			6.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Atlantic salmon & sea trout smolt				Atlantic salmon & sea trout smolt Length-weighted mortality rate	
Operating Condition:			Flood Tide	Net head=	1.25 m			
Discharge =			280.00	cumecs	Off design			
Fish swimming condition:	1		Fish swimming speed		0 bl/s			
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length (cm)	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.37	0.9%	1.71%	0.33%	2.9%	10.0%	0.3%
15	10	0.43	1.6%	1.71%	0.33%	3.6%	70.0%	2.5%
20	13	0.47	2.4%	1.71%	0.33%	4.4%	15.0%	0.7%
25	17	0.51	3.3%	1.71%	0.33%	5.3%	5.0%	0.3%
					Atlantic salmon & sea trout smolt			3.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Atlantic salmon adult				Atlantic salmon adult Length-weighted mortality rate	
Operating Condition:			Flood Tide	Net head=	1.25 m			
Discharge =			280.00	cumecs	Off design			
Fish swimming condition:	1		Fish swimming speed		0 bl/s			
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
40	27	0.58	6.2%	1.71%	0.33%	8.1%	5.0%	0.4%
50	34	0.61	8.4%	1.71%	0.33%	10.2%	35.0%	3.6%
60	40	0.64	10.6%	1.71%	0.33%	12.4%	50.0%	6.2%
70	47	0.66	12.8%	1.71%	0.33%	14.6%	7.5%	1.1%
80	54	0.68	15.1%	1.71%	0.33%	16.9%	2.0%	0.3%
90	60	0.70	17.5%	1.71%	0.33%	19.1%	0.5%	0.1%
					Atlantic salmon adult			11.7%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Sea trout adult				Sea trout adult Length-weighted mortality rate	
Operating Condition:			Flood Tide	Net head=	1.25 m			
Discharge =			280.00	cumecs	Off design			
Fish swimming condition:	1		Fish swimming speed		0 bl/s			
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.53	4.2%	1.71%	0.33%	6.2%	5.0%	0.3%
35	23	0.56	5.2%	1.71%	0.33%	7.1%	10.0%	0.7%
40	27	0.58	6.2%	1.71%	0.33%	8.1%	70.0%	5.7%
45	30	0.60	7.3%	1.71%	0.33%	9.2%	10.0%	0.9%
50	34	0.61	8.4%	1.71%	0.33%	10.2%	5.0%	0.5%
55	37	0.63	9.5%	1.71%	0.33%	11.3%	0.0%	0.0%
					Sea trout adult			8.1%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Shad adults				Shad adult Length-weighted mortality rate	
Operating Condition:			Flood Tide	Net head=	1.25 m			
Discharge =			280.00	cumecs	Off design			
Fish swimming condition:	1		Fish swimming speed		0 bl/s			
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
25	17	0.51	3.3%	43.04%	0.33%	45.1%	0.0%	0.0%
30	20	0.53	4.2%	43.04%	0.33%	45.6%	20.0%	9.1%
35	23	0.56	5.2%	43.04%	0.33%	46.2%	30.0%	13.9%
40	27	0.58	6.2%	43.04%	0.33%	46.8%	30.0%	14.0%
45	30	0.60	7.3%	43.04%	0.33%	47.4%	20.0%	9.5%
50	34	0.61	8.4%	43.04%	0.33%	48.0%	0.0%	0.0%
					Shad adult			46.5%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Herring				Herring Length-weighted mortality rate	
Operating Condition:			Flood Tide	Net head=	1.25 m			
Discharge =			280.00	cumecs	Off design			
Fish swimming condition:	1		Fish swimming speed		0 bl/s			
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.26	0.3%	43.04%	0.33%	43.4%	0.0%	0.0%
10	7	0.37	0.9%	43.04%	0.33%	43.7%	0.0%	0.0%
15	10	0.43	1.6%	43.04%	0.33%	44.1%	0.0%	0.0%
20	13	0.47	2.4%	43.04%	0.33%	44.6%	25.0%	11.2%
25	17	0.51	3.3%	43.04%	0.33%	45.1%	50.0%	22.6%
30	20	0.53	4.2%	43.04%	0.33%	45.6%	25.0%	11.4%
					Herring			45.1%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine				Glass eel/elver Length-weighted mortality rate	
Fish species:			Glass eel /elver					
Operating Condition:			Flood Tide	Net head=	1.25 m			
Discharge =			280.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0 bl/s			
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
6	4	0.12	0.1%	0.00%	0.33%	0.5%	30.0%	0.1%
8	5	0.16	0.3%	0.00%	0.33%	0.6%	30.0%	0.2%
10	7	0.20	0.4%	0.00%	0.33%	0.7%	20.0%	0.1%
12	8	0.23	0.6%	0.00%	0.33%	0.9%	10.0%	0.1%
14	9	0.25	0.7%	0.00%	0.33%	1.1%	5.0%	0.1%
16	11	0.27	0.9%	0.00%	0.33%	1.2%	5.0%	0.1%
					Glass eel/elver			0.7%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine				Silver eel Length-weighted mortality rate	
Fish species:			Silver eel					
Operating Condition:			Flood Tide	Net head=	1.25 m			
Discharge =			280.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0 bl/s			
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.37	2.4%	0.00%	0.33%	2.7%	5.0%	0.1%
40	27	0.41	3.7%	0.00%	0.33%	4.0%	15.0%	0.6%
50	34	0.44	5.1%	0.00%	0.33%	5.4%	20.0%	1.1%
60	40	0.47	6.6%	0.00%	0.33%	6.9%	30.0%	2.1%
70	47	0.50	8.1%	0.00%	0.33%	8.4%	20.0%	1.7%
80	54	0.52	9.8%	0.00%	0.33%	10.1%	10.0%	1.0%
					Silver eel			6.6%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine				Gadoids Length-weighted mortality rate	
Fish species:			Gadoids					
Operating Condition:			Flood Tide	Net head=	1.25 m			
Discharge =			280.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0 bl/s			
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.38	0.9%	4.33%	2.50%	7.6%	10.0%	0.8%
20	13	0.80	4.2%	4.33%	2.50%	10.6%	70.0%	7.4%
30	20	0.87	6.9%	4.33%	2.50%	13.2%	10.0%	1.3%
40	27	0.91	9.9%	4.33%	2.50%	15.9%	10.0%	1.6%
50	34	0.94	13.0%	4.33%	2.50%	18.8%	0.0%	0.0%
60	40	0.97	16.1%	4.33%	2.50%	21.8%	0.0%	0.0%
					Gadoids			11.1%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine				Bass Length-weighted mortality rate	
Fish species:			Bass					
Operating Condition:			Flood Tide	Net head=	1.25 m			
Discharge =			280.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0 bl/s			
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.29	0.3%	0.05%	2.50%	2.9%	5.0%	0.1%
10	7	0.40	1.0%	0.05%	2.50%	3.5%	25.0%	0.9%
20	13	0.51	2.6%	0.05%	2.50%	5.1%	50.0%	2.6%
30	20	0.57	4.6%	0.05%	2.50%	7.0%	17.0%	1.2%
40	27	0.61	6.7%	0.05%	2.50%	9.1%	2.5%	0.2%
50	34	0.65	8.9%	0.05%	2.50%	11.3%	0.5%	0.1%
					Bass			5.1%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine				Flatfish	
Fish species:			Flatfish				Length-weighted mortality rate	
Operating Condition:			Flood Tide	Net head=		1.25 m		
Discharge =			280.00	cumecs	Off design			
Fish swimming condition:	1		Fish swimming speed			0 bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.40	0.5%	0.00%	0.33%	0.8%	50.0%	0.4%
10	7	0.51	1.2%	0.00%	0.33%	1.6%	20.0%	0.3%
15	10	0.57	2.2%	0.00%	0.33%	2.5%	5.0%	0.1%
20	13	0.61	3.2%	0.00%	0.33%	3.5%	10.0%	0.3%
30	20	0.67	5.4%	0.00%	0.33%	5.7%	10.0%	0.6%
40	27	0.72	7.7%	0.00%	0.33%	8.0%	5.0%	0.4%
						Flatfish		2.2%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine				Lamprey	
Fish species:			Lamprey				Length-weighted mortality rate	
Operating Condition:			Flood Tide	Net head=		1.25 m		
Discharge =			280.00	cumecs	Off design			
Fish swimming condition:	1		Fish swimming speed			0 bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	20	0.37	2.4%	0.00%	0.33%	2.7%	10.0%	0.3%
20	27	0.41	3.7%	0.00%	0.33%	4.0%	10.0%	0.4%
30	34	0.44	5.1%	0.00%	0.33%	5.4%	20.0%	1.1%
40	40	0.47	6.6%	0.00%	0.33%	6.9%	20.0%	1.4%
50	47	0.50	8.1%	0.00%	0.33%	8.4%	20.0%	1.7%
60	54	0.52	9.8%	0.00%	0.33%	10.1%	20.0%	2.0%
						Lamprey		6.8%

Table A2.2: Operating Head: 1.75 m, Ebb and Flood Generation

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Atlantic salmon & sea trout smolt				Atlantic salmon & sea trout smolt	
Operating Condition:			Ebb Tide	Net head=	1.75	m	Length-weighted mortality rate	
Discharge =			300.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length (cm)	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.37	0.8%	1.08%	0.33%	2.2%	10.0%	0.2%
15	10	0.43	1.5%	1.08%	0.33%	2.9%	70.0%	2.0%
20	13	0.47	2.3%	1.08%	0.33%	3.7%	15.0%	0.6%
25	17	0.51	3.1%	1.08%	0.33%	4.5%	5.0%	0.2%
						Atlantic salmon & sea trout smolt		3.0%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Atlantic salmon adult				Atlantic salmon adult	
Operating Condition:			Ebb Tide	Net head=	1.75	m	Length-weighted mortality rate	
Discharge =			300.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
40	27	0.58	5.9%	1.08%	0.33%	7.2%	5.0%	0.4%
50	34	0.61	7.9%	1.08%	0.33%	9.2%	35.0%	3.2%
60	40	0.64	9.9%	1.08%	0.33%	11.2%	50.0%	5.6%
70	47	0.66	12.0%	1.08%	0.33%	13.2%	7.5%	1.0%
80	54	0.68	14.2%	1.08%	0.33%	15.4%	2.0%	0.3%
90	60	0.70	16.3%	1.08%	0.33%	17.5%	0.5%	0.1%
						Atlantic salmon adult		10.6%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Sea trout adult				Sea trout adult	
Operating Condition:			Ebb Tide	Net head=	1.75	m	Length-weighted mortality rate	
Discharge =			300.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.53	4.0%	1.08%	0.33%	5.4%	5.0%	0.3%
35	23	0.56	4.9%	1.08%	0.33%	6.3%	10.0%	0.6%
40	27	0.58	5.9%	1.08%	0.33%	7.2%	70.0%	5.1%
45	30	0.60	6.9%	1.08%	0.33%	8.2%	10.0%	0.8%
50	34	0.61	7.9%	1.08%	0.33%	9.2%	5.0%	0.5%
55	37	0.63	8.9%	1.08%	0.33%	10.2%	0.0%	0.0%
						Sea trout adult		7.2%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Shad adults				Shad adult	
Operating Condition:			Ebb Tide	Net head=	1.75	m	Length-weighted mortality rate	
Discharge =			300.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
25	17	0.51	3.1%	47.84%	0.33%	49.6%	0.0%	0.0%
30	20	0.53	4.0%	47.84%	0.33%	50.1%	20.0%	10.0%
35	23	0.56	4.9%	47.84%	0.33%	50.6%	30.0%	15.2%
40	27	0.58	5.9%	47.84%	0.33%	51.1%	30.0%	15.3%
45	30	0.60	6.9%	47.84%	0.33%	51.6%	20.0%	10.3%
50	34	0.61	7.9%	47.84%	0.33%	52.1%	0.0%	0.0%
						Shad adult		50.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Herring				Herring	
Operating Condition:			Ebb Tide	Net head=	1.75	m	Length-weighted mortality rate	
Discharge =			300.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.26	0.3%	47.84%	0.33%	48.2%	0.0%	0.0%
10	7	0.37	0.8%	47.84%	0.33%	48.4%	0.0%	0.0%
15	10	0.43	1.5%	47.84%	0.33%	48.8%	0.0%	0.0%
20	13	0.47	2.3%	47.84%	0.33%	49.2%	25.0%	12.3%
25	17	0.51	3.1%	47.84%	0.33%	49.6%	50.0%	24.8%
30	20	0.53	4.0%	47.84%	0.33%	50.1%	25.0%	12.5%
						Herring		49.6%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Glass eel /elver				Glass eel/elver	
Operating Condition:			Ebb Tide	Net head=	1.75	m	Length-weighted mortality rate	
Discharge =			300.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
6	4	0.12	0.1%	0.00%	0.33%	0.4%	30.0%	0.1%
8	5	0.16	0.2%	0.00%	0.33%	0.6%	30.0%	0.2%
10	7	0.20	0.4%	0.00%	0.33%	0.7%	20.0%	0.1%
12	8	0.23	0.5%	0.00%	0.33%	0.9%	10.0%	0.1%
14	9	0.25	0.7%	0.00%	0.33%	1.0%	5.0%	0.1%
16	11	0.27	0.9%	0.00%	0.33%	1.2%	5.0%	0.1%
						Glass eel/elver		0.6%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Silver eel				Silver eel	
Operating Condition:			Ebb Tide	Net head=	1.75	m	Length-weighted mortality rate	
Discharge =			300.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.37	2.3%	0.00%	0.33%	2.6%	5.0%	0.1%
40	27	0.41	3.5%	0.00%	0.33%	3.8%	15.0%	0.6%
50	34	0.44	4.8%	0.00%	0.33%	5.1%	20.0%	1.0%
60	40	0.47	6.2%	0.00%	0.33%	6.5%	30.0%	2.0%
70	47	0.50	7.7%	0.00%	0.33%	8.0%	20.0%	1.6%
80	54	0.52	9.2%	0.00%	0.33%	9.5%	10.0%	1.0%
						Silver eel		6.2%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Gadoids				Gadoids	
Operating Condition:			Ebb Tide	Net head=	1.75	m	Length-weighted mortality rate	
Discharge =			300.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.38	0.9%	2.74%	2.50%	6.0%	10.0%	0.6%
20	13	0.80	3.9%	2.74%	2.50%	8.9%	70.0%	6.2%
30	20	0.87	6.6%	2.74%	2.50%	11.4%	10.0%	1.1%
40	27	0.91	9.4%	2.74%	2.50%	14.0%	10.0%	1.4%
50	34	0.94	12.2%	2.74%	2.50%	16.7%	0.0%	0.0%
60	40	0.97	15.1%	2.74%	2.50%	19.5%	0.0%	0.0%
						Gadoids		9.4%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Bass				Bass	
Operating Condition:			Ebb Tide	Net head=	1.75	m	Length-weighted mortality rate	
Discharge =			300.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.29	0.3%	0.03%	2.50%	2.8%	5.0%	0.1%
10	7	0.40	0.9%	0.03%	2.50%	3.4%	25.0%	0.9%
20	13	0.51	2.5%	0.03%	2.50%	5.0%	50.0%	2.5%
30	20	0.57	4.3%	0.03%	2.50%	6.8%	17.0%	1.1%
40	27	0.61	6.3%	0.03%	2.50%	8.7%	2.5%	0.2%
50	34	0.65	8.4%	0.03%	2.50%	10.7%	0.5%	0.1%
						Bass		4.9%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Flatfish				Flatfish	
Operating Condition:			Ebb Tide	Net head=	1.75	m	Length-weighted mortality rate	
Discharge =			300.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.40	0.4%	0.00%	0.33%	0.8%	50.0%	0.4%
10	7	0.51	1.2%	0.00%	0.33%	1.5%	20.0%	0.3%
15	10	0.57	2.0%	0.00%	0.33%	2.4%	5.0%	0.1%
20	13	0.61	3.0%	0.00%	0.33%	3.3%	10.0%	0.3%
30	20	0.67	5.1%	0.00%	0.33%	5.4%	10.0%	0.5%
40	27	0.72	7.3%	0.00%	0.33%	7.6%	5.0%	0.4%
						Flatfish		2.0%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Lamprey				Lamprey	
Operating Condition:			Ebb Tide	Net head=	1.75	m	Length-weighted mortality rate	
Discharge =			300.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	20	0.37	2.3%	0.00%	0.33%	2.6%	10.0%	0.3%
20	27	0.41	3.5%	0.00%	0.33%	3.8%	10.0%	0.4%
30	34	0.44	4.8%	0.00%	0.33%	5.1%	20.0%	1.0%
40	40	0.47	6.2%	0.00%	0.33%	6.5%	20.0%	1.3%
50	47	0.50	7.7%	0.00%	0.33%	8.0%	20.0%	1.6%
60	54	0.52	9.2%	0.00%	0.33%	9.5%	20.0%	1.9%
						Lamprey		6.5%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Atlantic salmon & sea trout smolt				Atlantic salmon & sea trout smolt	
Operating Condition:			Flood Tide	Net head=	1.75	m	Length-weighted mortality rate	
Discharge =			300.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-Adjusted Length		Predicted Injuries Due to:					
Fish Length (cm)	(cm)	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.37	0.8%	1.71%	0.33%	2.9%	10.0%	0.3%
15	10	0.43	1.5%	1.71%	0.33%	3.5%	70.0%	2.5%
20	13	0.47	2.3%	1.71%	0.33%	4.3%	15.0%	0.6%
25	17	0.51	3.1%	1.71%	0.33%	5.1%	5.0%	0.3%
					Atlantic salmon & sea trout smolt			3.7%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			**Atlantic salmon adult**				**Atlantic salmon adult**	
Operating Condition:			**Flood Tide**	**Net head=**	**1.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**300.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
40	27	0.58	5.9%	1.71%	0.33%	7.8%	5.0%	0.4%
50	34	0.61	7.9%	1.71%	0.33%	9.8%	35.0%	3.4%
60	40	0.64	9.9%	1.71%	0.33%	11.8%	50.0%	5.9%
70	47	0.66	12.0%	1.71%	0.33%	13.8%	7.5%	1.0%
80	54	0.68	14.2%	1.71%	0.33%	15.9%	2.0%	0.3%
90	60	0.70	16.3%	1.71%	0.33%	18.0%	0.5%	0.1%
						Atlantic salmon adult		11.1%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			**Sea trout adult**				**Sea trout adult**	
Operating Condition:			**Flood Tide**	**Net head=**	**1.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**300.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.53	4.0%	1.71%	0.33%	6.0%	5.0%	0.3%
35	23	0.56	4.9%	1.71%	0.33%	6.9%	10.0%	0.7%
40	27	0.58	5.9%	1.71%	0.33%	7.8%	70.0%	5.5%
45	30	0.60	6.9%	1.71%	0.33%	8.8%	10.0%	0.9%
50	34	0.61	7.9%	1.71%	0.33%	9.8%	5.0%	0.5%
55	37	0.63	8.9%	1.71%	0.33%	10.8%	0.0%	0.0%
						Sea trout adult		7.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			**Shad adults**				**Shad adult**	
Operating Condition:			**Flood Tide**	**Net head=**	**1.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**300.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
25	17	0.51	3.1%	43.04%	0.33%	45.0%	0.0%	0.0%
30	20	0.53	4.0%	43.04%	0.33%	45.5%	20.0%	9.1%
35	23	0.56	4.9%	43.04%	0.33%	46.0%	30.0%	13.8%
40	27	0.58	5.9%	43.04%	0.33%	46.6%	30.0%	14.0%
45	30	0.60	6.9%	43.04%	0.33%	47.1%	20.0%	9.4%
50	34	0.61	7.9%	43.04%	0.33%	47.7%	0.0%	0.0%
						Shad adult		46.3%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			**Herring**				**Herring**	
Operating Condition:			**Flood Tide**	**Net head=**	**1.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**300.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.26	0.3%	43.04%	0.33%	43.4%	0.0%	0.0%
10	7	0.37	0.8%	43.04%	0.33%	43.7%	0.0%	0.0%
15	10	0.43	1.5%	43.04%	0.33%	44.1%	0.0%	0.0%
20	13	0.47	2.3%	43.04%	0.33%	44.5%	25.0%	11.1%
25	17	0.51	3.1%	43.04%	0.33%	45.0%	50.0%	22.5%
30	20	0.53	4.0%	43.04%	0.33%	45.5%	25.0%	11.4%
						Herring		45.0%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Glass eel /elver				Glass eel/elver	
Operating Condition:			Flood Tide	Net head=	1.75	m	Length-weighted mortality rate	
Discharge =			300.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
6	4	0.12	0.1%	0.00%	0.33%	0.4%	30.0%	0.1%
8	5	0.16	0.2%	0.00%	0.33%	0.6%	30.0%	0.2%
10	7	0.20	0.4%	0.00%	0.33%	0.7%	20.0%	0.1%
12	8	0.23	0.5%	0.00%	0.33%	0.9%	10.0%	0.1%
14	9	0.25	0.7%	0.00%	0.33%	1.0%	5.0%	0.1%
16	11	0.27	0.9%	0.00%	0.33%	1.2%	5.0%	0.1%
						Glass eel/elver		0.6%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Silver eel				Silver eel	
Operating Condition:			Flood Tide	Net head=	1.75	m	Length-weighted mortality rate	
Discharge =			300.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.37	2.3%	0.00%	0.33%	2.6%	5.0%	0.1%
40	27	0.41	3.5%	0.00%	0.33%	3.8%	15.0%	0.6%
50	34	0.44	4.8%	0.00%	0.33%	5.1%	20.0%	1.0%
60	40	0.47	6.2%	0.00%	0.33%	6.5%	30.0%	2.0%
70	47	0.50	7.7%	0.00%	0.33%	8.0%	20.0%	1.6%
80	54	0.52	9.2%	0.00%	0.33%	9.5%	10.0%	1.0%
						Silver eel		6.2%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Gadoids				Gadoids	
Operating Condition:			Flood Tide	Net head=	1.75	m	Length-weighted mortality rate	
Discharge =			300.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.38	0.9%	4.33%	2.50%	7.6%	10.0%	0.8%
20	13	0.80	3.9%	4.33%	2.50%	10.4%	70.0%	7.3%
30	20	0.87	6.6%	4.33%	2.50%	12.8%	10.0%	1.3%
40	27	0.91	9.4%	4.33%	2.50%	15.5%	10.0%	1.5%
50	34	0.94	12.2%	4.33%	2.50%	18.1%	0.0%	0.0%
60	40	0.97	15.1%	4.33%	2.50%	20.8%	0.0%	0.0%
						Gadoids		10.9%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Bass				Bass	
Operating Condition:			Flood Tide	Net head=	1.75	m	Length-weighted mortality rate	
Discharge =			300.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.29	0.3%	0.05%	2.50%	2.9%	5.0%	0.1%
10	7	0.40	0.9%	0.05%	2.50%	3.5%	25.0%	0.9%
20	13	0.51	2.5%	0.05%	2.50%	5.0%	50.0%	2.5%
30	20	0.57	4.3%	0.05%	2.50%	6.8%	17.0%	1.2%
40	27	0.61	6.3%	0.05%	2.50%	8.7%	2.5%	0.2%
50	34	0.65	8.4%	0.05%	2.50%	10.7%	0.5%	0.1%
						Bass		4.9%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Flatfish**				**Flatfish**	
Operating Condition:			**Flood Tide**	**Net head=**	**1.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**300.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Predicted Injuries Due to:				Length-frequency	Net mortality
			Strike	Shear	Pressure	Compound		
5	3	0.40	0.4%	0.00%	0.33%	0.8%	50.0%	0.4%
10	7	0.51	1.2%	0.00%	0.33%	1.5%	20.0%	0.3%
15	10	0.57	2.0%	0.00%	0.33%	2.4%	5.0%	0.1%
20	13	0.61	3.0%	0.00%	0.33%	3.3%	10.0%	0.3%
30	20	0.67	5.1%	0.00%	0.33%	5.4%	10.0%	0.5%
40	27	0.72	7.3%	0.00%	0.33%	7.6%	5.0%	0.4%
						Flatfish		2.0%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Lamprey**				**Lamprey**	
Operating Condition:			**Flood Tide**	**Net head=**	**1.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**300.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Predicted Injuries Due to:				Length-frequency	Net mortality
			Strike	Shear	Pressure	Compound		
10	20	0.37	2.3%	0.00%	0.33%	2.6%	10.0%	0.3%
20	27	0.41	3.5%	0.00%	0.33%	3.8%	10.0%	0.4%
30	34	0.44	4.8%	0.00%	0.33%	5.1%	20.0%	1.0%
40	40	0.47	6.2%	0.00%	0.33%	6.5%	20.0%	1.3%
50	47	0.50	7.7%	0.00%	0.33%	8.0%	20.0%	1.6%
60	54	0.52	9.2%	0.00%	0.33%	9.5%	20.0%	1.9%
						Lamprey		6.5%

Table A2.3: Operating Head: 2.25 m, Ebb and Flood Generation

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Atlantic salmon & sea trout smolt				Atlantic salmon & sea trout smolt	
Operating Condition:			Ebb Tide	Net head=	2.25	m	Length-weighted mortality rate	
Discharge =			360.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length (cm)	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.37	0.7%	1.08%	0.33%	2.1%	10.0%	0.2%
15	10	0.43	1.3%	1.08%	0.33%	2.7%	70.0%	1.9%
20	13	0.47	2.0%	1.08%	0.33%	3.3%	15.0%	0.5%
25	17	0.51	2.7%	1.08%	0.33%	4.1%	5.0%	0.2%
					Atlantic salmon & sea trout smolt			2.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Atlantic salmon adult				Atlantic salmon adult	
Operating Condition:			Ebb Tide	Net head=	2.25	m	Length-weighted mortality rate	
Discharge =			360.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
40	27	0.58	5.0%	1.08%	0.33%	6.3%	5.0%	0.3%
50	34	0.61	6.6%	1.08%	0.33%	7.9%	35.0%	2.8%
60	40	0.64	8.3%	1.08%	0.33%	9.6%	50.0%	4.8%
70	47	0.66	10.0%	1.08%	0.33%	11.3%	7.5%	0.8%
80	54	0.68	11.8%	1.08%	0.33%	13.1%	2.0%	0.3%
90	60	0.70	13.6%	1.08%	0.33%	14.9%	0.5%	0.1%
						Atlantic salmon adult		9.1%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Sea trout adult				Sea trout adult	
Operating Condition:			Ebb Tide	Net head=	2.25	m	Length-weighted mortality rate	
Discharge =			360.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.53	3.5%	1.08%	0.33%	4.8%	5.0%	0.2%
35	23	0.56	4.2%	1.08%	0.33%	5.6%	10.0%	0.6%
40	27	0.58	5.0%	1.08%	0.33%	6.3%	70.0%	4.4%
45	30	0.60	5.8%	1.08%	0.33%	7.1%	10.0%	0.7%
50	34	0.61	6.6%	1.08%	0.33%	7.9%	5.0%	0.4%
55	37	0.63	7.4%	1.08%	0.33%	8.7%	0.0%	0.0%
						Sea trout adult		6.3%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Shad adults				Shad adult	
Operating Condition:			Ebb Tide	Net head=	2.25	m	Length-weighted mortality rate	
Discharge =			360.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
25	17	0.51	2.7%	47.84%	0.33%	49.4%	0.0%	0.0%
30	20	0.53	3.5%	47.84%	0.33%	49.8%	20.0%	10.0%
35	23	0.56	4.2%	47.84%	0.33%	50.2%	30.0%	15.1%
40	27	0.58	5.0%	47.84%	0.33%	50.6%	30.0%	15.2%
45	30	0.60	5.8%	47.84%	0.33%	51.0%	20.0%	10.2%
50	34	0.61	6.6%	47.84%	0.33%	51.4%	0.0%	0.0%
						Shad adult		50.4%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Herring**				**Herring**	
Operating Condition:			**Ebb Tide**	**Net head=**	**2.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.26	0.2%	47.84%	0.33%	48.1%	0.0%	0.0%
10	7	0.37	0.7%	47.84%	0.33%	48.4%	0.0%	0.0%
15	10	0.43	1.3%	47.84%	0.33%	48.7%	0.0%	0.0%
20	13	0.47	2.0%	47.84%	0.33%	49.0%	25.0%	12.3%
25	17	0.51	2.7%	47.84%	0.33%	49.4%	50.0%	24.7%
30	20	0.53	3.5%	47.84%	0.33%	49.8%	25.0%	12.5%
						Herring		49.4%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Glass eel /elver**				**Glass eel/elver**	
Operating Condition:			**Ebb Tide**	**Net head=**	**2.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
6	4	0.12	0.1%	0.00%	0.33%	0.4%	30.0%	0.1%
8	5	0.16	0.2%	0.00%	0.33%	0.5%	30.0%	0.2%
10	7	0.20	0.3%	0.00%	0.33%	0.6%	20.0%	0.1%
12	8	0.23	0.4%	0.00%	0.33%	0.8%	10.0%	0.1%
14	9	0.25	0.6%	0.00%	0.33%	0.9%	5.0%	0.0%
16	11	0.27	0.7%	0.00%	0.33%	1.0%	5.0%	0.1%
						Glass eel/elver		0.6%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Silver eel**				**Silver eel**	
Operating Condition:			**Ebb Tide**	**Net head=**	**2.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.37	1.9%	0.00%	0.33%	2.3%	5.0%	0.1%
40	27	0.41	3.0%	0.00%	0.33%	3.3%	15.0%	0.5%
50	34	0.44	4.1%	0.00%	0.33%	4.4%	20.0%	0.9%
60	40	0.47	5.3%	0.00%	0.33%	5.6%	30.0%	1.7%
70	47	0.50	6.6%	0.00%	0.33%	6.9%	20.0%	1.4%
80	54	0.52	8.0%	0.00%	0.33%	8.3%	10.0%	0.8%
						Silver eel		5.4%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Gadoids**				**Gadoids**	
Operating Condition:			**Ebb Tide**	**Net head=**	**2.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.38	0.8%	2.74%	2.62%	6.0%	10.0%	0.6%
20	13	0.80	3.4%	2.74%	2.62%	8.5%	70.0%	5.9%
30	20	0.87	5.6%	2.74%	2.62%	10.6%	10.0%	1.1%
40	27	0.91	7.9%	2.74%	2.62%	12.7%	10.0%	1.3%
50	34	0.94	10.2%	2.74%	2.62%	14.9%	0.0%	0.0%
60	40	0.97	12.6%	2.74%	2.62%	17.2%	0.0%	0.0%
						Gadoids		8.9%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Bass**				**Bass**	
Operating Condition:			**Ebb Tide**	**Net head=**	**2.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.29	0.3%	0.03%	2.62%	2.9%	5.0%	0.1%
10	7	0.40	0.8%	0.03%	2.62%	3.4%	25.0%	0.9%
20	13	0.51	2.2%	0.03%	2.62%	4.7%	50.0%	2.4%
30	20	0.57	3.7%	0.03%	2.62%	6.2%	17.0%	1.1%
40	27	0.61	5.3%	0.03%	2.62%	7.8%	2.5%	0.2%
50	34	0.65	7.0%	0.03%	2.62%	9.4%	0.5%	0.0%
						Bass		4.7%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Flatfish**				**Flatfish**	
Operating Condition:			**Ebb Tide**	**Net head=**	**2.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.40	0.4%	0.00%	0.33%	0.7%	50.0%	0.3%
10	7	0.51	1.0%	0.00%	0.33%	1.3%	20.0%	0.3%
15	10	0.57	1.7%	0.00%	0.33%	2.1%	5.0%	0.1%
20	13	0.61	2.6%	0.00%	0.33%	2.9%	10.0%	0.3%
30	20	0.67	4.4%	0.00%	0.33%	4.7%	10.0%	0.5%
40	27	0.72	6.2%	0.00%	0.33%	6.5%	5.0%	0.3%
						Flatfish		1.8%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Lamprey**				**Lamprey**	
Operating Condition:			**Ebb Tide**	**Net head=**	**2.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	20	0.37	1.9%	0.00%	0.33%	2.3%	10.0%	0.2%
20	27	0.41	3.0%	0.00%	0.33%	3.3%	10.0%	0.3%
30	34	0.44	4.1%	0.00%	0.33%	4.4%	20.0%	0.9%
40	40	0.47	5.3%	0.00%	0.33%	5.6%	20.0%	1.1%
50	47	0.50	6.6%	0.00%	0.33%	6.9%	20.0%	1.4%
60	54	0.52	8.0%	0.00%	0.33%	8.3%	20.0%	1.7%
						Lamprey		5.6%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Atlantic salmon & sea trout smolt**				**Atlantic salmon & sea trout smolt**	
Operating Condition:			**Flood Tide**	**Net head=**	**2.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length (cm)	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.37	0.7%	1.71%	0.33%	2.7%	10.0%	0.3%
15	10	0.43	1.3%	1.71%	0.33%	3.3%	70.0%	2.3%
20	13	0.47	2.0%	1.71%	0.33%	4.0%	15.0%	0.6%
25	17	0.51	2.7%	1.71%	0.33%	4.7%	5.0%	0.2%
					Atlantic salmon & sea trout smolt			3.4%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Atlantic salmon adult**				**Atlantic salmon adult**	
Operating Condition:			**Flood Tide**	**Net head=**	**2.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
40	27	0.58	5.0%	1.71%	0.33%	6.9%	5.0%	0.3%
50	34	0.61	6.6%	1.71%	0.33%	8.5%	35.0%	3.0%
60	40	0.64	8.3%	1.71%	0.33%	10.2%	50.0%	5.1%
70	47	0.66	10.0%	1.71%	0.33%	11.9%	7.5%	0.9%
80	54	0.68	11.8%	1.71%	0.33%	13.6%	2.0%	0.3%
90	60	0.70	13.6%	1.71%	0.33%	15.4%	0.5%	0.1%
						Atlantic salmon adult		9.6%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Sea trout adult**				**Sea trout adult**	
Operating Condition:			**Flood Tide**	**Net head=**	**2.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.53	3.5%	1.71%	0.33%	5.4%	5.0%	0.3%
35	23	0.56	4.2%	1.71%	0.33%	6.2%	10.0%	0.6%
40	27	0.58	5.0%	1.71%	0.33%	6.9%	70.0%	4.8%
45	30	0.60	5.8%	1.71%	0.33%	7.7%	10.0%	0.8%
50	34	0.61	6.6%	1.71%	0.33%	8.5%	5.0%	0.4%
55	37	0.63	7.4%	1.71%	0.33%	9.3%	0.0%	0.0%
						Sea trout adult		6.9%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Shad adults**				**Shad adult**	
Operating Condition:			**Flood Tide**	**Net head=**	**2.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
25	17	0.51	2.7%	43.04%	0.33%	44.8%	0.0%	0.0%
30	20	0.53	3.5%	43.04%	0.33%	45.2%	20.0%	9.0%
35	23	0.56	4.2%	43.04%	0.33%	45.6%	30.0%	13.7%
40	27	0.58	5.0%	43.04%	0.33%	46.1%	30.0%	13.8%
45	30	0.60	5.8%	43.04%	0.33%	46.5%	20.0%	9.3%
50	34	0.61	6.6%	43.04%	0.33%	47.0%	0.0%	0.0%
						Shad adult		45.8%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Herring**				**Herring**	
Operating Condition:			**Flood Tide**	**Net head=**	**2.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.26	0.2%	43.04%	0.33%	43.4%	0.0%	0.0%
10	7	0.37	0.7%	43.04%	0.33%	43.6%	0.0%	0.0%
15	10	0.43	1.3%	43.04%	0.33%	44.0%	0.0%	0.0%
20	13	0.47	2.0%	43.04%	0.33%	44.3%	25.0%	11.1%
25	17	0.51	2.7%	43.04%	0.33%	44.8%	50.0%	22.4%
30	20	0.53	3.5%	43.04%	0.33%	45.2%	25.0%	11.3%
						Herring		44.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Glass eel /elver				Glass eel/elver	
Operating Condition:			Flood Tide	Net head=	2.25	m	Length-weighted mortality rate	
Discharge =			360.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
6	4	0.12	0.1%	0.00%	0.33%	0.4%	30.0%	0.1%
8	5	0.16	0.2%	0.00%	0.33%	0.5%	30.0%	0.2%
10	7	0.20	0.3%	0.00%	0.33%	0.6%	20.0%	0.1%
12	8	0.23	0.4%	0.00%	0.33%	0.8%	10.0%	0.1%
14	9	0.25	0.6%	0.00%	0.33%	0.9%	5.0%	0.0%
16	11	0.27	0.7%	0.00%	0.33%	1.0%	5.0%	0.1%
						Glass eel/elver		0.6%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Silver eel				Silver eel	
Operating Condition:			Flood Tide	Net head=	2.25	m	Length-weighted mortality rate	
Discharge =			360.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.37	1.9%	0.00%	0.33%	2.3%	5.0%	0.1%
40	27	0.41	3.0%	0.00%	0.33%	3.3%	15.0%	0.5%
50	34	0.44	4.1%	0.00%	0.33%	4.4%	20.0%	0.9%
60	40	0.47	5.3%	0.00%	0.33%	5.6%	30.0%	1.7%
70	47	0.50	6.6%	0.00%	0.33%	6.9%	20.0%	1.4%
80	54	0.52	8.0%	0.00%	0.33%	8.3%	10.0%	0.8%
						Silver eel		5.4%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Gadoids				Gadoids	
Operating Condition:			Flood Tide	Net head=	2.25	m	Length-weighted mortality rate	
Discharge =			360.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.38	0.8%	4.33%	2.62%	7.5%	10.0%	0.8%
20	13	0.80	3.4%	4.33%	2.62%	10.0%	70.0%	7.0%
30	20	0.87	5.6%	4.33%	2.62%	12.1%	10.0%	1.2%
40	27	0.91	7.9%	4.33%	2.62%	14.2%	10.0%	1.4%
50	34	0.94	10.2%	4.33%	2.62%	16.3%	0.0%	0.0%
60	40	0.97	12.6%	4.33%	2.62%	18.6%	0.0%	0.0%
						Gadoids		10.4%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Bass				Bass	
Operating Condition:			Flood Tide	Net head=	2.25	m	Length-weighted mortality rate	
Discharge =			360.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.29	0.3%	0.05%	2.62%	2.9%	5.0%	0.1%
10	7	0.40	0.8%	0.05%	2.62%	3.5%	25.0%	0.9%
20	13	0.51	2.2%	0.05%	2.62%	4.8%	50.0%	2.4%
30	20	0.57	3.7%	0.05%	2.62%	6.3%	17.0%	1.1%
40	27	0.61	5.3%	0.05%	2.62%	7.8%	2.5%	0.2%
50	34	0.65	7.0%	0.05%	2.62%	9.5%	0.5%	0.0%
						Bass		4.7%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			**Flatfish**				Flatfish	
Operating Condition:			**Flood Tide**	**Net head=**	2.25	m	Length-weighted mortality rate	
Discharge =			**360.00**	**cumecs**	**Off design**			
Fish swimming condition:		1	**Fish swimming speed**		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.40	0.4%	0.00%	0.33%	0.7%	50.0%	0.3%
10	7	0.51	1.0%	0.00%	0.33%	1.3%	20.0%	0.3%
15	10	0.57	1.7%	0.00%	0.33%	2.1%	5.0%	0.1%
20	13	0.61	2.6%	0.00%	0.33%	2.9%	10.0%	0.3%
30	20	0.67	4.4%	0.00%	0.33%	4.7%	10.0%	0.5%
40	27	0.72	6.2%	0.00%	0.33%	6.5%	5.0%	0.3%
						Flatfish		1.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			**Lamprey**				Lamprey	
Operating Condition:			**Flood Tide**	**Net head=**	2.25	m	Length-weighted mortality rate	
Discharge =			**360.00**	**cumecs**	**Off design**			
Fish swimming condition:		1	**Fish swimming speed**		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	20	0.37	1.9%	0.00%	0.33%	2.3%	10.0%	0.2%
20	27	0.41	3.0%	0.00%	0.33%	3.3%	10.0%	0.3%
30	34	0.44	4.1%	0.00%	0.33%	4.4%	20.0%	0.9%
40	40	0.47	5.3%	0.00%	0.33%	5.6%	20.0%	1.1%
50	47	0.50	6.6%	0.00%	0.33%	6.9%	20.0%	1.4%
60	54	0.52	8.0%	0.00%	0.33%	8.3%	20.0%	1.7%
						Lamprey		5.6%

Table A2.4: Operating Head: 2.75 m, Ebb and Flood Generation

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Atlantic salmon & sea trout smolt**				**Atlantic salmon & sea trout smolt**	
Operating Condition:			**Ebb Tide**	**Net head=**	**2.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**350.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-Adjusted Length		Predicted Injuries Due to:					
Fish Length (cm)	(cm)	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.37	0.7%	1.08%	0.33%	2.1%	10.0%	0.2%
15	10	0.43	1.3%	1.08%	0.33%	2.7%	70.0%	1.9%
20	13	0.47	2.0%	1.08%	0.33%	3.4%	15.0%	0.5%
25	17	0.51	2.8%	1.08%	0.33%	4.1%	5.0%	0.2%
					Atlantic salmon & sea trout smolt			2.8%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Atlantic salmon & sea trout smolt**				**Atlantic salmon & sea trout smolt**	
Operating Condition:			**Ebb Tide**	**Net head=**	**2.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**350.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-Adjusted Length		Predicted Injuries Due to:					
Fish Length (cm)	(cm)	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.37	0.7%	1.08%	0.33%	2.1%	10.0%	0.2%
15	10	0.43	1.3%	1.08%	0.33%	2.7%	70.0%	1.9%
20	13	0.47	2.0%	1.08%	0.33%	3.4%	15.0%	0.5%
25	17	0.51	2.8%	1.08%	0.33%	4.1%	5.0%	0.2%
					Atlantic salmon & sea trout smolt			2.8%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Sea trout adult**				**Sea trout adult**	
Operating Condition:			**Ebb Tide**	**Net head=**	**2.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**350.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.53	3.6%	1.08%	0.33%	4.9%	5.0%	0.2%
35	23	0.56	4.3%	1.08%	0.33%	5.7%	10.0%	0.6%
40	27	0.58	5.1%	1.08%	0.33%	6.5%	70.0%	4.5%
45	30	0.60	6.0%	1.08%	0.33%	7.3%	10.0%	0.7%
50	34	0.61	6.8%	1.08%	0.33%	8.1%	5.0%	0.4%
55	37	0.63	7.7%	1.08%	0.33%	9.0%	0.0%	0.0%
						Sea trout adult		6.5%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Shad adults**				**Shad adult**	
Operating Condition:			**Ebb Tide**	**Net head=**	**2.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**350.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
25	17	0.51	2.8%	47.84%	0.33%	49.4%	0.0%	0.0%
30	20	0.53	3.6%	47.84%	0.33%	49.9%	20.0%	10.0%
35	23	0.56	4.3%	47.84%	0.33%	50.3%	30.0%	15.1%
40	27	0.58	5.1%	47.84%	0.33%	50.7%	30.0%	15.2%
45	30	0.60	6.0%	47.84%	0.33%	51.1%	20.0%	10.2%
50	34	0.61	6.8%	47.84%	0.33%	51.6%	0.0%	0.0%
						Shad adult		50.5%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Herring				Herring	
Operating Condition:			Ebb Tide	Net head=	2.75	m	Length-weighted mortality rate	
Discharge =			350.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.26	0.2%	47.84%	0.33%	48.1%	0.0%	0.0%
10	7	0.37	0.7%	47.84%	0.33%	48.4%	0.0%	0.0%
15	10	0.43	1.3%	47.84%	0.33%	48.7%	0.0%	0.0%
20	13	0.47	2.0%	47.84%	0.33%	49.1%	25.0%	12.3%
25	17	0.51	2.8%	47.84%	0.33%	49.4%	50.0%	24.7%
30	20	0.53	3.6%	47.84%	0.33%	49.9%	25.0%	12.5%
						Herring		49.5%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Glass eel /elver				Glass eel/elver	
Operating Condition:			Ebb Tide	Net head=	2.75	m	Length-weighted mortality rate	
Discharge =			350.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
6	4	0.12	0.1%	0.00%	0.33%	0.4%	30.0%	0.1%
8	5	0.16	0.2%	0.00%	0.33%	0.5%	30.0%	0.2%
10	7	0.20	0.3%	0.00%	0.33%	0.7%	20.0%	0.1%
12	8	0.23	0.5%	0.00%	0.33%	0.8%	10.0%	0.1%
14	9	0.25	0.6%	0.00%	0.33%	0.9%	5.0%	0.0%
16	11	0.27	0.7%	0.00%	0.33%	1.1%	5.0%	0.1%
						Glass eel/elver		0.6%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Silver eel				Silver eel	
Operating Condition:			Ebb Tide	Net head=	2.75	m	Length-weighted mortality rate	
Discharge =			350.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.37	2.0%	0.00%	0.33%	2.3%	5.0%	0.1%
40	27	0.41	3.1%	0.00%	0.33%	3.4%	15.0%	0.5%
50	34	0.44	4.2%	0.00%	0.33%	4.5%	20.0%	0.9%
60	40	0.47	5.5%	0.00%	0.33%	5.8%	30.0%	1.7%
70	47	0.50	6.8%	0.00%	0.33%	7.1%	20.0%	1.4%
80	54	0.52	8.2%	0.00%	0.33%	8.5%	10.0%	0.8%
						Silver eel		5.5%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Gadoids				Gadoids	
Operating Condition:			Ebb Tide	Net head=	2.75	m	Length-weighted mortality rate	
Discharge =			350.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.38	0.8%	2.74%	2.62%	6.0%	10.0%	0.6%
20	13	0.80	3.5%	2.74%	2.62%	8.6%	70.0%	6.0%
30	20	0.87	5.8%	2.74%	2.62%	10.8%	10.0%	1.1%
40	27	0.91	8.1%	2.74%	2.62%	13.0%	10.0%	1.3%
50	34	0.94	10.5%	2.74%	2.62%	15.2%	0.0%	0.0%
60	40	0.97	13.0%	2.74%	2.62%	17.6%	0.0%	0.0%
						Gadoids		9.0%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Bass				Bass	
Operating Condition:			Ebb Tide	Net head=	2.75	m	Length-weighted mortality rate	
Discharge =			350.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.29	0.3%	0.03%	2.62%	2.9%	5.0%	0.1%
10	7	0.40	0.8%	0.03%	2.62%	3.5%	25.0%	0.9%
20	13	0.51	2.2%	0.03%	2.62%	4.8%	50.0%	2.4%
30	20	0.57	3.8%	0.03%	2.62%	6.3%	17.0%	1.1%
40	27	0.61	5.5%	0.03%	2.62%	8.0%	2.5%	0.2%
50	34	0.65	7.2%	0.03%	2.62%	9.7%	0.5%	0.0%
						Bass		4.7%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Flatfish				Flatfish	
Operating Condition:			Ebb Tide	Net head=	2.75	m	Length-weighted mortality rate	
Discharge =			350.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.40	0.4%	0.00%	0.33%	0.7%	50.0%	0.4%
10	7	0.51	1.0%	0.00%	0.33%	1.3%	20.0%	0.3%
15	10	0.57	1.8%	0.00%	0.33%	2.1%	5.0%	0.1%
20	13	0.61	2.6%	0.00%	0.33%	2.9%	10.0%	0.3%
30	20	0.67	4.5%	0.00%	0.33%	4.8%	10.0%	0.5%
40	27	0.72	6.4%	0.00%	0.33%	6.7%	5.0%	0.3%
						Flatfish		1.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Lamprey				Lamprey	
Operating Condition:			Ebb Tide	Net head=	2.75	m	Length-weighted mortality rate	
Discharge =			350.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	20	0.37	2.0%	0.00%	0.33%	2.3%	10.0%	0.2%
20	27	0.41	3.1%	0.00%	0.33%	3.4%	10.0%	0.3%
30	34	0.44	4.2%	0.00%	0.33%	4.5%	20.0%	0.9%
40	40	0.47	5.5%	0.00%	0.33%	5.8%	20.0%	1.2%
50	47	0.50	6.8%	0.00%	0.33%	7.1%	20.0%	1.4%
60	54	0.52	8.2%	0.00%	0.33%	8.5%	20.0%	1.7%
						Lamprey		5.7%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Atlantic salmon & sea trout smolt				Atlantic salmon & sea trout smolt	
Operating Condition:			Flood Tide	Net head=	2.75	m	Length-weighted mortality rate	
Discharge =			350.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length (cm)	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.37	0.7%	1.71%	0.33%	2.8%	10.0%	0.3%
15	10	0.43	1.3%	1.71%	0.33%	3.3%	70.0%	2.3%
20	13	0.47	2.0%	1.71%	0.33%	4.0%	15.0%	0.6%
25	17	0.51	2.8%	1.71%	0.33%	4.7%	5.0%	0.2%
						Atlantic salmon & sea trout smolt		3.5%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Atlantic salmon adult				Atlantic salmon adult	
Operating Condition:			Flood Tide	Net head=	2.75	m	Length-weighted mortality rate	
Discharge =			350.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
40	27	0.58	5.1%	1.71%	0.33%	7.1%	5.0%	0.4%
50	34	0.61	6.8%	1.71%	0.33%	8.7%	35.0%	3.0%
60	40	0.64	8.6%	1.71%	0.33%	10.4%	50.0%	5.2%
70	47	0.66	10.3%	1.71%	0.33%	12.2%	7.5%	0.9%
80	54	0.68	12.2%	1.71%	0.33%	14.0%	2.0%	0.3%
90	60	0.70	14.1%	1.71%	0.33%	15.8%	0.5%	0.1%
						Atlantic salmon adult		9.9%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Sea trout adult				Sea trout adult	
Operating Condition:			Flood Tide	Net head=	2.75	m	Length-weighted mortality rate	
Discharge =			350.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.53	3.6%	1.71%	0.33%	5.5%	5.0%	0.3%
35	23	0.56	4.3%	1.71%	0.33%	6.3%	10.0%	0.6%
40	27	0.58	5.1%	1.71%	0.33%	7.1%	70.0%	5.0%
45	30	0.60	6.0%	1.71%	0.33%	7.9%	10.0%	0.8%
50	34	0.61	6.8%	1.71%	0.33%	8.7%	5.0%	0.4%
55	37	0.63	7.7%	1.71%	0.33%	9.6%	0.0%	0.0%
						Sea trout adult		7.1%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Shad adults				Shad adult	
Operating Condition:			Flood Tide	Net head=	2.75	m	Length-weighted mortality rate	
Discharge =			350.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
25	17	0.51	2.8%	43.04%	0.33%	44.8%	0.0%	0.0%
30	20	0.53	3.6%	43.04%	0.33%	45.2%	20.0%	9.0%
35	23	0.56	4.3%	43.04%	0.33%	45.7%	30.0%	13.7%
40	27	0.58	5.1%	43.04%	0.33%	46.1%	30.0%	13.8%
45	30	0.60	6.0%	43.04%	0.33%	46.6%	20.0%	9.3%
50	34	0.61	6.8%	43.04%	0.33%	47.1%	0.0%	0.0%
						Shad adult		45.9%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Herring				Herring	
Operating Condition:			Flood Tide	Net head=	2.75	m	Length-weighted mortality rate	
Discharge =			350.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.26	0.2%	43.04%	0.33%	43.4%	0.0%	0.0%
10	7	0.37	0.7%	43.04%	0.33%	43.6%	0.0%	0.0%
15	10	0.43	1.3%	43.04%	0.33%	44.0%	0.0%	0.0%
20	13	0.47	2.0%	43.04%	0.33%	44.4%	25.0%	11.1%
25	17	0.51	2.8%	43.04%	0.33%	44.8%	50.0%	22.4%
30	20	0.53	3.6%	43.04%	0.33%	45.2%	25.0%	11.3%
						Herring		44.8%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Glass eel /elver**				**Glass eel/elver**	
Operating Condition:			**Flood Tide**	**Net head=**	**2.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**350.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
6	4	0.12	0.1%	0.00%	0.33%	0.4%	30.0%	0.1%
8	5	0.16	0.2%	0.00%	0.33%	0.5%	30.0%	0.2%
10	7	0.20	0.3%	0.00%	0.33%	0.7%	20.0%	0.1%
12	8	0.23	0.5%	0.00%	0.33%	0.8%	10.0%	0.1%
14	9	0.25	0.6%	0.00%	0.33%	0.9%	5.0%	0.0%
16	11	0.27	0.7%	0.00%	0.33%	1.1%	5.0%	0.1%
						Glass eel/elver		0.6%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Silver eel**				**Silver eel**	
Operating Condition:			**Flood Tide**	**Net head=**	**2.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**350.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.37	2.0%	0.00%	0.33%	2.3%	5.0%	0.1%
40	27	0.41	3.1%	0.00%	0.33%	3.4%	15.0%	0.5%
50	34	0.44	4.2%	0.00%	0.33%	4.5%	20.0%	0.9%
60	40	0.47	5.5%	0.00%	0.33%	5.8%	30.0%	1.7%
70	47	0.50	6.8%	0.00%	0.33%	7.1%	20.0%	1.4%
80	54	0.52	8.2%	0.00%	0.33%	8.5%	10.0%	0.8%
						Silver eel		5.5%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Gadoids**				**Gadoids**	
Operating Condition:			**Flood Tide**	**Net head=**	**2.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**350.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.38	0.8%	4.33%	2.62%	7.6%	10.0%	0.8%
20	13	0.80	3.5%	4.33%	2.62%	10.1%	70.0%	7.1%
30	20	0.87	5.8%	4.33%	2.62%	12.2%	10.0%	1.2%
40	27	0.91	8.1%	4.33%	2.62%	14.4%	10.0%	1.4%
50	34	0.94	10.5%	4.33%	2.62%	16.6%	0.0%	0.0%
60	40	0.97	13.0%	4.33%	2.62%	18.9%	0.0%	0.0%
						Gadoids		10.5%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Bass**				**Bass**	
Operating Condition:			**Flood Tide**	**Net head=**	**2.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**350.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.29	0.3%	0.05%	2.62%	2.9%	5.0%	0.1%
10	7	0.40	0.8%	0.05%	2.62%	3.5%	25.0%	0.9%
20	13	0.51	2.2%	0.05%	2.62%	4.8%	50.0%	2.4%
30	20	0.57	3.8%	0.05%	2.62%	6.4%	17.0%	1.1%
40	27	0.61	5.5%	0.05%	2.62%	8.0%	2.5%	0.2%
50	34	0.65	7.2%	0.05%	2.62%	9.7%	0.5%	0.0%
						Bass		4.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Flatfish				Flatfish	
Operating Condition:			Flood Tide	Net head=	2.75	m	Length-weighted mortality rate	
Discharge =			350.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.40	0.4%	0.00%	0.33%	0.7%	50.0%	0.4%
10	7	0.51	1.0%	0.00%	0.33%	1.3%	20.0%	0.3%
15	10	0.57	1.8%	0.00%	0.33%	2.1%	5.0%	0.1%
20	13	0.61	2.6%	0.00%	0.33%	2.9%	10.0%	0.3%
30	20	0.67	4.5%	0.00%	0.33%	4.8%	10.0%	0.5%
40	27	0.72	6.4%	0.00%	0.33%	6.7%	5.0%	0.3%
						Flatfish		1.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Lamprey				Lamprey	
Operating Condition:			Flood Tide	Net head=	2.75	m	Length-weighted mortality rate	
Discharge =			350.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	20	0.37	2.0%	0.00%	0.33%	2.3%	10.0%	0.2%
20	27	0.41	3.1%	0.00%	0.33%	3.4%	10.0%	0.3%
30	34	0.44	4.2%	0.00%	0.33%	4.5%	20.0%	0.9%
40	40	0.47	5.5%	0.00%	0.33%	5.8%	20.0%	1.2%
50	47	0.50	6.8%	0.00%	0.33%	7.1%	20.0%	1.4%
60	54	0.52	8.2%	0.00%	0.33%	8.5%	20.0%	1.7%
						Lamprey		5.7%

Table A2.5: Operating Head: 3.25 m, Ebb and Flood Generation

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Atlantic salmon & sea trout smolt**				**Atlantic salmon & sea trout smolt**	
Operating Condition:			**Ebb Tide**	**Net head=**	**3.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length (cm)	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.37	0.7%	1.08%	0.33%	2.1%	10.0%	0.2%
15	10	0.43	1.3%	1.08%	0.33%	2.7%	70.0%	1.9%
20	13	0.47	2.0%	1.08%	0.33%	3.4%	15.0%	0.5%
25	17	0.51	2.7%	1.08%	0.33%	4.1%	5.0%	0.2%
						Atlantic salmon & sea trout smolt		2.8%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Atlantic salmon adult**				**Atlantic salmon adult**	
Operating Condition:			**Ebb Tide**	**Net head=**	**3.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
40	27	0.58	5.0%	1.08%	0.33%	6.4%	5.0%	0.3%
50	34	0.61	6.6%	1.08%	0.33%	8.0%	35.0%	2.8%
60	40	0.64	8.3%	1.08%	0.33%	9.6%	50.0%	4.8%
70	47	0.66	10.1%	1.08%	0.33%	11.3%	7.5%	0.9%
80	54	0.68	11.9%	1.08%	0.33%	13.1%	2.0%	0.3%
90	60	0.70	13.7%	1.08%	0.33%	14.9%	0.5%	0.1%
						Atlantic salmon adult		9.1%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Sea trout adult**				**Sea trout adult**	
Operating Condition:			**Ebb Tide**	**Net head=**	**3.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.53	3.5%	1.08%	0.33%	4.8%	5.0%	0.2%
35	23	0.56	4.2%	1.08%	0.33%	5.6%	10.0%	0.6%
40	27	0.58	5.0%	1.08%	0.33%	6.4%	70.0%	4.4%
45	30	0.60	5.8%	1.08%	0.33%	7.1%	10.0%	0.7%
50	34	0.61	6.6%	1.08%	0.33%	8.0%	5.0%	0.4%
55	37	0.63	7.5%	1.08%	0.33%	8.8%	0.0%	0.0%
						Sea trout adult		6.4%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Sea trout adult**				**Sea trout adult**	
Operating Condition:			**Ebb Tide**	**Net head=**	**3.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.53	3.5%	1.08%	0.33%	4.8%	5.0%	0.2%
35	23	0.56	4.2%	1.08%	0.33%	5.6%	10.0%	0.6%
40	27	0.58	5.0%	1.08%	0.33%	6.4%	70.0%	4.4%
45	30	0.60	5.8%	1.08%	0.33%	7.1%	10.0%	0.7%
50	34	0.61	6.6%	1.08%	0.33%	8.0%	5.0%	0.4%
55	37	0.63	7.5%	1.08%	0.33%	8.8%	0.0%	0.0%
						Sea trout adult		6.4%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Herring				Herring	
Operating Condition:			Ebb Tide	Net head=	3.25	m	Length-weighted mortality rate	
Discharge =			360.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.26	0.2%	47.84%	0.33%	48.1%	0.0%	0.0%
10	7	0.37	0.7%	47.84%	0.33%	48.4%	0.0%	0.0%
15	10	0.43	1.3%	47.84%	0.33%	48.7%	0.0%	0.0%
20	13	0.47	2.0%	47.84%	0.33%	49.0%	25.0%	12.3%
25	17	0.51	2.7%	47.84%	0.33%	49.4%	50.0%	24.7%
30	20	0.53	3.5%	47.84%	0.33%	49.8%	25.0%	12.5%
						Herring		49.4%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Glass eel /elver				Glass eel/elver	
Operating Condition:			Ebb Tide	Net head=	3.25	m	Length-weighted mortality rate	
Discharge =			360.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
6	4	0.12	0.1%	0.00%	0.33%	0.4%	30.0%	0.1%
8	5	0.16	0.2%	0.00%	0.33%	0.5%	30.0%	0.2%
10	7	0.20	0.3%	0.00%	0.33%	0.6%	20.0%	0.1%
12	8	0.23	0.4%	0.00%	0.33%	0.8%	10.0%	0.1%
14	9	0.25	0.6%	0.00%	0.33%	0.9%	5.0%	0.0%
16	11	0.27	0.7%	0.00%	0.33%	1.0%	5.0%	0.1%
						Glass eel/elver		0.6%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Silver eel				Silver eel	
Operating Condition:			Ebb Tide	Net head=	3.25	m	Length-weighted mortality rate	
Discharge =			360.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.37	2.0%	0.00%	0.33%	2.3%	5.0%	0.1%
40	27	0.41	3.0%	0.00%	0.33%	3.3%	15.0%	0.5%
50	34	0.44	4.1%	0.00%	0.33%	4.4%	20.0%	0.9%
60	40	0.47	5.4%	0.00%	0.33%	5.7%	30.0%	1.7%
70	47	0.50	6.7%	0.00%	0.33%	7.0%	20.0%	1.4%
80	54	0.52	8.0%	0.00%	0.33%	8.3%	10.0%	0.8%
						Silver eel		5.4%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Gadoids				Gadoids	
Operating Condition:			Ebb Tide	Net head=	3.25	m	Length-weighted mortality rate	
Discharge =			360.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.38	0.8%	2.74%	2.62%	6.0%	10.0%	0.6%
20	13	0.80	3.4%	2.74%	2.62%	8.5%	70.0%	6.0%
30	20	0.87	5.6%	2.74%	2.62%	10.6%	10.0%	1.1%
40	27	0.91	7.9%	2.74%	2.62%	12.8%	10.0%	1.3%
50	34	0.94	10.2%	2.74%	2.62%	15.0%	0.0%	0.0%
60	40	0.97	12.7%	2.74%	2.62%	17.3%	0.0%	0.0%
						Gadoids		8.9%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Bass**				**Bass**	
Operating Condition:			**Ebb Tide**	**Net head=**	**3.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.29	0.3%	0.03%	2.62%	2.9%	5.0%	0.1%
10	7	0.40	0.8%	0.03%	2.62%	3.4%	25.0%	0.9%
20	13	0.51	2.2%	0.03%	2.62%	4.8%	50.0%	2.4%
30	20	0.57	3.7%	0.03%	2.62%	6.3%	17.0%	1.1%
40	27	0.61	5.3%	0.03%	2.62%	7.8%	2.5%	0.2%
50	34	0.65	7.0%	0.03%	2.62%	9.5%	0.5%	0.0%
						Bass		4.7%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Flatfish**				**Flatfish**	
Operating Condition:			**Ebb Tide**	**Net head=**	**3.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.40	0.4%	0.00%	0.33%	0.7%	50.0%	0.3%
10	7	0.51	1.0%	0.00%	0.33%	1.3%	20.0%	0.3%
15	10	0.57	1.7%	0.00%	0.33%	2.1%	5.0%	0.1%
20	13	0.61	2.6%	0.00%	0.33%	2.9%	10.0%	0.3%
30	20	0.67	4.4%	0.00%	0.33%	4.7%	10.0%	0.5%
40	27	0.72	6.2%	0.00%	0.33%	6.5%	5.0%	0.3%
						Flatfish		1.8%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Lamprey**				**Lamprey**	
Operating Condition:			**Ebb Tide**	**Net head=**	**3.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	20	0.37	2.0%	0.00%	0.33%	2.3%	10.0%	0.2%
20	27	0.41	3.0%	0.00%	0.33%	3.3%	10.0%	0.3%
30	34	0.44	4.1%	0.00%	0.33%	4.4%	20.0%	0.9%
40	40	0.47	5.4%	0.00%	0.33%	5.7%	20.0%	1.1%
50	47	0.50	6.7%	0.00%	0.33%	7.0%	20.0%	1.4%
60	54	0.52	8.0%	0.00%	0.33%	8.3%	20.0%	1.7%
						Lamprey		5.6%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Atlantic salmon & sea trout smolt**				**Atlantic salmon & sea trout smolt**	
Operating Condition:			**Flood Tide**	**Net head=**	**3.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length (cm)	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.37	0.7%	1.71%	0.33%	2.7%	10.0%	0.3%
15	10	0.43	1.3%	1.71%	0.33%	3.3%	70.0%	2.3%
20	13	0.47	2.0%	1.71%	0.33%	4.0%	15.0%	0.6%
25	17	0.51	2.7%	1.71%	0.33%	4.7%	5.0%	0.2%
					Atlantic salmon & sea trout smolt			3.4%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Atlantic salmon adult				Atlantic salmon adult	
Operating Condition:			Flood Tide	Net head=	3.25	m	Length-weighted mortality rate	
Discharge =			360.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
40	27	0.58	5.0%	1.71%	0.33%	6.9%	5.0%	0.3%
50	34	0.61	6.6%	1.71%	0.33%	8.5%	35.0%	3.0%
60	40	0.64	8.3%	1.71%	0.33%	10.2%	50.0%	5.1%
70	47	0.66	10.1%	1.71%	0.33%	11.9%	7.5%	0.9%
80	54	0.68	11.9%	1.71%	0.33%	13.7%	2.0%	0.3%
90	60	0.70	13.7%	1.71%	0.33%	15.5%	0.5%	0.1%
						Atlantic salmon adult		9.7%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Sea trout adult				Sea trout adult	
Operating Condition:			Flood Tide	Net head=	3.25	m	Length-weighted mortality rate	
Discharge =			360.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.53	3.5%	1.71%	0.33%	5.4%	5.0%	0.3%
35	23	0.56	4.2%	1.71%	0.33%	6.2%	10.0%	0.6%
40	27	0.58	5.0%	1.71%	0.33%	6.9%	70.0%	4.9%
45	30	0.60	5.8%	1.71%	0.33%	7.7%	10.0%	0.8%
50	34	0.61	6.6%	1.71%	0.33%	8.5%	5.0%	0.4%
55	37	0.63	7.5%	1.71%	0.33%	9.4%	0.0%	0.0%
						Sea trout adult		7.0%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Shad adults				Shad adult	
Operating Condition:			Flood Tide	Net head=	3.25	m	Length-weighted mortality rate	
Discharge =			360.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
25	17	0.51	2.7%	43.04%	0.33%	44.8%	0.0%	0.0%
30	20	0.53	3.5%	43.04%	0.33%	45.2%	20.0%	9.0%
35	23	0.56	4.2%	43.04%	0.33%	45.6%	30.0%	13.7%
40	27	0.58	5.0%	43.04%	0.33%	46.1%	30.0%	13.8%
45	30	0.60	5.8%	43.04%	0.33%	46.5%	20.0%	9.3%
50	34	0.61	6.6%	43.04%	0.33%	47.0%	0.0%	0.0%
						Shad adult		45.9%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Herring				Herring	
Operating Condition:			Flood Tide	Net head=	3.25	m	Length-weighted mortality rate	
Discharge =			360.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.26	0.2%	43.04%	0.33%	43.4%	0.0%	0.0%
10	7	0.37	0.7%	43.04%	0.33%	43.6%	0.0%	0.0%
15	10	0.43	1.3%	43.04%	0.33%	44.0%	0.0%	0.0%
20	13	0.47	2.0%	43.04%	0.33%	44.4%	25.0%	11.1%
25	17	0.51	2.7%	43.04%	0.33%	44.8%	50.0%	22.4%
30	20	0.53	3.5%	43.04%	0.33%	45.2%	25.0%	11.3%
						Herring		44.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Glass eel /elver				Glass eel/elver	
Operating Condition:			Flood Tide	Net head=	3.25	m	Length-weighted mortality rate	
Discharge =			360.00	cumecs	Off design			
Fish swimming condition:	1		Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
6	4	0.12	0.1%	0.00%	0.33%	0.4%	30.0%	0.1%
8	5	0.16	0.2%	0.00%	0.33%	0.5%	30.0%	0.2%
10	7	0.20	0.3%	0.00%	0.33%	0.6%	20.0%	0.1%
12	8	0.23	0.4%	0.00%	0.33%	0.8%	10.0%	0.1%
14	9	0.25	0.6%	0.00%	0.33%	0.9%	5.0%	0.0%
16	11	0.27	0.7%	0.00%	0.33%	1.0%	5.0%	0.1%
						Glass eel/elver		0.6%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Silver eel				Silver eel	
Operating Condition:			Flood Tide	Net head=	3.25	m	Length-weighted mortality rate	
Discharge =			360.00	cumecs	Off design			
Fish swimming condition:	1		Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.37	2.0%	0.00%	0.33%	2.3%	5.0%	0.1%
40	27	0.41	3.0%	0.00%	0.33%	3.3%	15.0%	0.5%
50	34	0.44	4.1%	0.00%	0.33%	4.4%	20.0%	0.9%
60	40	0.47	5.4%	0.00%	0.33%	5.7%	30.0%	1.7%
70	47	0.50	6.7%	0.00%	0.33%	7.0%	20.0%	1.4%
80	54	0.52	8.0%	0.00%	0.33%	8.3%	10.0%	0.8%
						Silver eel		5.4%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Gadoids				Gadoids	
Operating Condition:			Flood Tide	Net head=	3.25	m	Length-weighted mortality rate	
Discharge =			360.00	cumecs	Off design			
Fish swimming condition:	1		Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.38	0.8%	4.33%	2.62%	7.5%	10.0%	0.8%
20	13	0.80	3.4%	4.33%	2.62%	10.0%	70.0%	7.0%
30	20	0.87	5.6%	4.33%	2.62%	12.1%	10.0%	1.2%
40	27	0.91	7.9%	4.33%	2.62%	14.2%	10.0%	1.4%
50	34	0.94	10.2%	4.33%	2.62%	16.4%	0.0%	0.0%
60	40	0.97	12.7%	4.33%	2.62%	18.6%	0.0%	0.0%
						Gadoids		10.4%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Bass				Bass	
Operating Condition:			Flood Tide	Net head=	3.25	m	Length-weighted mortality rate	
Discharge =			360.00	cumecs	Off design			
Fish swimming condition:	1		Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.29	0.3%	0.05%	2.62%	2.9%	5.0%	0.1%
10	7	0.40	0.8%	0.05%	2.62%	3.5%	25.0%	0.9%
20	13	0.51	2.2%	0.05%	2.62%	4.8%	50.0%	2.4%
30	20	0.57	3.7%	0.05%	2.62%	6.3%	17.0%	1.1%
40	27	0.61	5.3%	0.05%	2.62%	7.8%	2.5%	0.2%
50	34	0.65	7.0%	0.05%	2.62%	9.5%	0.5%	0.0%
						Bass		4.7%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**						
Fish species:			**Flatfish**					**Flatfish**	
Operating Condition:			**Flood Tide**	**Net head=**	**3.25**	**m**		**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**Off design**				
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**			
	Swimming-Factor-		Predicted Injuries Due to:						
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound		Length-frequency	Net mortality
5	3	0.40	0.4%	0.00%	0.33%	0.7%		50.0%	0.3%
10	7	0.51	1.0%	0.00%	0.33%	1.3%		20.0%	0.3%
15	10	0.57	1.7%	0.00%	0.33%	2.1%		5.0%	0.1%
20	13	0.61	2.6%	0.00%	0.33%	2.9%		10.0%	0.3%
30	20	0.67	4.4%	0.00%	0.33%	4.7%		10.0%	0.5%
40	27	0.72	6.2%	0.00%	0.33%	6.5%		5.0%	0.3%
						Flatfish			1.8%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**						
Fish species:			**Lamprey**					**Lamprey**	
Operating Condition:			**Flood Tide**	**Net head=**	**3.25**	**m**		**Length-weighted mortality rate**	
Discharge =			**360.00**	**cumecs**	**Off design**				
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**			
	Swimming-Factor-		Predicted Injuries Due to:						
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound		Length-frequency	Net mortality
10	20	0.37	2.0%	0.00%	0.33%	2.3%		10.0%	0.2%
20	27	0.41	3.0%	0.00%	0.33%	3.3%		10.0%	0.3%
30	34	0.44	4.1%	0.00%	0.33%	4.4%		20.0%	0.9%
40	40	0.47	5.4%	0.00%	0.33%	5.7%		20.0%	1.1%
50	47	0.50	6.7%	0.00%	0.33%	7.0%		20.0%	1.4%
60	54	0.52	8.0%	0.00%	0.33%	8.3%		20.0%	1.7%
						Lamprey			5.6%

Table A2.6: Operating Head: 3.75 m, Ebb and Flood Generation

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Atlantic salmon & sea trout smolt**				**Atlantic salmon & sea trout smolt**	
Operating Condition:			**Ebb Tide**	**Net head=**	**3.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**370.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length (cm)	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.37	0.7%	1.08%	0.33%	2.1%	10.0%	0.2%
15	10	0.43	1.3%	1.08%	0.33%	2.7%	70.0%	1.9%
20	13	0.47	1.9%	1.08%	0.33%	3.3%	15.0%	0.5%
25	17	0.51	2.7%	1.08%	0.33%	4.0%	5.0%	0.2%
						Atlantic salmon & sea trout smolt		2.8%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Atlantic salmon adult**				**Atlantic salmon adult**	
Operating Condition:			**Ebb Tide**	**Net head=**	**3.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**370.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
40	27	0.58	4.9%	1.08%	0.33%	6.2%	5.0%	0.3%
50	34	0.61	6.5%	1.08%	0.33%	7.8%	35.0%	2.7%
60	40	0.64	8.1%	1.08%	0.33%	9.4%	50.0%	4.7%
70	47	0.66	9.8%	1.08%	0.33%	11.1%	7.5%	0.8%
80	54	0.68	11.6%	1.08%	0.33%	12.8%	2.0%	0.3%
90	60	0.70	13.4%	1.08%	0.33%	14.6%	0.5%	0.1%
						Atlantic salmon adult		8.9%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Sea trout adult**				**Sea trout adult**	
Operating Condition:			**Ebb Tide**	**Net head=**	**3.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**370.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.53	3.4%	1.08%	0.33%	4.7%	5.0%	0.2%
35	23	0.56	4.1%	1.08%	0.33%	5.5%	10.0%	0.5%
40	27	0.58	4.9%	1.08%	0.33%	6.2%	70.0%	4.4%
45	30	0.60	5.7%	1.08%	0.33%	7.0%	10.0%	0.7%
50	34	0.61	6.5%	1.08%	0.33%	7.8%	5.0%	0.4%
55	37	0.63	7.3%	1.08%	0.33%	8.6%	0.0%	0.0%
						Sea trout adult		6.2%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Shad adults**				**Shad adult**	
Operating Condition:			**Ebb Tide**	**Net head=**	**3.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**370.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
25	17	0.51	2.7%	47.84%	0.33%	49.4%	0.0%	0.0%
30	20	0.53	3.4%	47.84%	0.33%	49.8%	20.0%	10.0%
35	23	0.56	4.1%	47.84%	0.33%	50.2%	30.0%	15.0%
40	27	0.58	4.9%	47.84%	0.33%	50.6%	30.0%	15.2%
45	30	0.60	5.7%	47.84%	0.33%	51.0%	20.0%	10.2%
50	34	0.61	6.5%	47.84%	0.33%	51.4%	0.0%	0.0%
						Shad adult		50.4%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Herring**				**Herring**	
Operating Condition:			**Ebb Tide**	**Net head=**	**3.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**370.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.26	0.2%	47.84%	0.33%	48.1%	0.0%	0.0%
10	7	0.37	0.7%	47.84%	0.33%	48.4%	0.0%	0.0%
15	10	0.43	1.3%	47.84%	0.33%	48.7%	0.0%	0.0%
20	13	0.47	1.9%	47.84%	0.33%	49.0%	25.0%	12.3%
25	17	0.51	2.7%	47.84%	0.33%	49.4%	50.0%	24.7%
30	20	0.53	3.4%	47.84%	0.33%	49.8%	25.0%	12.4%
						Herring		49.4%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Glass eel /elver**				**Glass eel/elver**	
Operating Condition:			**Ebb Tide**	**Net head=**	**3.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**370.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
6	4	0.12	0.1%	0.00%	0.33%	0.4%	30.0%	0.1%
8	5	0.16	0.2%	0.00%	0.33%	0.5%	30.0%	0.2%
10	7	0.20	0.3%	0.00%	0.33%	0.6%	20.0%	0.1%
12	8	0.23	0.4%	0.00%	0.33%	0.8%	10.0%	0.1%
14	9	0.25	0.6%	0.00%	0.33%	0.9%	5.0%	0.0%
16	11	0.27	0.7%	0.00%	0.33%	1.0%	5.0%	0.1%
						Glass eel/elver		0.6%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Silver eel**				**Silver eel**	
Operating Condition:			**Ebb Tide**	**Net head=**	**3.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**370.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.37	1.9%	0.00%	0.33%	2.2%	5.0%	0.1%
40	27	0.41	2.9%	0.00%	0.33%	3.2%	15.0%	0.5%
50	34	0.44	4.1%	0.00%	0.33%	4.4%	20.0%	0.9%
60	40	0.47	5.3%	0.00%	0.33%	5.6%	30.0%	1.7%
70	47	0.50	6.5%	0.00%	0.33%	6.8%	20.0%	1.4%
80	54	0.52	7.9%	0.00%	0.33%	8.2%	10.0%	0.8%
						Silver eel		5.3%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Gadoids**				**Gadoids**	
Operating Condition:			**Ebb Tide**	**Net head=**	**3.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**370.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.38	0.7%	2.74%	2.62%	6.0%	10.0%	0.6%
20	13	0.80	3.3%	2.74%	2.62%	8.5%	70.0%	5.9%
30	20	0.87	5.5%	2.74%	2.62%	10.5%	10.0%	1.0%
40	27	0.91	7.7%	2.74%	2.62%	12.6%	10.0%	1.3%
50	34	0.94	10.0%	2.74%	2.62%	14.8%	0.0%	0.0%
60	40	0.97	12.4%	2.74%	2.62%	17.0%	0.0%	0.0%
						Gadoids		8.8%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Bass**				**Bass**	
Operating Condition:			**Ebb Tide**	**Net head=**	**3.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**370.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.29	0.3%	0.03%	2.62%	2.9%	5.0%	0.1%
10	7	0.40	0.8%	0.03%	2.62%	3.4%	25.0%	0.9%
20	13	0.51	2.1%	0.03%	2.62%	4.7%	50.0%	2.4%
30	20	0.57	3.6%	0.03%	2.62%	6.2%	17.0%	1.0%
40	27	0.61	5.2%	0.03%	2.62%	7.7%	2.5%	0.2%
50	34	0.65	6.8%	0.03%	47.84%	51.4%	0.5%	0.3%
						Bass		4.9%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Flatfish**				**Flatfish**	
Operating Condition:			**Ebb Tide**	**Net head=**	**3.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**370.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.40	0.4%	0.00%	0.33%	0.7%	50.0%	0.3%
10	7	0.51	1.0%	0.00%	0.33%	1.3%	20.0%	0.3%
15	10	0.57	1.7%	0.00%	0.33%	2.0%	5.0%	0.1%
20	13	0.61	2.5%	0.00%	0.33%	2.8%	10.0%	0.3%
30	20	0.67	4.3%	0.00%	0.33%	4.6%	10.0%	0.5%
40	27	0.72	6.1%	0.00%	0.33%	6.4%	5.0%	0.3%
						Flatfish		1.8%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Lamprey**				**Lamprey**	
Operating Condition:			**Ebb Tide**	**Net head=**	**3.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**370.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	20	0.37	1.9%	0.00%	0.33%	2.2%	10.0%	0.2%
20	27	0.41	2.9%	0.00%	0.33%	3.2%	10.0%	0.3%
30	34	0.44	4.1%	0.00%	0.33%	4.4%	20.0%	0.9%
40	40	0.47	5.3%	0.00%	0.33%	5.6%	20.0%	1.1%
50	47	0.50	6.5%	0.00%	0.33%	6.8%	20.0%	1.4%
60	54	0.52	7.9%	0.00%	0.00%	7.9%	20.0%	1.6%
						Lamprey		5.5%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Atlantic salmon & sea trout smolt**				**Atlantic salmon & sea trout smolt**	
Operating Condition:			**Flood Tide**	**Net head=**	**3.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**370.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length (cm)	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.37	0.7%	1.71%	0.33%	2.7%	10.0%	0.3%
15	10	0.43	1.3%	1.71%	0.33%	3.3%	70.0%	2.3%
20	13	0.47	1.9%	1.71%	0.33%	3.9%	15.0%	0.6%
25	17	0.51	2.7%	1.71%	0.33%	4.6%	5.0%	0.2%
						Atlantic salmon & sea trout smolt		3.4%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Atlantic salmon adult				Atlantic salmon adult	
Operating Condition:			Flood Tide	Net head=	3.75	m	Length-weighted mortality rate	
Discharge =			370.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
40	27	0.58	4.9%	1.71%	0.33%	6.8%	5.0%	0.3%
50	34	0.61	6.5%	1.71%	0.33%	8.4%	35.0%	2.9%
60	40	0.64	8.1%	1.71%	0.33%	10.0%	50.0%	5.0%
70	47	0.66	9.8%	1.71%	0.33%	11.7%	7.5%	0.9%
80	54	0.68	11.6%	1.71%	0.33%	13.4%	2.0%	0.3%
90	60	0.70	13.4%	1.71%	0.33%	15.2%	0.5%	0.1%
						Atlantic salmon adult		9.5%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Sea trout adult				Sea trout adult	
Operating Condition:			Flood Tide	Net head=	3.75	m	Length-weighted mortality rate	
Discharge =			370.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.53	3.4%	1.71%	0.33%	5.4%	5.0%	0.3%
35	23	0.56	4.1%	1.71%	0.33%	6.1%	10.0%	0.6%
40	27	0.58	4.9%	1.71%	0.33%	6.8%	70.0%	4.8%
45	30	0.60	5.7%	1.71%	0.33%	7.6%	10.0%	0.8%
50	34	0.61	6.5%	1.71%	0.33%	8.4%	5.0%	0.4%
55	37	0.63	7.3%	1.71%	0.33%	9.2%	0.0%	0.0%
						Sea trout adult		6.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Shad adults				Shad adult	
Operating Condition:			Flood Tide	Net head=	3.75	m	Length-weighted mortality rate	
Discharge =			370.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
25	17	0.51	2.7%	43.04%	0.33%	44.7%	0.0%	0.0%
30	20	0.53	3.4%	43.04%	0.33%	45.2%	20.0%	9.0%
35	23	0.56	4.1%	43.04%	0.33%	45.6%	30.0%	13.7%
40	27	0.58	4.9%	43.04%	0.33%	46.0%	30.0%	13.8%
45	30	0.60	5.7%	43.04%	0.33%	46.5%	20.0%	9.3%
50	34	0.61	6.5%	43.04%	0.33%	46.9%	0.0%	0.0%
						Shad adult		45.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Herring				Herring	
Operating Condition:			Flood Tide	Net head=	3.75	m	Length-weighted mortality rate	
Discharge =			370.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.26	0.2%	43.04%	0.33%	43.4%	0.0%	0.0%
10	7	0.37	0.7%	43.04%	0.33%	43.6%	0.0%	0.0%
15	10	0.43	1.3%	43.04%	0.33%	44.0%	0.0%	0.0%
20	13	0.47	1.9%	43.04%	0.33%	44.3%	25.0%	11.1%
25	17	0.51	2.7%	43.04%	0.33%	44.7%	50.0%	22.4%
30	20	0.53	3.4%	43.04%	0.33%	45.2%	25.0%	11.3%
						Herring		44.7%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Glass eel /elver**				**Glass eel/elver**	
Operating Condition:			**Flood Tide**	**Net head=**	**3.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**370.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
6	4	0.12	0.1%	0.00%	0.33%	0.4%	30.0%	0.1%
8	5	0.16	0.2%	0.00%	0.33%	0.5%	30.0%	0.2%
10	7	0.20	0.3%	0.00%	0.33%	0.6%	20.0%	0.1%
12	8	0.23	0.4%	0.00%	0.33%	0.8%	10.0%	0.1%
14	9	0.25	0.6%	0.00%	0.33%	0.9%	5.0%	0.0%
16	11	0.27	0.7%	0.00%	0.33%	1.0%	5.0%	0.1%
						Glass eel/elver		0.6%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Silver eel**				**Silver eel**	
Operating Condition:			**Flood Tide**	**Net head=**	**3.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**370.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.37	1.9%	0.00%	0.33%	2.2%	5.0%	0.1%
40	27	0.41	2.9%	0.00%	0.33%	3.2%	15.0%	0.5%
50	34	0.44	4.1%	0.00%	0.33%	4.4%	20.0%	0.9%
60	40	0.47	5.3%	0.00%	0.33%	5.6%	30.0%	1.7%
70	47	0.50	6.5%	0.00%	0.33%	6.8%	20.0%	1.4%
80	54	0.52	7.9%	0.00%	0.33%	8.2%	10.0%	0.8%
						Silver eel		5.3%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Gadoids**				**Gadoids**	
Operating Condition:			**Flood Tide**	**Net head=**	**3.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**370.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.38	0.7%	4.33%	2.62%	7.5%	10.0%	0.8%
20	13	0.80	3.3%	4.33%	2.62%	10.0%	70.0%	7.0%
30	20	0.87	5.5%	4.33%	2.62%	12.0%	10.0%	1.2%
40	27	0.91	7.7%	4.33%	2.62%	14.0%	10.0%	1.4%
50	34	0.94	10.0%	4.33%	2.62%	16.2%	0.0%	0.0%
60	40	0.97	12.4%	4.33%	2.62%	18.4%	0.0%	0.0%
						Gadoids		10.3%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Bass**				**Bass**	
Operating Condition:			**Flood Tide**	**Net head=**	**3.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**370.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.29	0.3%	0.05%	2.62%	2.9%	5.0%	0.1%
10	7	0.40	0.8%	0.05%	2.62%	3.4%	25.0%	0.9%
20	13	0.51	2.1%	0.05%	2.62%	4.7%	50.0%	2.4%
30	20	0.57	3.6%	0.05%	2.62%	6.2%	17.0%	1.1%
40	27	0.61	5.2%	0.05%	2.62%	7.7%	2.5%	0.2%
50	34	0.65	6.8%	0.05%	43.04%	47.0%	0.5%	0.2%
						Bass		4.9%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Flatfish				Flatfish	
Operating Condition:			Flood Tide	Net head=	3.75	m	Length-weighted mortality rate	
Discharge =			370.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.40	0.4%	0.00%	0.33%	0.7%	50.0%	0.3%
10	7	0.51	1.0%	0.00%	0.33%	1.3%	20.0%	0.3%
15	10	0.57	1.7%	0.00%	0.33%	2.0%	5.0%	0.1%
20	13	0.61	2.5%	0.00%	0.33%	2.8%	10.0%	0.3%
30	20	0.67	4.3%	0.00%	0.33%	4.6%	10.0%	0.5%
40	27	0.72	6.1%	0.00%	0.33%	6.4%	5.0%	0.3%
						Flatfish		1.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Lamprey				Lamprey	
Operating Condition:			Flood Tide	Net head=	3.75	m	Length-weighted mortality rate	
Discharge =			370.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	20	0.37	1.9%	0.00%	0.33%	2.2%	10.0%	0.2%
20	27	0.41	2.9%	0.00%	0.33%	3.2%	10.0%	0.3%
30	34	0.44	4.1%	0.00%	0.33%	4.4%	20.0%	0.9%
40	40	0.47	5.3%	0.00%	0.33%	5.6%	20.0%	1.1%
50	47	0.50	6.5%	0.00%	0.33%	6.8%	20.0%	1.4%
60	54	0.52	7.9%	0.00%	0.00%	7.9%	20.0%	1.6%
						Lamprey		5.5%

Table A2.7: Operating Head: 4.25 m, Ebb and Flood Generation

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Atlantic salmon & sea trout smolt**				**Atlantic salmon & sea trout smolt**	
Operating Condition:			**Ebb Tide**	**Net head=**	**4.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length (cm)	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.37	0.7%	1.08%	0.33%	2.1%	10.0%	0.2%
15	10	0.43	1.3%	1.08%	0.33%	2.7%	70.0%	1.9%
20	13	0.47	1.9%	1.08%	0.33%	3.3%	15.0%	0.5%
25	17	0.51	2.7%	1.08%	0.33%	4.0%	5.0%	0.2%
						Atlantic salmon & sea trout smolt		2.8%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Atlantic salmon adult**				**Atlantic salmon adult**	
Operating Condition:			**Ebb Tide**	**Net head=**	**4.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
40	27	0.58	4.9%	1.08%	0.33%	6.2%	5.0%	0.3%
50	34	0.61	6.4%	1.08%	0.33%	7.8%	35.0%	2.7%
60	40	0.64	8.1%	1.08%	0.33%	9.4%	50.0%	4.7%
70	47	0.66	9.8%	1.08%	0.33%	11.1%	7.5%	0.8%
80	54	0.68	11.5%	1.08%	0.33%	12.8%	2.0%	0.3%
90	60	0.70	13.3%	1.08%	0.33%	14.5%	0.5%	0.1%
						Atlantic salmon adult		8.9%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Sea trout adult**				**Sea trout adult**	
Operating Condition:			**Ebb Tide**	**Net head=**	**4.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.53	3.4%	1.08%	0.33%	4.7%	5.0%	0.2%
35	23	0.56	4.1%	1.08%	0.33%	5.5%	10.0%	0.5%
40	27	0.58	4.9%	1.08%	0.33%	6.2%	70.0%	4.3%
45	30	0.60	5.7%	1.08%	0.33%	7.0%	10.0%	0.7%
50	34	0.61	6.4%	1.08%	0.33%	7.8%	5.0%	0.4%
55	37	0.63	7.3%	1.08%	0.33%	8.6%	0.0%	0.0%
						Sea trout adult		6.2%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Shad adults**				**Shad adult**	
Operating Condition:			**Ebb Tide**	**Net head=**	**4.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
25	17	0.51	2.7%	47.84%	0.33%	49.4%	0.0%	0.0%
30	20	0.53	3.4%	47.84%	0.33%	49.8%	20.0%	10.0%
35	23	0.56	4.1%	47.84%	0.33%	50.1%	30.0%	15.0%
40	27	0.58	4.9%	47.84%	0.33%	50.5%	30.0%	15.2%
45	30	0.60	5.7%	47.84%	0.33%	50.9%	20.0%	10.2%
50	34	0.61	6.4%	47.84%	0.33%	51.4%	0.0%	0.0%
						Shad adult		50.3%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Glass eel /elver**				**Glass eel/elver**	
Operating Condition:			**Ebb Tide**	**Net head=**	**4.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
6	4	0.12	0.1%	0.00%	0.33%	0.4%	30.0%	0.1%
8	5	0.16	0.2%	0.00%	0.33%	0.5%	30.0%	0.2%
10	7	0.20	0.3%	0.00%	0.33%	0.6%	20.0%	0.1%
12	8	0.23	0.4%	0.00%	0.33%	0.8%	10.0%	0.1%
14	9	0.25	0.6%	0.00%	0.33%	0.9%	5.0%	0.0%
16	11	0.27	0.7%	0.00%	0.33%	1.0%	5.0%	0.1%
						Glass eel/elver		0.6%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Herring**				**Herring**	
Operating Condition:			**Ebb Tide**	**Net head=**	**4.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.26	0.2%	47.84%	0.33%	48.1%	0.0%	0.0%
10	7	0.37	0.7%	47.84%	0.33%	48.4%	0.0%	0.0%
15	10	0.43	1.3%	47.84%	0.33%	48.7%	0.0%	0.0%
20	13	0.47	1.9%	47.84%	0.33%	49.0%	25.0%	12.3%
25	17	0.51	2.7%	47.84%	0.33%	49.4%	50.0%	24.7%
30	20	0.53	3.4%	47.84%	0.33%	49.8%	25.0%	12.4%
						Herring		49.4%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Silver eel**				**Silver eel**	
Operating Condition:			**Ebb Tide**	**Net head=**	**4.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.37	1.9%	0.00%	0.33%	2.2%	5.0%	0.1%
40	27	0.41	2.9%	0.00%	0.33%	3.2%	15.0%	0.5%
50	34	0.44	4.0%	0.00%	0.33%	4.4%	20.0%	0.9%
60	40	0.47	5.2%	0.00%	0.33%	5.6%	30.0%	1.7%
70	47	0.50	6.5%	0.00%	0.33%	6.8%	20.0%	1.4%
80	54	0.52	7.8%	0.00%	0.33%	8.1%	10.0%	0.8%
						Silver eel		5.3%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Gadoids**				**Gadoids**	
Operating Condition:			**Ebb Tide**	**Net head=**	**4.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.38	0.7%	2.74%	2.62%	6.0%	10.0%	0.6%
20	13	0.80	3.3%	2.74%	2.62%	8.4%	70.0%	5.9%
30	20	0.87	5.5%	2.74%	2.62%	10.5%	10.0%	1.0%
40	27	0.91	7.7%	2.74%	2.62%	12.5%	10.0%	1.3%
50	34	0.94	9.9%	2.74%	2.62%	14.7%	0.0%	0.0%
60	40	0.97	12.3%	2.74%	2.62%	16.9%	0.0%	0.0%
						Gadoids		8.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Bass				Bass	
Operating Condition:			Ebb Tide	Net head=	4.25	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.29	0.3%	0.03%	2.62%	2.9%	5.0%	0.1%
10	7	0.40	0.8%	0.03%	2.62%	3.4%	25.0%	0.9%
20	13	0.51	2.1%	0.03%	2.62%	4.7%	50.0%	2.4%
30	20	0.57	3.6%	0.03%	2.62%	6.1%	17.0%	1.0%
40	27	0.61	5.2%	0.03%	2.62%	7.7%	2.5%	0.2%
50	34	0.65	6.8%	0.03%	2.62%	9.3%	0.5%	0.0%
						Bass		4.6%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Flatfish				Flatfish	
Operating Condition:			Ebb Tide	Net head=	4.25	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.40	0.4%	0.00%	0.33%	0.7%	50.0%	0.3%
10	7	0.51	1.0%	0.00%	0.33%	1.3%	20.0%	0.3%
15	10	0.57	1.7%	0.00%	0.33%	2.0%	5.0%	0.1%
20	13	0.61	2.5%	0.00%	0.33%	2.8%	10.0%	0.3%
30	20	0.67	4.3%	0.00%	0.33%	4.6%	10.0%	0.5%
40	27	0.72	6.1%	0.00%	0.33%	6.4%	5.0%	0.3%
						Flatfish		1.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Lamprey				Lamprey	
Operating Condition:			Ebb Tide	Net head=	4.25	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	20	0.37	1.9%	0.00%	0.33%	2.2%	10.0%	0.2%
20	27	0.41	2.9%	0.00%	0.33%	3.2%	10.0%	0.3%
30	34	0.44	4.0%	0.00%	0.33%	4.4%	20.0%	0.9%
40	40	0.47	5.2%	0.00%	0.33%	5.6%	20.0%	1.1%
50	47	0.50	6.5%	0.00%	0.33%	6.8%	20.0%	1.4%
60	54	0.52	7.8%	0.00%	0.33%	8.1%	20.0%	1.6%
						Lamprey		5.5%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Atlantic salmon & sea trout smolt				Atlantic salmon & sea trout smolt	
Operating Condition:			Flood Tide	Net head=	4.25	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor- Adjusted Length		Predicted Injuries Due to:					
Fish Length (cm)	(cm)	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.37	0.7%	1.71%	0.33%	2.7%	10.0%	0.3%
15	10	0.43	1.3%	1.71%	0.33%	3.3%	70.0%	2.3%
20	13	0.47	1.9%	1.71%	0.33%	3.9%	15.0%	0.6%
25	17	0.51	2.7%	1.71%	0.33%	4.6%	5.0%	0.2%
						Atlantic salmon & sea trout smolt		3.4%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Atlantic salmon adult				Atlantic salmon adult	
Operating Condition:			Flood Tide	Net head=	4.25	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
40	27	0.58	4.9%	1.71%	0.33%	6.8%	5.0%	0.3%
50	34	0.61	6.4%	1.71%	0.33%	8.3%	35.0%	2.9%
60	40	0.64	8.1%	1.71%	0.33%	10.0%	50.0%	5.0%
70	47	0.66	9.8%	1.71%	0.33%	11.6%	7.5%	0.9%
80	54	0.68	11.5%	1.71%	0.33%	13.3%	2.0%	0.3%
90	60	0.70	13.3%	1.71%	0.33%	15.1%	0.5%	0.1%
						Atlantic salmon adult		9.5%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Sea trout adult				Sea trout adult	
Operating Condition:			Flood Tide	Net head=	4.25	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.53	3.4%	1.71%	0.33%	5.3%	5.0%	0.3%
35	23	0.56	4.1%	1.71%	0.33%	6.1%	10.0%	0.6%
40	27	0.58	4.9%	1.71%	0.33%	6.8%	70.0%	4.8%
45	30	0.60	5.7%	1.71%	0.33%	7.6%	10.0%	0.8%
50	34	0.61	6.4%	1.71%	0.33%	8.3%	5.0%	0.4%
55	37	0.63	7.3%	1.71%	0.33%	9.1%	0.0%	0.0%
						Sea trout adult		6.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Shad adults				Shad adult	
Operating Condition:			Flood Tide	Net head=	4.25	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
25	17	0.51	2.7%	43.04%	0.33%	44.7%	0.0%	0.0%
30	20	0.53	3.4%	43.04%	0.33%	45.1%	20.0%	9.0%
35	23	0.56	4.1%	43.04%	0.33%	45.6%	30.0%	13.7%
40	27	0.58	4.9%	43.04%	0.33%	46.0%	30.0%	13.8%
45	30	0.60	5.7%	43.04%	0.33%	46.4%	20.0%	9.3%
50	34	0.61	6.4%	43.04%	0.33%	46.9%	0.0%	0.0%
						Shad adult		45.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Herring				Herring	
Operating Condition:			Flood Tide	Net head=	4.25	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.26	0.2%	43.04%	0.33%	43.4%	0.0%	0.0%
10	7	0.37	0.7%	43.04%	0.33%	43.6%	0.0%	0.0%
15	10	0.43	1.3%	43.04%	0.33%	44.0%	0.0%	0.0%
20	13	0.47	1.9%	43.04%	0.33%	44.3%	25.0%	11.1%
25	17	0.51	2.7%	43.04%	0.33%	44.7%	50.0%	22.4%
30	20	0.53	3.4%	43.04%	0.33%	45.1%	25.0%	11.3%
						Herring		44.7%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Glass eel /elver**				**Glass eel/elver**	
Operating Condition:			**Flood Tide**	**Net head=**	**4.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Predicted Injuries Due to: Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
6	4	0.12	0.1%	0.00%	0.33%	0.4%	30.0%	0.1%
8	5	0.16	0.2%	0.00%	0.33%	0.5%	30.0%	0.2%
10	7	0.20	0.3%	0.00%	0.33%	0.6%	20.0%	0.1%
12	8	0.23	0.4%	0.00%	0.33%	0.8%	10.0%	0.1%
14	9	0.25	0.6%	0.00%	0.33%	0.9%	5.0%	0.0%
16	11	0.27	0.7%	0.00%	0.33%	1.0%	5.0%	0.1%
						Glass eel/elver		0.6%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Silver eel**				**Silver eel**	
Operating Condition:			**Flood Tide**	**Net head=**	**4.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Predicted Injuries Due to: Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.37	1.9%	0.00%	0.33%	2.2%	5.0%	0.1%
40	27	0.41	2.9%	0.00%	0.33%	3.2%	15.0%	0.5%
50	34	0.44	4.0%	0.00%	0.33%	4.4%	20.0%	0.9%
60	40	0.47	5.2%	0.00%	0.33%	5.6%	30.0%	1.7%
70	47	0.50	6.5%	0.00%	0.33%	6.8%	20.0%	1.4%
80	54	0.52	7.8%	0.00%	0.33%	8.1%	10.0%	0.8%
						Silver eel		5.3%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Gadoids**				**Gadoids**	
Operating Condition:			**Flood Tide**	**Net head=**	**4.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Predicted Injuries Due to: Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.38	0.7%	4.33%	2.62%	7.5%	10.0%	0.8%
20	13	0.80	3.3%	4.33%	2.62%	9.9%	70.0%	7.0%
30	20	0.87	5.5%	4.33%	2.62%	11.9%	10.0%	1.2%
40	27	0.91	7.7%	4.33%	2.62%	14.0%	10.0%	1.4%
50	34	0.94	9.9%	4.33%	2.62%	16.1%	0.0%	0.0%
60	40	0.97	12.3%	4.33%	2.62%	18.3%	0.0%	0.0%
						Gadoids		10.3%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Bass**				**Bass**	
Operating Condition:			**Flood Tide**	**Net head=**	**4.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Predicted Injuries Due to: Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.29	0.3%	0.05%	2.62%	2.9%	5.0%	0.1%
10	7	0.40	0.8%	0.05%	2.62%	3.4%	25.0%	0.9%
20	13	0.51	2.1%	0.05%	2.62%	4.7%	50.0%	2.4%
30	20	0.57	3.6%	0.05%	2.62%	6.2%	17.0%	1.0%
40	27	0.61	5.2%	0.05%	2.62%	7.7%	2.5%	0.2%
50	34	0.65	6.8%	0.05%	2.62%	9.3%	0.5%	0.0%
						Bass		4.7%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**						
Fish species:			**Flatfish**					**Flatfish**	
Operating Condition:			**Flood Tide**	**Net head=**	**4.25**	**m**		**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**				
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**			
	Swimming-Factor-		Predicted Injuries Due to:						
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound		Length-frequency	Net mortality
5	3	0.40	0.4%	0.00%	0.33%	0.7%		50.0%	0.3%
10	7	0.51	1.0%	0.00%	0.33%	1.3%		20.0%	0.3%
15	10	0.57	1.7%	0.00%	0.33%	2.0%		5.0%	0.1%
20	13	0.61	2.5%	0.00%	0.33%	2.8%		10.0%	0.3%
30	20	0.67	4.3%	0.00%	0.33%	4.6%		10.0%	0.5%
40	27	0.72	6.1%	0.00%	0.33%	6.4%		5.0%	0.3%
						Flatfish			1.8%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**						
Fish species:			**Lamprey**					**Lamprey**	
Operating Condition:			**Flood Tide**	**Net head=**	**4.25**	**m**		**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**				
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**			
	Swimming-Factor-		Predicted Injuries Due to:						
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound		Length-frequency	Net mortality
10	20	0.37	1.9%	0.00%	0.33%	2.2%		10.0%	0.2%
20	27	0.41	2.9%	0.00%	0.33%	3.2%		10.0%	0.3%
30	34	0.44	4.0%	0.00%	0.33%	4.4%		20.0%	0.9%
40	40	0.47	5.2%	0.00%	0.33%	5.6%		20.0%	1.1%
50	47	0.50	6.5%	0.00%	0.33%	6.8%		20.0%	1.4%
60	54	0.52	7.8%	0.00%	0.33%	8.1%		20.0%	1.6%
						Lamprey			5.5%

Table A2.8: Operating Head: 4.25 m, Ebb and Flood Generation

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Atlantic salmon & sea trout smolt				Atlantic salmon & sea trout smolt	
Operating Condition:			Ebb Tide	Net head=	4.75	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length (cm)	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.37	0.7%	1.08%	0.33%	2.1%	10.0%	0.2%
15	10	0.43	1.3%	1.08%	0.33%	2.7%	70.0%	1.9%
20	13	0.47	2.0%	1.08%	0.33%	3.3%	15.0%	0.5%
25	17	0.51	2.7%	1.08%	0.33%	4.0%	5.0%	0.2%
					Atlantic salmon & sea trout smolt			2.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Atlantic salmon adult				Atlantic salmon adult	
Operating Condition:			Ebb Tide	Net head=	4.75	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
40	27	0.58	4.9%	1.08%	0.33%	6.2%	5.0%	0.3%
50	34	0.61	6.5%	1.08%	0.33%	7.8%	35.0%	2.7%
60	40	0.64	8.2%	1.08%	0.33%	9.4%	50.0%	4.7%
70	47	0.66	9.9%	1.08%	0.33%	11.1%	7.5%	0.8%
80	54	0.68	11.6%	1.08%	0.33%	12.9%	2.0%	0.3%
90	60	0.70	13.4%	1.08%	0.33%	14.6%	0.5%	0.1%
						Atlantic salmon adult		8.9%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Sea trout adult				Sea trout adult	
Operating Condition:			Ebb Tide	Net head=	4.75	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.53	3.4%	1.08%	0.33%	4.8%	5.0%	0.2%
35	23	0.56	4.1%	1.08%	0.33%	5.5%	10.0%	0.5%
40	27	0.58	4.9%	1.08%	0.33%	6.2%	70.0%	4.4%
45	30	0.60	5.7%	1.08%	0.33%	7.0%	10.0%	0.7%
50	34	0.61	6.5%	1.08%	0.33%	7.8%	5.0%	0.4%
55	37	0.63	7.3%	1.08%	0.33%	8.6%	0.0%	0.0%
						Sea trout adult		6.3%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Shad adults				Shad adult	
Operating Condition:			Ebb Tide	Net head=	4.75	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
25	17	0.51	2.7%	47.84%	0.33%	49.4%	0.0%	0.0%
30	20	0.53	3.4%	47.84%	0.33%	49.8%	20.0%	10.0%
35	23	0.56	4.1%	47.84%	0.33%	50.2%	30.0%	15.0%
40	27	0.58	4.9%	47.84%	0.33%	50.6%	30.0%	15.2%
45	30	0.60	5.7%	47.84%	0.33%	51.0%	20.0%	10.2%
50	34	0.61	6.5%	47.84%	0.33%	51.4%	0.0%	0.0%
						Shad adult		50.4%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Herring**				**Herring**	
Operating Condition:			**Ebb Tide**	**Net head=**	**4.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.26	0.2%	47.84%	0.33%	48.1%	0.0%	0.0%
10	7	0.37	0.7%	47.84%	0.33%	48.4%	0.0%	0.0%
15	10	0.43	1.3%	47.84%	0.33%	48.7%	0.0%	0.0%
20	13	0.47	2.0%	47.84%	0.33%	49.0%	25.0%	12.3%
25	17	0.51	2.7%	47.84%	0.33%	49.4%	50.0%	24.7%
30	20	0.53	3.4%	47.84%	0.33%	49.8%	25.0%	12.4%
						Herring		49.4%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Glass eel /elver**				**Glass eel/elver**	
Operating Condition:			**Ebb Tide**	**Net head=**	**4.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
6	4	0.12	0.1%	0.00%	0.33%	0.4%	30.0%	0.1%
8	5	0.16	0.2%	0.00%	0.33%	0.5%	30.0%	0.2%
10	7	0.20	0.3%	0.00%	0.33%	0.6%	20.0%	0.1%
12	8	0.23	0.4%	0.00%	0.33%	0.8%	10.0%	0.1%
14	9	0.25	0.6%	0.00%	0.33%	0.9%	5.0%	0.0%
16	11	0.27	0.7%	0.00%	0.33%	1.0%	5.0%	0.1%
						Glass eel/elver		0.6%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Silver eel**				**Silver eel**	
Operating Condition:			**Ebb Tide**	**Net head=**	**4.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.37	1.9%	0.00%	0.33%	2.2%	5.0%	0.1%
40	27	0.41	3.0%	0.00%	0.33%	3.3%	15.0%	0.5%
50	34	0.44	4.1%	0.00%	0.33%	4.4%	20.0%	0.9%
60	40	0.47	5.3%	0.00%	0.33%	5.6%	30.0%	1.7%
70	47	0.50	6.6%	0.00%	0.33%	6.9%	20.0%	1.4%
80	54	0.52	7.9%	0.00%	0.33%	8.2%	10.0%	0.8%
						Silver eel		5.4%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Gadoids**				**Gadoids**	
Operating Condition:			**Ebb Tide**	**Net head=**	**4.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.38	0.8%	2.74%	2.62%	6.0%	10.0%	0.6%
20	13	0.80	3.4%	2.74%	2.62%	8.5%	70.0%	5.9%
30	20	0.87	5.5%	2.74%	2.62%	10.5%	10.0%	1.1%
40	27	0.91	7.7%	2.74%	2.62%	12.6%	10.0%	1.3%
50	34	0.94	10.0%	2.74%	2.62%	14.8%	0.0%	0.0%
60	40	0.97	12.4%	2.74%	2.62%	17.0%	0.0%	0.0%
						Gadoids		8.8%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Bass**				**Bass**	
Operating Condition:			**Ebb Tide**	**Net head=**	**4.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.29	0.3%	0.03%	2.62%	2.9%	5.0%	0.1%
10	7	0.40	0.8%	0.03%	2.62%	3.4%	25.0%	0.9%
20	13	0.51	2.1%	0.03%	2.62%	4.7%	50.0%	2.4%
30	20	0.57	3.6%	0.03%	2.62%	6.2%	17.0%	1.1%
40	27	0.61	5.2%	0.03%	2.62%	7.7%	2.5%	0.2%
50	34	0.65	6.9%	0.03%	2.62%	9.3%	0.5%	0.0%
						Bass		4.7%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Flatfish**				**Flatfish**	
Operating Condition:			**Ebb Tide**	**Net head=**	**4.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.40	0.4%	0.00%	0.33%	0.7%	50.0%	0.3%
10	7	0.51	1.0%	0.00%	0.33%	1.3%	20.0%	0.3%
15	10	0.57	1.7%	0.00%	0.33%	2.0%	5.0%	0.1%
20	13	0.61	2.5%	0.00%	0.33%	2.9%	10.0%	0.3%
30	20	0.67	4.3%	0.00%	0.33%	4.6%	10.0%	0.5%
40	27	0.72	6.1%	0.00%	0.33%	6.4%	5.0%	0.3%
						Flatfish		1.8%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Lamprey**				**Lamprey**	
Operating Condition:			**Ebb Tide**	**Net head=**	**4.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	20	0.37	1.9%	0.00%	0.33%	2.2%	10.0%	0.2%
20	27	0.41	3.0%	0.00%	0.33%	3.3%	10.0%	0.3%
30	34	0.44	4.1%	0.00%	0.33%	4.4%	20.0%	0.9%
40	40	0.47	5.3%	0.00%	0.33%	5.6%	20.0%	1.1%
50	47	0.50	6.6%	0.00%	0.33%	6.9%	20.0%	1.4%
60	54	0.52	7.9%	0.00%	0.33%	8.2%	20.0%	1.6%
						Lamprey		5.6%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Atlantic salmon & sea trout smolt**				**Atlantic salmon & sea trout smolt**	
Operating Condition:			**Flood Tide**	**Net head=**	**4.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
			Predicted Injuries Due to:					
Fish Length (cm)	Swimming-Factor-Adjusted Length (cm)	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.37	0.7%	1.71%	0.33%	2.7%	10.0%	0.3%
15	10	0.43	1.3%	1.71%	0.33%	3.3%	70.0%	2.3%
20	13	0.47	2.0%	1.71%	0.33%	4.0%	15.0%	0.6%
25	17	0.51	2.7%	1.71%	0.33%	4.7%	5.0%	0.2%
					Atlantic salmon & sea trout smolt			3.4%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Atlantic salmon adult**				**Atlantic salmon adult**	
Operating Condition:			**Flood Tide**	**Net head=**	**4.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
40	27	0.58	4.9%	1.71%	0.33%	6.8%	5.0%	0.3%
50	34	0.61	6.5%	1.71%	0.33%	8.4%	35.0%	2.9%
60	40	0.64	8.2%	1.71%	0.33%	10.0%	50.0%	5.0%
70	47	0.66	9.9%	1.71%	0.33%	11.7%	7.5%	0.9%
80	54	0.68	11.6%	1.71%	0.33%	13.4%	2.0%	0.3%
90	60	0.70	13.4%	1.71%	0.33%	15.2%	0.5%	0.1%
						Atlantic salmon adult		9.5%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Sea trout adult**				**Sea trout adult**	
Operating Condition:			**Flood Tide**	**Net head=**	**4.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.53	3.4%	1.71%	0.33%	5.4%	5.0%	0.3%
35	23	0.56	4.1%	1.71%	0.33%	6.1%	10.0%	0.6%
40	27	0.58	4.9%	1.71%	0.33%	6.8%	70.0%	4.8%
45	30	0.60	5.7%	1.71%	0.33%	7.6%	10.0%	0.8%
50	34	0.61	6.5%	1.71%	0.33%	8.4%	5.0%	0.4%
55	37	0.63	7.3%	1.71%	0.33%	9.2%	0.0%	0.0%
						Sea trout adult		6.8%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Shad adults**				**Shad adult**	
Operating Condition:			**Flood Tide**	**Net head=**	**4.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
25	17	0.51	2.7%	43.04%	0.33%	44.7%	0.0%	0.0%
30	20	0.53	3.4%	43.04%	0.33%	45.2%	20.0%	9.0%
35	23	0.56	4.1%	43.04%	0.33%	45.6%	30.0%	13.7%
40	27	0.58	4.9%	43.04%	0.33%	46.0%	30.0%	13.8%
45	30	0.60	5.7%	43.04%	0.33%	46.5%	20.0%	9.3%
50	34	0.61	6.5%	43.04%	0.33%	46.9%	0.0%	0.0%
						Shad adult		45.8%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Herring**				**Herring**	
Operating Condition:			**Flood Tide**	**Net head=**	**4.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.26	0.2%	43.04%	0.33%	43.4%	0.0%	0.0%
10	7	0.37	0.7%	43.04%	0.33%	43.6%	0.0%	0.0%
15	10	0.43	1.3%	43.04%	0.33%	44.0%	0.0%	0.0%
20	13	0.47	2.0%	43.04%	0.33%	44.3%	25.0%	11.1%
25	17	0.51	2.7%	43.04%	0.33%	44.7%	50.0%	22.4%
30	20	0.53	3.4%	43.04%	0.33%	45.2%	25.0%	11.3%
						Herring		44.7%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Glass eel /elver**				**Glass eel/elver**	
Operating Condition:			**Flood Tide**	**Net head=**	**4.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
6	4	0.12	0.1%	0.00%	0.33%	0.4%	30.0%	0.1%
8	5	0.16	0.2%	0.00%	0.33%	0.5%	30.0%	0.2%
10	7	0.20	0.3%	0.00%	0.33%	0.6%	20.0%	0.1%
12	8	0.23	0.4%	0.00%	0.33%	0.8%	10.0%	0.1%
14	9	0.25	0.6%	0.00%	0.33%	0.9%	5.0%	0.0%
16	11	0.27	0.7%	0.00%	0.33%	1.0%	5.0%	0.1%
						Glass eel/elver		0.6%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Silver eel**				**Silver eel**	
Operating Condition:			**Flood Tide**	**Net head=**	**4.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.37	1.9%	0.00%	0.33%	2.2%	5.0%	0.1%
40	27	0.41	3.0%	0.00%	0.33%	3.3%	15.0%	0.5%
50	34	0.44	4.1%	0.00%	0.33%	4.4%	20.0%	0.9%
60	40	0.47	5.3%	0.00%	0.33%	5.6%	30.0%	1.7%
70	47	0.50	6.6%	0.00%	0.33%	6.9%	20.0%	1.4%
80	54	0.52	7.9%	0.00%	0.33%	8.2%	10.0%	0.8%
						Silver eel		5.4%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Gadoids**				**Gadoids**	
Operating Condition:			**Flood Tide**	**Net head=**	**4.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.38	0.8%	4.33%	2.62%	7.5%	10.0%	0.8%
20	13	0.80	3.4%	4.33%	2.62%	10.0%	70.0%	7.0%
30	20	0.87	5.5%	4.33%	2.62%	12.0%	10.0%	1.2%
40	27	0.91	7.7%	4.33%	2.62%	14.0%	10.0%	1.4%
50	34	0.94	10.0%	4.33%	2.62%	16.2%	0.0%	0.0%
60	40	0.97	12.4%	4.33%	2.62%	18.4%	0.0%	0.0%
						Gadoids		10.3%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Bass**				**Bass**	
Operating Condition:			**Flood Tide**	**Net head=**	**4.75**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.29	0.3%	0.05%	2.62%	2.9%	5.0%	0.1%
10	7	0.40	0.8%	0.05%	2.62%	3.4%	25.0%	0.9%
20	13	0.51	2.1%	0.05%	2.62%	4.8%	50.0%	2.4%
30	20	0.57	3.6%	0.05%	2.62%	6.2%	17.0%	1.1%
40	27	0.61	5.2%	0.05%	2.62%	7.7%	2.5%	0.2%
50	34	0.65	6.9%	0.05%	2.62%	9.4%	0.5%	0.0%
						Bass		4.7%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Flatfish				Flatfish	
Operating Condition:			Flood Tide	Net head=	4.75	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.40	0.4%	0.00%	0.33%	0.7%	50.0%	0.3%
10	7	0.51	1.0%	0.00%	0.33%	1.3%	20.0%	0.3%
15	10	0.57	1.7%	0.00%	0.33%	2.0%	5.0%	0.1%
20	13	0.61	2.5%	0.00%	0.33%	2.9%	10.0%	0.3%
30	20	0.67	4.3%	0.00%	0.33%	4.6%	10.0%	0.5%
40	27	0.72	6.1%	0.00%	0.33%	6.4%	5.0%	0.3%
						Flatfish		1.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Lamprey				Lamprey	
Operating Condition:			Flood Tide	Net head=	4.75	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	20	0.37	1.9%	0.00%	0.33%	2.2%	10.0%	0.2%
20	27	0.41	3.0%	0.00%	0.33%	3.3%	10.0%	0.3%
30	34	0.44	4.1%	0.00%	0.33%	4.4%	20.0%	0.9%
40	40	0.47	5.3%	0.00%	0.33%	5.6%	20.0%	1.1%
50	47	0.50	6.6%	0.00%	0.33%	6.9%	20.0%	1.4%
60	54	0.52	7.9%	0.00%	0.33%	8.2%	20.0%	1.6%
						Lamprey		5.6%

Table A2.9: Operating Head: 5.25 m, Ebb and Flood Generation

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Atlantic salmon & sea trout smolt**				**Atlantic salmon & sea trout smolt**	
Operating Condition:			**Ebb Tide**	**Net head=**	**5.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length (cm)	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.37	0.7%	1.08%	0.33%	2.1%	10.0%	0.2%
15	10	0.43	1.3%	1.08%	0.33%	2.7%	70.0%	1.9%
20	13	0.47	2.0%	1.08%	0.33%	3.4%	15.0%	0.5%
25	17	0.51	2.7%	1.08%	0.33%	4.1%	5.0%	0.2%
					Atlantic salmon & sea trout smolt			2.8%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Atlantic salmon adult**				**Atlantic salmon adult**	
Operating Condition:			**Ebb Tide**	**Net head=**	**5.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
40	27	0.58	5.0%	1.08%	0.33%	6.3%	5.0%	0.3%
50	34	0.61	6.6%	1.08%	0.33%	7.9%	35.0%	2.8%
60	40	0.64	8.2%	1.08%	0.33%	9.5%	50.0%	4.8%
70	47	0.66	10.0%	1.08%	0.33%	11.2%	7.5%	0.8%
80	54	0.68	11.7%	1.08%	0.33%	13.0%	2.0%	0.3%
90	60	0.70	13.6%	1.08%	0.33%	14.8%	0.5%	0.1%
						Atlantic salmon adult		9.0%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Sea trout adult**				**Sea trout adult**	
Operating Condition:			**Ebb Tide**	**Net head=**	**5.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.53	3.4%	1.08%	0.33%	4.8%	5.0%	0.2%
35	23	0.56	4.2%	1.08%	0.33%	5.5%	10.0%	0.6%
40	27	0.58	5.0%	1.08%	0.33%	6.3%	70.0%	4.4%
45	30	0.60	5.8%	1.08%	0.33%	7.1%	10.0%	0.7%
50	34	0.61	6.6%	1.08%	0.33%	7.9%	5.0%	0.4%
55	37	0.63	7.4%	1.08%	0.33%	8.7%	0.0%	0.0%
						Sea trout adult		6.3%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Shad adults**				**Shad adult**	
Operating Condition:			**Ebb Tide**	**Net head=**	**5.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**On design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
25	17	0.51	2.7%	47.84%	0.33%	49.4%	0.0%	0.0%
30	20	0.53	3.4%	47.84%	0.33%	49.8%	20.0%	10.0%
35	23	0.56	4.2%	47.84%	0.33%	50.2%	30.0%	15.1%
40	27	0.58	5.0%	47.84%	0.33%	50.6%	30.0%	15.2%
45	30	0.60	5.8%	47.84%	0.33%	51.0%	20.0%	10.2%
50	34	0.61	6.6%	47.84%	0.33%	51.4%	0.0%	0.0%
						Shad adult		50.4%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Herring				Herring	
Operating Condition:			Ebb Tide	Net head=	5.25	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.26	0.2%	47.84%	0.33%	48.1%	0.0%	0.0%
10	7	0.37	0.7%	47.84%	0.33%	48.4%	0.0%	0.0%
15	10	0.43	1.3%	47.84%	0.33%	48.7%	0.0%	0.0%
20	13	0.47	2.0%	47.84%	0.33%	49.0%	25.0%	12.3%
25	17	0.51	2.7%	47.84%	0.33%	49.4%	50.0%	24.7%
30	20	0.53	3.4%	47.84%	0.33%	49.8%	25.0%	12.4%
						Herring		49.4%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Glass eel /elver				Glass eel/elver	
Operating Condition:			Ebb Tide	Net head=	5.25	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
6	4	0.12	0.1%	0.00%	0.33%	0.4%	30.0%	0.1%
8	5	0.16	0.2%	0.00%	0.33%	0.5%	30.0%	0.2%
10	7	0.20	0.3%	0.00%	0.33%	0.6%	20.0%	0.1%
12	8	0.23	0.4%	0.00%	0.33%	0.8%	10.0%	0.1%
14	9	0.25	0.6%	0.00%	0.33%	0.9%	5.0%	0.0%
16	11	0.27	0.7%	0.00%	0.33%	1.0%	5.0%	0.1%
						Glass eel/elver		0.6%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Silver eel				Silver eel	
Operating Condition:			Ebb Tide	Net head=	5.25	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.37	1.9%	0.00%	0.33%	2.3%	5.0%	0.1%
40	27	0.41	3.0%	0.00%	0.33%	3.3%	15.0%	0.5%
50	34	0.44	4.1%	0.00%	0.33%	4.4%	20.0%	0.9%
60	40	0.47	5.4%	0.00%	0.33%	5.7%	30.0%	1.7%
70	47	0.50	6.7%	0.00%	0.33%	7.0%	20.0%	1.4%
80	54	0.52	8.0%	0.00%	0.33%	8.3%	10.0%	0.8%
						Silver eel		5.4%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Gadoids				Gadoids	
Operating Condition:			Ebb Tide	Net head=	5.25	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.38	0.8%	2.74%	2.62%	6.0%	10.0%	0.6%
20	13	0.80	3.4%	2.74%	2.62%	8.5%	70.0%	6.0%
30	20	0.87	5.6%	2.74%	2.62%	10.6%	10.0%	1.1%
40	27	0.91	7.8%	2.74%	2.62%	12.7%	10.0%	1.3%
50	34	0.94	10.1%	2.74%	2.62%	14.9%	0.0%	0.0%
60	40	0.97	12.5%	2.74%	2.62%	17.1%	0.0%	0.0%
						Gadoids		8.9%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Bass				Bass	
Operating Condition:			Ebb Tide	Net head=	5.25	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.29	0.3%	0.03%	2.62%	2.9%	5.0%	0.1%
10	7	0.40	0.8%	0.03%	2.62%	3.4%	25.0%	0.9%
20	13	0.51	2.2%	0.03%	2.62%	4.8%	50.0%	2.4%
30	20	0.57	3.7%	0.03%	2.62%	6.2%	17.0%	1.1%
40	27	0.61	5.3%	0.03%	2.62%	7.8%	2.5%	0.2%
50	34	0.65	6.9%	0.03%	2.62%	9.4%	0.5%	0.0%
						Bass		4.7%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Flatfish				Flatfish	
Operating Condition:			Ebb Tide	Net head=	5.25	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.40	0.4%	0.00%	0.33%	0.7%	50.0%	0.3%
10	7	0.51	1.0%	0.00%	0.33%	1.3%	20.0%	0.3%
15	10	0.57	1.7%	0.00%	0.33%	2.1%	5.0%	0.1%
20	13	0.61	2.6%	0.00%	0.33%	2.9%	10.0%	0.3%
30	20	0.67	4.3%	0.00%	0.33%	4.7%	10.0%	0.5%
40	27	0.72	6.2%	0.00%	0.33%	6.5%	5.0%	0.3%
						Flatfish		1.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Lamprey				Lamprey	
Operating Condition:			Ebb Tide	Net head=	5.25	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	On design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	20	0.37	1.9%	0.00%	0.33%	2.3%	10.0%	0.2%
20	27	0.41	3.0%	0.00%	0.33%	3.3%	10.0%	0.3%
30	34	0.44	4.1%	0.00%	0.33%	4.4%	20.0%	0.9%
40	40	0.47	5.4%	0.00%	0.33%	5.7%	20.0%	1.1%
50	47	0.50	6.7%	0.00%	0.33%	7.0%	20.0%	1.4%
60	54	0.52	8.0%	0.00%	0.33%	8.3%	20.0%	1.7%
						Lamprey		5.6%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Atlantic salmon & sea trout smolt				Atlantic salmon & sea trout smolt	
Operating Condition:			Flood Tide	Net head=	5.25	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length (cm)	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.37	0.7%	1.71%	0.33%	2.7%	10.0%	0.3%
15	10	0.43	1.3%	1.71%	0.33%	3.3%	70.0%	2.3%
20	13	0.47	2.0%	1.71%	0.33%	4.0%	15.0%	0.6%
25	17	0.51	2.7%	1.71%	0.33%	4.7%	5.0%	0.2%
						Atlantic salmon & sea trout smolt		3.4%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Atlantic salmon adult**				**Atlantic salmon adult**	
Operating Condition:			**Flood Tide**	**Net head=**	**5.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
40	27	0.58	5.0%	1.71%	0.33%	6.9%	5.0%	0.3%
50	34	0.61	6.6%	1.71%	0.33%	8.5%	35.0%	3.0%
60	40	0.64	8.2%	1.71%	0.33%	10.1%	50.0%	5.1%
70	47	0.66	10.0%	1.71%	0.33%	11.8%	7.5%	0.9%
80	54	0.68	11.7%	1.71%	0.33%	13.5%	2.0%	0.3%
90	60	0.70	13.6%	1.71%	0.33%	15.3%	0.5%	0.1%
						Atlantic salmon adult		9.6%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Sea trout adult**				**Sea trout adult**	
Operating Condition:			**Flood Tide**	**Net head=**	**5.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.53	3.4%	1.71%	0.33%	5.4%	5.0%	0.3%
35	23	0.56	4.2%	1.71%	0.33%	6.1%	10.0%	0.6%
40	27	0.58	5.0%	1.71%	0.33%	6.9%	70.0%	4.8%
45	30	0.60	5.8%	1.71%	0.33%	7.7%	10.0%	0.8%
50	34	0.61	6.6%	1.71%	0.33%	8.5%	5.0%	0.4%
55	37	0.63	7.4%	1.71%	0.33%	9.3%	0.0%	0.0%
						Sea trout adult		6.9%

Fish species:			**Shad adults**				**Shad adult**	
Operating Condition:			**Flood Tide**	**Net head=**	**5.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
25	17	0.51	2.7%	43.04%	0.33%	44.8%	0.0%	0.0%
30	20	0.53	3.4%	43.04%	0.33%	45.2%	20.0%	9.0%
35	23	0.56	4.2%	43.04%	0.33%	45.6%	30.0%	13.7%
40	27	0.58	5.0%	43.04%	0.33%	46.0%	30.0%	13.8%
45	30	0.60	5.8%	43.04%	0.33%	46.5%	20.0%	9.3%
50	34	0.61	6.6%	43.04%	0.33%	47.0%	0.0%	0.0%
						Shad adult		45.8%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Herring**				**Herring**	
Operating Condition:			**Flood Tide**	**Net head=**	**5.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.26	0.2%	43.04%	0.33%	43.4%	0.0%	0.0%
10	7	0.37	0.7%	43.04%	0.33%	43.6%	0.0%	0.0%
15	10	0.43	1.3%	43.04%	0.33%	44.0%	0.0%	0.0%
20	13	0.47	2.0%	43.04%	0.33%	44.4%	25.0%	11.1%
25	17	0.51	2.7%	43.04%	0.33%	44.8%	50.0%	22.4%
30	20	0.53	3.4%	43.04%	0.33%	45.2%	25.0%	11.3%
						Herring		44.8%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Glass eel /elver**				**Glass eel/elver**	
Operating Condition:			**Flood Tide**	**Net head=**	**5.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
6	4	0.12	0.1%	0.00%	0.33%	0.4%	30.0%	0.1%
8	5	0.16	0.2%	0.00%	0.33%	0.5%	30.0%	0.2%
10	7	0.20	0.3%	0.00%	0.33%	0.6%	20.0%	0.1%
12	8	0.23	0.4%	0.00%	0.33%	0.8%	10.0%	0.1%
14	9	0.25	0.6%	0.00%	0.33%	0.9%	5.0%	0.0%
16	11	0.27	0.7%	0.00%	0.33%	1.0%	5.0%	0.1%
						Glass eel/elver		0.6%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Silver eel**				**Silver eel**	
Operating Condition:			**Flood Tide**	**Net head=**	**5.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
30	20	0.37	1.9%	0.00%	0.33%	2.3%	5.0%	0.1%
40	27	0.41	3.0%	0.00%	0.33%	3.3%	15.0%	0.5%
50	34	0.44	4.1%	0.00%	0.33%	4.4%	20.0%	0.9%
60	40	0.47	5.4%	0.00%	0.33%	5.7%	30.0%	1.7%
70	47	0.50	6.7%	0.00%	0.33%	7.0%	20.0%	1.4%
80	54	0.52	8.0%	0.00%	0.33%	8.3%	10.0%	0.8%
						Silver eel		5.4%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Gadoids**				**Gadoids**	
Operating Condition:			**Flood Tide**	**Net head=**	**5.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	7	0.38	0.8%	4.33%	2.62%	7.5%	10.0%	0.8%
20	13	0.80	3.4%	4.33%	2.62%	10.0%	70.0%	7.0%
30	20	0.87	5.6%	4.33%	2.62%	12.0%	10.0%	1.2%
40	27	0.91	7.8%	4.33%	2.62%	14.1%	10.0%	1.4%
50	34	0.94	10.1%	4.33%	2.62%	16.3%	0.0%	0.0%
60	40	0.97	12.5%	4.33%	2.62%	18.5%	0.0%	0.0%
						Gadoids		10.4%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Bass**				**Bass**	
Operating Condition:			**Flood Tide**	**Net head=**	**5.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.29	0.3%	0.05%	2.62%	2.9%	5.0%	0.1%
10	7	0.40	0.8%	0.05%	2.62%	3.5%	25.0%	0.9%
20	13	0.51	2.2%	0.05%	2.62%	4.8%	50.0%	2.4%
30	20	0.57	3.7%	0.05%	2.62%	6.2%	17.0%	1.1%
40	27	0.61	5.3%	0.05%	2.62%	7.8%	2.5%	0.2%
50	34	0.65	6.9%	0.05%	2.62%	9.4%	0.5%	0.0%
						Bass		4.7%

Project Name:			**Swansea Tidal Lagoon Scheme 7m Bulb Turbine**					
Fish species:			**Flatfish**				**Flatfish**	
Operating Condition:			**Flood Tide**	**Net head=**	**5.25**	**m**	**Length-weighted mortality rate**	
Discharge =			**375.00**	**cumecs**	**Off design**			
Fish swimming condition:		**1**	**Fish swimming speed**		**0**	**bl/s**		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
5	3	0.40	0.4%	0.00%	0.33%	0.7%	50.0%	0.3%
10	7	0.51	1.0%	0.00%	0.33%	1.3%	20.0%	0.3%
15	10	0.57	1.7%	0.00%	0.33%	2.1%	5.0%	0.1%
20	13	0.61	2.6%	0.00%	0.33%	2.9%	10.0%	0.3%
30	20	0.67	4.3%	0.00%	0.33%	4.7%	10.0%	0.5%
40	27	0.72	6.2%	0.00%	0.33%	6.5%	5.0%	0.3%
						Flatfish		1.8%

Project Name:			Swansea Tidal Lagoon Scheme 7m Bulb Turbine					
Fish species:			Lamprey				Lamprey	
Operating Condition:			Flood Tide	Net head=	5.25	m	Length-weighted mortality rate	
Discharge =			375.00	cumecs	Off design			
Fish swimming condition:		1	Fish swimming speed		0	bl/s		
	Swimming-Factor-		Predicted Injuries Due to:					
Fish Length (cm)	Adjusted Length	Mutilation Ratio	Strike	Shear	Pressure	Compound	Length-frequency	Net mortality
10	20	0.37	1.9%	0.00%	0.33%	2.3%	10.0%	0.2%
20	27	0.41	3.0%	0.00%	0.33%	3.3%	10.0%	0.3%
30	34	0.44	4.1%	0.00%	0.33%	4.4%	20.0%	0.9%
40	40	0.47	5.4%	0.00%	0.33%	5.7%	20.0%	1.1%
50	47	0.50	6.7%	0.00%	0.33%	7.0%	20.0%	1.4%
60	54	0.52	8.0%	0.00%	0.33%	8.3%	20.0%	1.7%
						Lamprey		5.6%

Appendix 3 STRIKER v.4 Predicted fish injury rates across operating heads by species/lifestage, ebb generation

Table A3.1 Atlantic salmon & sea trout smolt

Turbine Operating Head (m)	Frequency of Occurrence (%)	Compound Injury Rate (%)	Frequency-Weighted Injury Rate (%)
1.0-1.5	1.81	2.9	2.7
1.5-2.0	11.50	2.9	
2.0-2.5	12.71	2.6	
2.5-3.0	12.21	2.7	
3.0-3.5	12.81	2.7	
3.5-4.0	16.60	2.6	
4.0-4.5	19.00	2.6	
4.5-5.0	11.67	2.6	
5.0-5.5	1.67	2.7	

Table A3.2 Atlantic salmon & sea trout adult/kelt

Turbine Operating Head (m)	Frequency of Occurrence (%)	Compound Injury Rate (%)	Frequency-Weighted Injury Rate (%)
1.0-1.5	1.81	10.1	8.4
1.5-2.0	11.50	9.6	
2.0-2.5	12.71	8.3	
2.5-3.0	12.21	8.5	
3.0-3.5	12.81	8.3	
3.5-4.0	16.60	8.1	
4.0-4.5	19.00	8.1	
4.5-5.0	11.67	8.2	
5.0-5.5	1.67	8.2	

Table A3.3 Adult herring

Turbine Operating Head (m)	Frequency of Occurrence (%)	Compound Injury Rate (%)	Frequency-Weighted Injury Rate (%)
1.0-1.5	1.81	49.5	49.3%
1.5-2.0	11.50	49.5	
2.0-2.5	12.71	49.3	
2.5-3.0	12.21	49.3	
3.0-3.5	12.81	49.3	
3.5-4.0	16.60	49.2	
4.0-4.5	19.00	49.2	
4.5-5.0	11.67	49.3	
5.0-5.5	1.67	49.3	

Table A3.4 Shad adults

Turbine Operating Head (m)	Frequency of Occurrence (%)	Compound Injury Rate (%)	Frequency-Weighted Injury Rate (%)
1.0-1.5	1.81	50.7	50.2
1.5-2.0	11.50	50.5	
2.0-2.5	12.71	50.2	
2.5-3.0	12.21	50.2	
3.0-3.5	12.81	50.2	
3.5-4.0	16.60	50.1	
4.0-4.5	19.00	50.1	
4.5-5.0	11.67	50.1	
5.0-5.5	1.67	50.1	

Table A3.5 Glass eel /elver

Turbine Operating Head (m)	Frequency of Occurrence (%)	Compound Injury Rate (%)	Frequency-Weighted Injury Rate (%)
1.0-1.5	1.81	0.62	0.57
1.5-2.0	11.50	0.60	
2.0-2.5	12.71	0.56	
2.5-3.0	12.21	0.57	
3.0-3.5	12.81	0.56	
3.5-4.0	16.60	0.56	
4.0-4.5	19.00	0.56	
4.5-5.0	11.67	0.56	
5.0-5.5	1.67	0.56	

Table A3.6 Silver eel

Turbine Operating Head (m)	Frequency of Occurrence (%)	Compound Injury Rate (%)	Frequency-Weighted Injury Rate (%)
1.0-1.5	1.81	5.9	4.9
1.5-2.0	11.50	5.6	
2.0-2.5	12.71	4.8	
2.5-3.0	12.21	5.0	
3.0-3.5	12.81	4.9	
3.5-4.0	16.60	4.8	
4.0-4.5	19.00	4.8	
4.5-5.0	11.67	4.8	
5.0-5.5	1.67	4.9	

Table A3.7 Gadoids (cod, whiting, bib, hake etc.)

Turbine Operating Head (m)	Frequency of Occurrence (%)	Compound Injury Rate (%)	Frequency-Weighted Injury Rate (%)
1.0-1.5	1.81	9.1	8.5
1.5-2.0	11.50	8.9	
2.0-2.5	12.71	8.5	
2.5-3.0	12.21	8.6	
3.0-3.5	12.81	8.5	
3.5-4.0	16.60	8.4	
4.0-4.5	19.00	8.4	
4.5-5.0	11.67	8.5	
5.0-5.5	1.67	8.5	

Table A3.8 Bass

Turbine Operating Head (m)	Frequency of Occurrence (%)	Compound Injury Rate (%)	Frequency-Weighted Injury Rate (%)
1.0-1.5	1.81	4.8	4.5
1.5-2.0	11.50	4.6	
2.0-2.5	12.71	4.5	
2.5-3.0	12.21	4.5	
3.0-3.5	12.81	4.5	
3.5-4.0	16.60	4.6	
4.0-4.5	19.00	4.4	
4.5-5.0	11.67	4.4	
5.0-5.5	1.67	4.5	

Table A3.9 Flatfish (plaice, sole, dab, rays)

Turbine Operating Head (m)	Frequency of Occurrence (%)	Compound Injury Rate (%)	Frequency-Weighted Injury Rate (%)
1.0-1.5	1.81	2.0	1.7
1.5-2.0	11.50	1.9	
2.0-2.5	12.71	1.6	
2.5-3.0	12.21	1.7	
3.0-3.5	12.81	1.6	
3.5-4.0	16.60	1.6	
4.0-4.5	19.00	1.6	
4.5-5.0	11.67	1.6	
5.0-5.5	1.67	1.6	

Table A3.10 Lamprey

Turbine Operating Head (m)	Frequency of Occurrence (%)	Compound Injury Rate (%)	Frequency-Weighted Injury Rate (%)
1.0-1.5	1.81	6.1	
1.5-2.0	11.50	5.8	
2.0-2.5	12.71	5.0	
2.5-3.0	12.21	5.2	
3.0-3.5	12.81	5.1	
3.5-4.0	16.60	4.9	
4.0-4.5	19.00	5.0	
4.5-5.0	11.67	5.0	
5.0-5.5	1.67	5.1	

Appendix 4 **STRIKER v.4** Predicted fish injury rates across operating heads by species/lifestage, flood generation

Table A4.1 Atlantic salmon & sea trout smolt

Turbine Operating Head (m)	Frequency of Occurrence (%)	Compound Injury Rate (%)	Frequency-Weighted Injury Rate (%)
1.0-1.5	1.81	3.56	3.3
1.5-2.0	11.50	3.48	
2.0-2.5	12.71	3.27	
2.5-3.0	12.21	3.30	
3.0-3.5	12.81	3.28	
3.5-4.0	16.60	3.25	
4.0-4.5	19.00	3.25	
4.5-5.0	11.67	3.26	
5.0-5.5	1.67	3.27	

Table A4.2 Atlantic salmon & sea trout adult/kelt

Turbine Operating Head (m)	Frequency of Occurrence (%)	Compound Injury Rate (%)	Frequency-Weighted Injury Rate (%)
1.0-1.5	1.81	10.66	9.0
1.5-2.0	11.50	10.17	
2.0-2.5	12.71	8.84	
2.5-3.0	12.21	9.06	
3.0-3.5	12.81	8.88	
3.5-4.0	16.60	8.72	
4.0-4.5	19.00	8.68	
4.5-5.0	11.67	8.74	
5.0-5.5	1.67	8.80	

Table A4.3 Adult herring

Turbine Operating Head (m)	Frequency of Occurrence (%)	Compound Injury Rate (%)	Frequency-Weighted Injury Rate (%)
1.0-1.5	1.81	44.91	44.6
1.5-2.0	11.50	44.81	
2.0-2.5	12.71	44.59	
2.5-3.0	12.21	44.63	
3.0-3.5	12.81	44.60	
3.5-4.0	16.60	44.58	
4.0-4.5	19.00	44.57	
4.5-5.0	11.67	44.58	
5.0-5.5	1.67	44.60	

Table A4.4 Shad adults

Turbine Operating Head (m)	Frequency of Occurrence (%)	Compound Injury Rate (%)	Frequency-Weighted Injury Rate (%)
1.0-1.5	1.81	46.12	45.6
1.5-2.0	11.50	45.97	
2.0-2.5	12.71	45.57	
2.5-3.0	12.21	45.64	
3.0-3.5	12.81	45.58	
3.5-4.0	16.60	45.53	
4.0-4.5	19.00	45.51	
4.5-5.0	11.67	45.53	
5.0-5.5	1.67	45.56	

Table A4.5 Glass eel /elver

Turbine Operating Head (m)	Frequency of Occurrence (%)	Compound Injury Rate (%)	Frequency-Weighted Injury Rate (%)
1.0-1.5	1.81	0.62	0.57
1.5-2.0	11.50	0.60	
2.0-2.5	12.71	0.56	
2.5-3.0	12.21	0.57	
3.0-3.5	12.81	0.56	
3.5-4.0	16.60	0.56	
4.0-4.5	19.00	0.56	
4.5-5.0	11.67	0.56	
5.0-5.5	1.67	0.56	

Table A4.6 Silver eel

Turbine Operating Head (m)	Frequency of Occurrence (%)	Compound Injury Rate (%)	Frequency-Weighted Injury Rate (%)
1.0-1.5	1.81	5.89	4.9%
1.5-2.0	11.50	5.58	
2.0-2.5	12.71	4.84	
2.5-3.0	12.21	4.96	
3.0-3.5	12.81	4.87	
3.5-4.0	16.60	4.78	
4.0-4.5	19.00	4.77	
4.5-5.0	11.67	4.81	
5.0-5.5	1.67	4.87	

Table A4.7 Gadoids (cod, whiting, bib, hake etc.)

Turbine Operating Head (m)	Frequency of Occurrence (%)	Compound Injury Rate (%)	Frequency-Weighted Injury Rate (%)
1.0-1.5	1.81	10.62	10.0
1.5-2.0	11.50	10.41	
2.0-2.5	12.71	9.99	
2.5-3.0	12.21	10.08	
3.0-3.5	12.81	10.01	
3.5-4.0	16.60	9.95	
4.0-4.5	19.00	9.94	
4.5-5.0	11.67	9.97	
5.0-5.5	1.67	10.00	

Table A4.8 Bass

Turbine Operating Head (m)	Frequency of Occurrence (%)	Compound Injury Rate (%)	Frequency-Weighted Injury Rate (%)
1.0-1.5	1.81	4.79	4.5
1.5-2.0	11.50	4.67	
2.0-2.5	12.71	4.48	
2.5-3.0	12.21	4.53	
3.0-3.5	12.81	4.49	
3.5-4.0	16.60	4.64	
4.0-4.5	19.00	4.45	
4.5-5.0	11.67	4.46	
5.0-5.5	1.67	4.49	

Table A4.9 Flatfish (plaice, sole, dab, rays)

Turbine Operating Head (m)	Frequency of Occurrence (%)	Compound Injury Rate (%)	Frequency-Weighted Injury Rate (%)
1.0-1.5	1.81	1.95	1.7
1.5-2.0	11.50	1.86	
2.0-2.5	12.71	1.64	
2.5-3.0	12.21	1.67	
3.0-3.5	12.81	1.64	
3.5-4.0	16.60	1.62	
4.0-4.5	19.00	1.61	
4.5-5.0	11.67	1.62	
5.0-5.5	1.67	1.64	

Table A4.10 Lamprey

Turbine Operating Head (m)	Frequency of Occurrence (%)	Compound Injury Rate (%)	Frequency-Weighted Injury Rate (%)
1.0-1.5	1.81	6.12	5.1
1.5-2.0	11.50	5.80	
2.0-2.5	12.71	5.02	
2.5-3.0	12.21	5.15	
3.0-3.5	12.81	5.05	
3.5-4.0	16.60	4.90	
4.0-4.5	19.00	4.95	
4.5-5.0	11.67	5.00	
5.0-5.5	1.67	5.06	