



Chapter 13.0

Fish including Commercial and Recreational Fisheries

13.0 Fish, including Commercial and Recreational Fisheries

13.1 Overview of existing situation

13.1.1 General overview

13.1.1.1 The Severn Estuary and Bristol Channel fish community comprises over 100 recorded species of fish (Potts and Swaby, 1993; Henderson and Bird, 2010), including a number of internationally and nationally designated estuarine and migratory fish species. The main functional groups for estuarine fish assemblages are generally summarised by the following categories (Elliott *et al.*, 2007);

- i. estuarine species - live in estuaries for whole life-cycle (e.g. flounder),
- ii. marine migrants - adults live and spawn in the marine environment, with juveniles frequently found in estuaries in large numbers,
- iii. marine stragglers - live and breed in the marine environment. No estuarine habitat requirements but can be found occasionally in estuaries (e.g. mackerel, dogfish),
- iv. diadromous comprised of anadromous (migrating from the sea into fresh water to breed (e.g. salmon, sea trout, smelt, shad, lamprey) and catadromous (migrating from fresh water into the sea to breed e.g. eel), and
- v. freshwater stragglers - species found in low numbers in estuaries that are restricted to areas of low salinity.

13.1.1.2 The most common estuarine and migratory fish species in the inner Bristol Channel fall into the marine stragglers, followed by marine migrants (Henderson, 2007). The other ecological categories comprise less than 5% of the fish assemblage each. The fish assemblage within the Severn Estuary is similar to that of the inner Bristol Channel (Potter *et al.*, 1986). As would be expected, due to the greater freshwater discharge into the Severn Estuary however, the proportion of freshwater straggler species in the Estuary is far higher than the Bristol Channel (Potter *et al.*, 1997). Numerically, most fish within the Estuary are considered to be juveniles, reflecting its use as a nursery area (Claridge *et al.*, 1986).

13.1.1.3 The diadromous species which migrate through the Severn Estuary are all protected under either national or international conservation designations. Ten other species (marine migrants: cod (*Gadus morhua*), herring (*Clupea hargenus*), plaice (*Pleuronectes platessa*), sole (*Solea solea*), whiting (*Merlangius merlangus*); and marine stragglers: blue whiting (*Micromesistius poutassou*), hake (*Merluccius merluccius*), horse mackerel (*Trachurus trachurus*), ling (*Molva molva*) and saithe (*Pollachius virens*)) recorded in the Severn Estuary and Bristol Channel were recognised under a Species Action Plan as part of the UK Biodiversity Action Plan (UK BAP). This is now succeeded by the UK Post-2010 Biodiversity Framework which includes a number of strategic goals and supporting targets to be achieved by 2020 (JNCC and Defra 2012). Although the UK BAP has been superseded, the list

of UK BAP priority habitats and species remains a useful reference for local authority decision-makers. In addition the whole estuarine fish community is designated under Ramsar Criterion 8 as it is 'one of the most diverse in Britain'¹. A number of UK waterbodies have been designated under the Natura 2000 series of sites as Special Areas for Conservation (SACs) (Figure 13.1) for, amongst other features, the presence of fish species considered to be most in need of conservation at a European level. Table 13.1 lists the designated sites within the Severn Estuary and gives a brief overview of the fish receptors designated as primary and qualifying features.

Table 13.1 Designated sites of relevance to the Project and associated primary and qualifying fish species.

Designated site	Primary fish species	Qualifying fish species
Severn Estuary (Ramsar)	Salmon (<i>Salmo salar</i>) Sea trout (<i>Salmo trutta</i>) Sea lamprey (<i>Petromyzon marinus</i>) River lamprey (<i>Lampetra fluviatilis</i>) Allis shad (<i>Alosa alosa</i>) Twaite shad (<i>Alosa fallax</i>) European eel (<i>Anguilla Anguilla</i>)	
Severn Estuary (SAC)	Sea lamprey (<i>Petromyzon marinus</i>) River lamprey (<i>Lampetra fluviatilis</i>) Twaite shad (<i>Alosa fallax</i>)	
River Usk (SAC)	Sea lamprey (<i>Petromyzon marinus</i>) Brook lamprey (<i>Lampetra planeri</i>) River lamprey (<i>Lampetra fluviatilis</i>) Twaite shad (<i>Alosa fallax</i>) Atlantic salmon (<i>Salmo salar</i>) Bullhead (<i>Cottus gobio</i>)	Allis shad (<i>Alosa alosa</i>)
River Wye (SAC)	Sea lamprey (<i>Petromyzon marinus</i>) Brook lamprey (<i>Lampetra planeri</i>) River lamprey (<i>Lampetra fluviatilis</i>) Twaite shad (<i>Alosa fallax</i>) Atlantic salmon (<i>Salmo salar</i>) Bullhead (<i>Cottus gobio</i>)	Allis shad (<i>Alosa alosa</i>)

¹ <http://jncc.defra.gov.uk/pdf/RIS/UK11081.pdf>

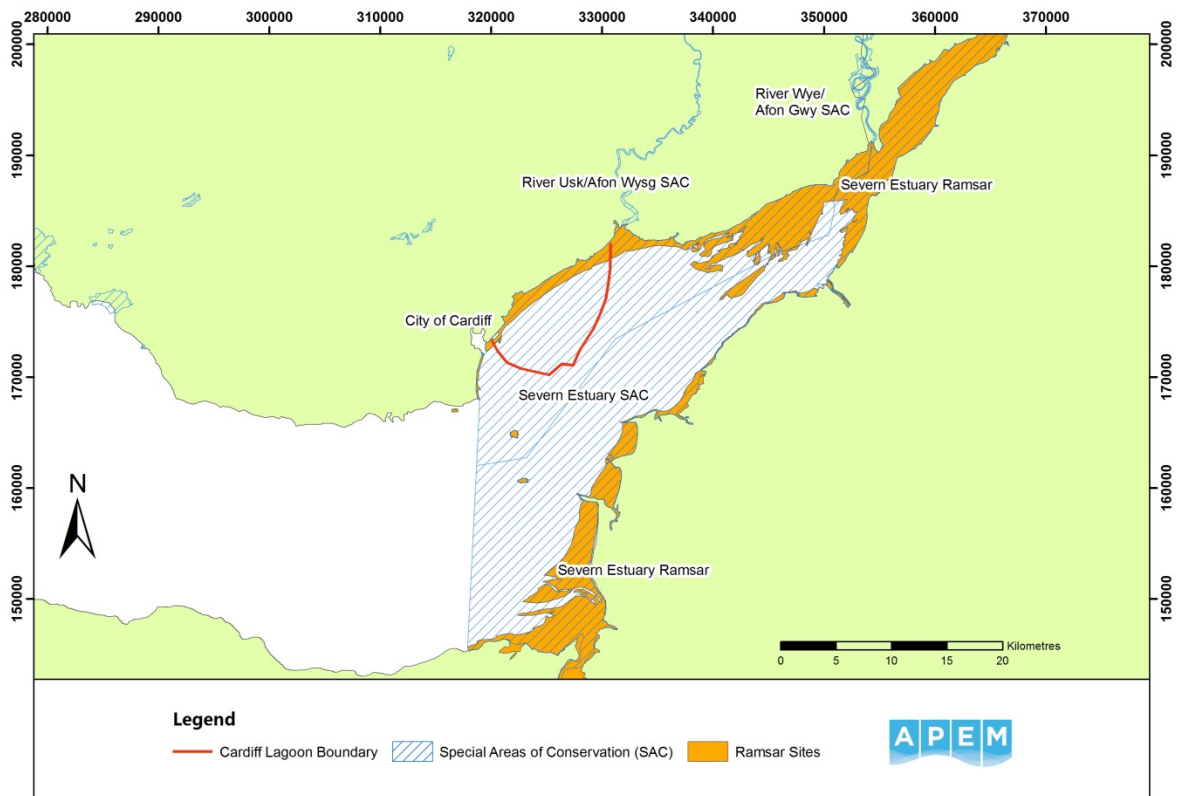


Figure 13.1 Map of designated sites of relevance to the Project

13.1.2 Estuarine fish community

- 13.1.2.1 Non-migratory estuarine and marine fish form part of the overall fish community found in the coastal waters around Newport and Cardiff and they contribute to commercial fish stocks and recreational fishing. A variety of species and lifestyles spend part or all of their lifecycle in the area, with some species then moving out into more open waters to feed or spawn. A major marine fish spawning area exists off Trevoze Head in Cornwall, for example.
- 13.1.2.2 The Severn Estuary is strongly macrotidal, giving rise to powerful tidal currents, naturally high suspended sediment concentrations and poor light penetration, which limits primary production. Thus detritivores such as brown shrimp (*Crangon crangon*) support species such as whiting and cod through the winter.
- 13.1.2.3 The Severn Estuary area is not notable for commercial fishing. This is partly due to the limited range and quantity of commercially valuable fish present, but it is also due to the difficulties of operating fishing vessels in a macrotidal environment. Sea fishing activity is regulated and recorded by the Welsh Government and the Marine Management Organisation (MMO). Data sourced from them shows the absence of landings data for the eastern Bristol Channel/Severn Estuary (Figure 13.2).

- 13.1.2.4 Recreational sea fishing is popular along the coast of South Wales and supports tourism as well as charter boats and tackle shops. Cod, whiting, conger eel, bass and flatfish are frequently targeted.

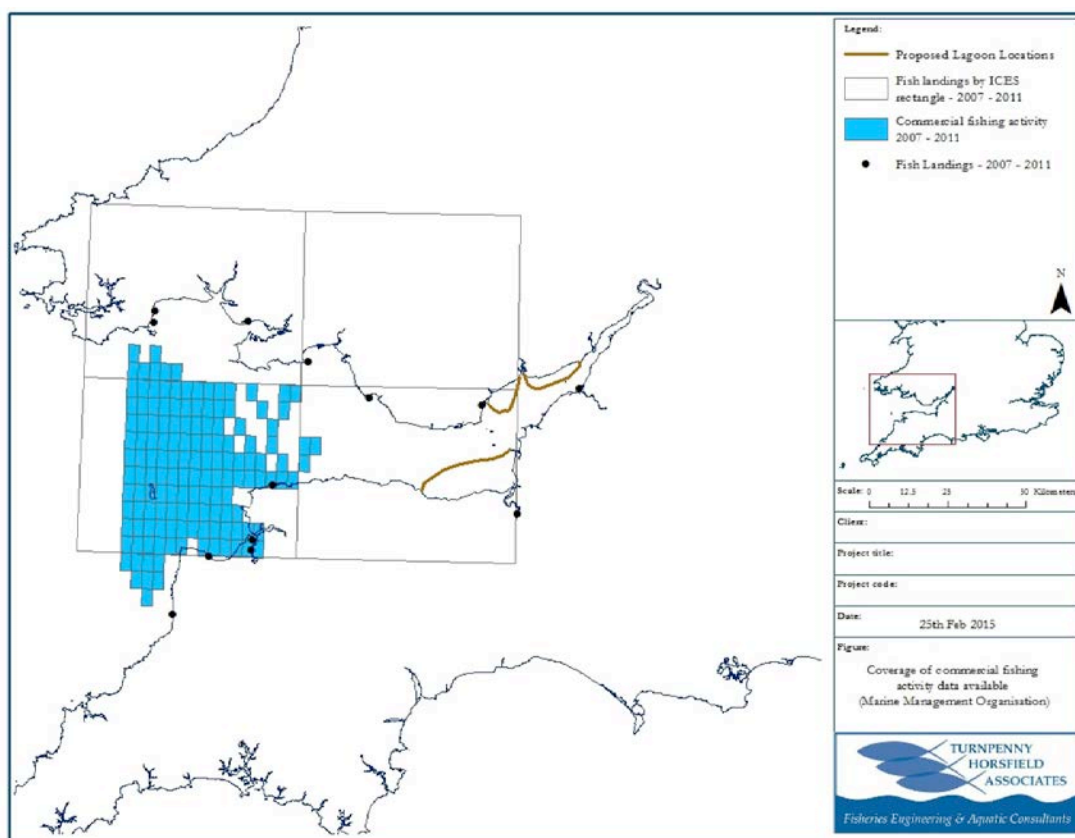


Figure 13.2 Marine Management Organisation (MMO) records of statistical rectangles in the Bristol Channel - Severn Estuary area from which commercial fish landings are reported

13.1.3 Migratory fish community

- 13.1.3.1 The Severn Estuary is particularly important for the run of migratory fish between the rivers and the sea (Bird, 2008). Species using the estuary include salmon, sea trout, sea lamprey, river lamprey, allis shad, twaite shad and eel. The population of twaite shad, eels and sea lamprey in particular are considered to be larger than any other UK estuary (Maitland and Lyle, 1990; Bird, 2008). The rare and endangered allis shad is now only an occasional visitor, although formerly a substantial spawning population was present (Cardiff Harbour Authority, 2012).

- 13.1.3.2 Of the anadromous species all but sea trout are listed under the European Habitat and Species Directive (92/43/EEC) in Annex II (species whose conservation requires the designation of SACs). Atlantic salmon and river lamprey are additionally listed under Annex V (species whose exploitation and management in the wild may be subject to management measures). Additionally, the European Union has adopted Council Regulation No 1100/2007/EC establishing measures for the recovery of the stock of European eel, subsequently transposed into UK law by The Eels (England and Wales) Regulations 2009. All seven of the diadromous fish species passing

through the Severn Estuary were on the UK list of priority species and habitats requiring conservation action under the UK BAP.

- 13.1.3.3 A number of UK Rivers have been designated under the Natura 2000 series of sites as Special Areas for Conservation (SACs) for the presence of either all or some of these migratory fish species. The Rivers Usk and Wye have been designated as SACs with regards to the five protected anadromous fish species utilising the Severn Estuary (sea lamprey, brook lamprey, river lamprey, Twaite shad and Atlantic salmon²). The Usk is also a Site of Special Scientific Interest (SSSI). The Severn Estuary itself is a SAC due to the presence of allis and twaite shad and river and sea lamprey. The Severn Estuary is also a Ramsar site. All seven diadromous fish species (Atlantic salmon, sea trout, sea lamprey, river lamprey, allis shad, twaite shad and European eel) are qualifying features under Ramsar Criteria 4 and 8, in that the Severn Estuary is 'important for the run of these migratory fish between sea and river via the estuary' and the estuary is 'a key migration route to their spawning grounds in the many tributaries that flow into the estuary'³.
- 13.1.3.4 There are a number of other rivers entering the Severn Estuary and Bristol Channel which also support these diadromous species including, on the Welsh coast, the Rivers Ely and Taff (upstream of the Cardiff Barrage), the river Rhymney (which would be encompassed within the Project) and the River Ebbw (adjacent to the River Usk) and on the English coast, the rivers Parrett and Avon. Additionally, on the Welsh Coast, the Wentlooge levels are an area of low-lying estuarine alluvial wetland and intertidal mudflats on the north bank of the Severn estuary which would be encompassed by the Project. They are an important wetland resource, parts of which have been designated as SSSIs and have the potential to support migratory fish, in particular eels.
- 13.1.3.5 In addition to fish stocks within the rivers entering the Severn Estuary near the Project, those from other rivers outside of this area may also be affected. A number of the diadromous fish species within the Severn Estuary stray during their migratory movement and can enter other estuaries and rivers before returning to their natal river. As such, fish populations from these rivers, may also be impacted by the Project.
- 13.1.3.6 The Severn Estuary contains three nationally important salmon fisheries (Rivers Severn, Wye and Usk), which together with the Taff, represent 11.6% of the England and Wales salmon rod catch (Environment Agency, 2013). Additionally, the Wye and the Usk were in the top five rivers with the highest declared rod catch of salmon in 2013. Sea trout fisheries in the area (including the Rhymney River) have a lesser importance (0.56% of England and Wales sea trout rod catch in 2013),

² http://jncc.defra.gov.uk/ProtectedSites/SACselection/SAC_list.asp?Country=W

³ <http://jncc.defra.gov.uk/pdf/RIS/UK11081.pdf>

although nearby fisheries (from the River Ogmore to Tywi) are nationally significant, comprising 10% of the England and Wales total.

- 13.1.3.7 Within the Severn Estuary exploitation of salmon by nets and fixed engines continues but fishing effort and catches have greatly reduced over the past few decades. Some of the putcher and net fishermen are seeking to maintain the history and heritage of salmon fishing in the estuary, whilst catching few fish, numbers of salmon are considered to be significant by the standards of today.

13.1.4 Legislative and policy requirements

- 13.1.4.1 A summary of relevant legislation, policies and guidance relating to fish and fisheries, together with any general legislation that has fish specific considerations that may be relevant to the Project, is given below.

- 13.1.4.2 The UK is party to a number of international conventions that can have implications for fish, fisheries and commercial and recreational fishers, and it is also required to implement directives issued by the European Commission (EC). This is achieved through UK Acts of Parliament, supported by Statutory Instruments (SIs). Within Wales, such obligations are administered by Welsh Government through Statutory Instruments.

International Conventions

- i. The Convention on the Conservation of European Wildlife and Natural Habitats 1979 (the Bern Convention)
- ii. The Convention on Biological Diversity 1992 (Biodiversity Convention or CBD)
- iii. The Convention on the Conservation of Migratory Species of Wild Animals 1979 (the Bonn Convention or CMS)
- iv. The Convention for the Protection of the Marine Environment of the North-East Atlantic 1992 (the OSPAR Convention)

EC Legislation

- i. EC Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) (EC Habitats Directive)
- ii. EC Marine Strategy Framework Directive (2008/56/EC)
- iii. The Water Framework Directive (2000/60/EC)

UK Acts, SIs and Policy Statements

- i. Countryside and Rights of Way Act 2000
- ii. The Natural Environment and Rural Communities Act (NERC Act) 2006
- iii. The Environment Act 1995
- iv. The Wildlife and Countryside Act 1981 (as amended)
- v. The Marine and Coastal Access Act 2009 (Marine Act)

- vi. The Salmon and Freshwater Fisheries Act 1975 (SAFFA)
- vii. Food and Environment Protection Act 1985
- viii. The Eels (England and Wales) Regulations 2009
- ix. The Water Environment (Water Framework Directive) (England and Wales) Regulations 2003 SI 3242
- x. The Conservation of Habitats and Species Regulations 2010 (Habitats Regulations)
- xi. UK Post-2010 Biodiversity Framework (2012)
- xii. Technical Advice Note 5, Nature Conservation and Planning (2009)

13.2 Scope of potential impact to be assessed

13.2.1 Introduction

- 13.2.1.1 The Environmental Impact Assessment (EIA) will assess predicted construction, operational and decommissioning effects of the Project on the ecology of fish and shellfish within the area of the lagoon and offshore works. It will also extend to the wider areas of the Bristol Channel and Celtic Sea that form part of the full life-cycle habitat for species of conservation, commercial and recreational fishing interest. A wide range of fish species that frequent or occasionally visit the Cardiff and adjacent Newport coastal areas and their connecting inland rivers and waterbodies have been identified through an initial desk study.
- 13.2.1.2 The approach to assessment of the potential impacts is outlined here. These are divided into three time frames covering (1) Construction Phase, (2) Operational Phase and (3) Decommissioning Phase. Since the Project has a planned lifespan from construction to decommissioning of 120 years, the assessment is also required to take account of projected climate change effects over this period. The assessment must also consider potential cumulative and in-combination effects of other projects within its geographic range of environmental influence, for example other marine renewable schemes, nuclear and fossil-fuelled power stations and port developments. Potential cumulative projects are discussed further in Chapter 3 Structure of the Environmental Statement.
- 13.2.1.3 Various geographic ranges or 'study areas' are relevant to the fisheries assessment. The shortest range is within the seabed construction footprint and the hydraulic 'near-field' (as defined in Chapter 8 Coastal Processes, Sediment Transport and Contamination, but essentially the area where there are detectable current and suspended sediment changes associated with turbine and sluice operation). During the construction phase there will also be a 'short term' effect on the wider local area in which fish may be affected by underwater noise from dredging and piling and other marine activities. Most of the direct effects on fish will occur within these areas. Beyond these areas, the wider effects on river and other freshwater habitats for migratory (diadromous) species and on more distant estuarine and marine habitat for other fish species will be considered. Potential for these longer range

effects will also be reported for Water Framework Directive (WFD) assessments and Habitats Regulations Assessments (HRA).

13.2.1.4 The specific types of impact that will be considered and their potential effects on fish and fish-related activities are set out in Tables 13.2 to 13.4 below for the three project phases, together with explanatory text. It should be noted that these assessments will utilise information from other EIA studies including coastal processes, marine water quality, intertidal and subtidal benthic ecology, marine transport and navigation and marine noise and vibration. There will therefore be a close link between specialists working on these various topic areas to confirm data required and to share findings of assessments.

13.2.1.5 The DECC commissioned Strategic Environmental Assessment of tidal power options in the Severn Estuary (DECC STP SEA) involved extensive assessment of the potential impacts of tidal power developments in the Severn Estuary including lagoons adjacent to Cardiff. As part of the study, liaison was undertaken with the relevant regulatory authorities and stakeholders and a wealth of knowledge, data and information relevant to such an assessment were considered. The outputs of this study, its key recommendations, assessment approaches and identified uncertainties have therefore been considered within the various sections of this scoping assessment to ensure that lessons learnt as part of the study are maintained.

13.2.2 Construction

Table 13.2 Potential effects from construction phase

Construction			Estuarine/Marine species	Migratory species
Potential source of impact	Potential development impact	Potential effect		
Dredging, sand reclamation, formation and removal of temporary cofferdams	Increases in suspended sediment and deposition	Smother spawning grounds Impact on larval/juvenile fish Injury and mortality Behavioural disturbance	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓
Piling, dredging, rock armour placement, increased vessel movements	Increases in underwater noise and vibration	Behavioural disturbance Injury and mortality	✓ ✓	✓ ✓
Construction lighting	Increases in artificial light emissions	Behavioural disturbance	✓	✓
Construction of breakwater, temporary cofferdams and area for rock storage	Habitat modification	Loss/disturbance to spawning habitat Loss/disturbance to foraging habitat Gain of spawning habitat Gain of foraging habitat	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓

Construction			Estuarine/Marine species	Migratory species
Potential source of impact	Potential development impact	Potential effect		
	Habitat fragmentation and isolation	Delays to passage Fragmentation of migratory routes Increased energetic cost	✓ ✓	✓ ✓ ✓
	Changes to freshwater exchange and release	Delays to passage Increased energetic cost		✓ ✓
Dewatering of temporary cofferdams for turbine and sluice gate housing	Habitat loss due to dewatering of cofferdam	Injury and mortality due to Dewatering	✓	✓
Dredging	Entrainment from draghead	Injury and mortality Reduced fitness	✓ ✓	✓ ✓
Discharge from works to environment, accidental spillages	Changes to water quality	Behavioural disturbance Loss/disturbance to spawning habitat Loss/disturbance to foraging habitat Injury and mortality	✓ ✓ ✓ ✓	✓ ✓ ✓
Construction activities & temporary + new permanent structures impede navigation	Increase in fishing vessel steaming time	Increased fuel costs Loss of fishing time		

Increases in suspended sediment and deposition/erosion

- 13.2.2.1 The assessment of potential effects from increases in suspended sediment will be undertaken using an understanding of the Project construction activities which could result in the associated impact. These include activities such as dredging and the installation and removal of the cofferdam. Additionally, information on the current suspended sediment levels within the study area and the potential changes that could occur as a result of the planned construction activities will be considered. The sensitivity and tolerance of the fish receptors will be determined to assess if effects could occur during construction.

Increases in underwater noise and vibration

- 13.2.2.2 The potential effects of underwater noise and vibration upon the fish receptors will be undertaken based on an understanding of the sensitivity of the species under consideration. The potential lethal, sublethal and behavioural avoidance effects that could occur will be determined. The assessment will be based on the Project construction activities which could generate underwater noise and vibration as well as the levels that they could generate above the background levels in the local area.

Increases in artificial light emissions

- 13.2.2.3 Artificial lighting will be used during the construction phase both to illuminate required works, as necessary, and to mark structures for public and maritime safety. Artificial light has the potential to influence the behaviour of fish, for example attracting some clupeid species such as herring while repelling other species such as eels. The lighting plan for the construction phase will be reviewed to assess the risk to fish and best practice will be adopted during construction, e.g. minimising direct illumination of the water surface.

Habitat modification

- 13.2.2.4 Habitat modifications would include changes in the seabed structure, e.g. by dredging to maintain access channels for construction vessels, by relocation of seabed materials and by addition or removal of structures that form habitat for fish. The extent of affected habitat area will be estimated and assessed in relation to available like-for-like habitat area in the Severn Estuary and Bristol Channel.

Habitat fragmentation and isolation

- 13.2.2.5 An understanding of the extent of impediment to fish passage into the area encompassed by the lagoon and the freshwater bodies flowing into it through the construction of the breakwater and temporary cofferdams will be undertaken. Fish utilisation of the habitat within the lagoon area and the freshwater bodies will be identified. Fish species of conservation importance migrating through the area to reach encompassed freshwater bodies will be a particular focus. A significant uncertainty identified during the DECC STP SEA was the utilisation of estuarine

habitat and residence time of migratory fish species, which will be key for this assessment in relation to the habitat to be encompassed by the lagoon.

Changes to freshwater exchange and release

- 13.2.2.6 An understanding of the potential impact of the lagoon construction activities in particular the installation of the breakwater and cofferdams on freshwater exchange and release from freshwater bodies to be encompassed and those in close proximity will be undertaken. This effect is likely to be minimal until the point of lagoon closure. The migratory fish species using these cues will be identified and the potential effects of changes to them determined. The behaviour of migratory fish species in the Estuary currently and with a tidal power scheme in place was seen as a significant knowledge gap during the DECC STP SEA which introduced uncertainty to the assessment process and modelling techniques.

Habitat loss

- 13.2.2.7 Loss of habitat during construction will result from the installation and dewatering of temporary cofferdams, trenching for cables and from the formation of permanent structures on the seabed, including the breakwater and dolphins. Loss of seabed habitat could affect benthic and epibenthic species, for example sandeels (e.g. *Ammodytes* spp.) flatfishes and rays (Rajidae). Areas of loss will be assessed in relation to overall habitat areas within the Severn Estuary and Bristol Channel.

Entrainment from draghead

- 13.2.2.8 Suction of water through the draghead during dredging operations could impact on buried fish such as overwintering stages of sandeel which prefer sandy substrates. An assessment of the areas of sandy substrate to be affected, timing of works, along with published data on entrainment of fish through dragheads will be used to assess this effect.

Deterioration in water quality

- 13.2.2.9 The potential effects on fish species within the vicinity of the construction works resulting from accidental spillages or discharges to the marine environment affecting water quality will be examined.

Impediment to navigation

- 13.2.2.10 Fishing boats and charter vessels may incur additional fuel costs and steaming times through needing to navigate around the safety zone associated with construction activities, including dredging, temporary cofferdams and breakwater during construction. An assessment of the potential effects will be undertaken considering also, the findings of the navigation and marine transport assessment (see Chapter 19).

13.2.3 Operation

Table 13.3 Potential effects from operation phase

Operation			Estuarine/Marine species	Migratory species
Potential source of impact	Potential development impact	Potential effect		
Operation and presence of Tidal Lagoon	Increases in suspended sediment and deposition	Smother spawning grounds	✓	
		Impact on larval/juvenile fish	✓	✓
		Injury and mortality	✓	✓
		Behavioural disturbance	✓	✓
	Habitat fragmentation and isolation	Delays to migration		✓
		Fragmentation of migratory routes Increased energetic cost	✓ ✓	✓ ✓
	Changes to freshwater exchange and release	Delays to migration		✓
		Increased energetic cost		✓
	Habitat modification	Loss/disturbance to spawning habitat	✓	
		Loss/disturbance to foraging habitat	✓	✓
Gain of spawning habitat		✓		
Gain of foraging habitat		✓	✓	
Increased predation	Injury and mortality	✓	✓	
	Reduced fitness	✓	✓	
Entrainment from draghead	Injury and mortality	✓	✓	
	Reduced fitness	✓	✓	
Fluctuations in Lagoon water levels	Behavioural disturbance	✓	✓	
	Injury and mortality	✓	✓	
	Stranding and mortality of fish	✓	✓	
Turbine operation	Entrainment and injury from turbines	Injury and mortality	✓	✓
		Reduced fitness	✓	✓
	Waterborne noise and vibration from the turbines	Behavioural disturbance	✓	✓
Sluice operation	Entrainment and injury from sluices	Injury and mortality	✓	✓
		Reduced fitness	✓	✓
Operational lighting	Increases in light emissions	Behavioural disturbance	✓	✓

Operation			Estuarine/Marine species	Migratory species
Potential source of impact	Potential development impact	Potential effect		
Changes in hydrological conditions	Deterioration in water quality	Behavioural disturbance	✓	✓
		Injury and mortality	✓	✓
	Changes to migratory cues and passage routes	Behavioural alterations to migration	✓	✓
		Delays to migration		✓
		Increased energetic cost	✓	✓
		Reduced fitness	✓	✓
Seabed cables	Creation of EMFs	Behavioural avoidance	✓	✓
Recreational activities within the Tidal Lagoon	Waterborne noise and vibration from recreational activities	Behavioural disturbance	✓	✓
Breakwater impedes navigation	Increase in fishing vessel steaming time	Increased fuel costs Loss of fishing time		
Increase in recreational angling	Increased pressure on fish populations as a result of recreational angling	Increased fish mortality	✓	✓

Increases in suspended sediment and deposition/erosion

- 13.2.3.1 An assessment of the potential for the operation of the Project to increase suspended sediment and deposition or erosion within and outside of the lagoon will be undertaken. The assessment will use information on the current suspended sediment levels, potential changes to these levels and areas of potential deposition as well as the sensitivity and tolerance of the fish receptors.

Habitat fragmentation and isolation

- 13.2.3.2 To understand the potential effects of habitat fragmentation and isolation as a result of the Project, the fish utilisation of the area to be included within the lagoon, the freshwater and estuarine water bodies that will be encompassed by the lagoon and the migratory fish species utilising these water bodies will be determined. Impacts on the fish receptors utilising these different habitats in terms of delayed or impeded access will then be assessed.

Changes to freshwater exchange and release

- 13.2.3.3 Impacts upon the freshwater exchange and release from encompassed freshwater bodies and those in close proximity to the breakwater will be determined. The migratory fish species using these cues and the potential effects of changes to them will be identified and the potential effects assessed.

Habitat modification

- 13.2.3.4 The large flows of water passing through the turbines and sluices with every tide will cause changes to the seabed in proximity to the turbine houses, notably the removal of fine deposits. The need for maintenance dredging during the operational life of the Project will mean that habitat within the lagoon will alter both in terms of water depth and bed composition between dredge cycles. The changes in habitat area for benthic and epibenthic fishes and shellfishes will be assessed in relation to available areas.

Increased predation

- 13.2.3.5 Areas of water turbulence around sluices and turbines attract planktivorous fish such as sprat and herring and can break up shoals of these small schooling species making them more vulnerable to predation by seabirds and piscivorous fish such as bass. Attraction of predators to these areas could also impact on salmon and sea trout smolts passing in close proximity to the area. Passage of any fish through the turbines could also cause disorientation rendering them more vulnerable to predation. These effects will be assessed with reference to other examples where similar effects have been observed.

Entrainment from draghead

- 13.2.3.6 Periodic maintenance dredging of the lagoon will be required. The effects as identified for the construction phase will be assessed.

Fluctuations in lagoon water levels

- 13.2.3.7 Fish living in the intertidal zone and utilising the intertidal as a route into connected freshwater bodies are adapted to follow tidal movements up and down the shoreline. Unnaturally high rates of ebbing can cause fish to become stranded. To examine this possibility, the rate of change in tidal level for pre- and post-operational conditions will be compared using a hydrodynamic model to ensure that the operation condition is regulated to remain as close to the natural condition as possible.

Entrainment and injury from turbines

- 13.2.3.8 Tidal-range hydroelectric turbines are broadly similar to those used at inland hydropower dams but are optimised for the varying tidal heads. Injury risk to fish arises from the potential for collision with fixed stay vanes and guide vanes and rotating runner blades, and from passage through areas of intense turbulence, hydraulic shear and from sharp pressure changes. The turbines used will be selected for fish-friendly characteristics, such as large dimensions, variable speed, minimum runner gap and small number of blades. The effects will be assessed using the STRIKER 4™ turbine fish injury computer model, a version optimised for tidal power applications. The DECC STP SEA identified the requirement to fully consider uncertainty within such modelling techniques and display the range of predicted impacts. Where possible, modelling will therefore be undertaken using stochastic functions. Presentation of fish to the lagoon and its turbines will depend on the behaviour of the fish, their residence time in the estuary, their point of origin and destination. Modelling will therefore be required to determine the number of presentations for a given species life stage. The DECC STP SEA identified a number of significant knowledge gaps regarding the migratory behaviour, residence time and habitat utilisation of migratory fish within the Estuary. Where required studies will therefore be considered to fill such knowledge gaps and reduce the uncertainty associated with any proposed modelling approaches. The DECC STP SEA identified the requirement to assess impacts at a population level, where possible quantitative point estimate effects will therefore be modelled to determine impacts at the population level using life cycle modelling.

Waterborne noise and vibration from the turbines

- 13.2.3.9 Noise emissions from bulb turbines propagating into the surrounding water body have the potential to disturb fish. Likely emissions will be estimated in terms of noise frequency and level. These will be considered in relation to existing background noise levels and they will be assessed in relation to scientific data on fish noise disturbance thresholds. Note, no formal standards currently exist for marine noise emissions.

Entrainment and injury from sluices

- 13.2.3.10 The sluices may be opened for periods towards the beginning and end of each filling and emptying cycle of the lagoon to optimise energy efficiency. The large volumes of water passing through will inevitably entrain numbers of small fish that cannot resist the flows. Generally this is not harmful, being similar to natural movements of water through rock passages, etc. However, hydraulic shear stresses can be expected to occur in close proximity to the gate margins. Shear stress values will be assessed in relation to limits known to be safe for fish passage.

Increases in artificial light emissions

- 13.2.3.11 Lighting will be incorporated in to the design of the Project to ensure a safe environment for operatives, navigation and any members of public accessing parts of the facility. The potential effects will be assessed and mitigation measures implemented where appropriate.

Deterioration in water quality

- 13.2.3.12 Changes to the hydrological conditions within the lagoon and surrounding area will be determined in relation to their potential impacts upon water quality. The fish species using these areas and the nature of their behaviour within them will need to be identified as well as their sensitivity and tolerance to water quality changes.

Changes to migratory cues and passage routes

- 13.2.3.13 An understanding of changes to the hydrological conditions within the Estuary outside of the lagoon will be determined. The potential for alterations in flow conditions to impact upon the migration of fish, their route of passage and potentially the ultimate destination freshwater body will then be assessed. Modelling will be required to determine such potential changes based upon fish behaviour characteristics, residence time, point of origin and destination. Where required studies will be considered to fill significant knowledge gaps in the behavioural characteristics of migratory fish species to reduce the uncertainty in such modelling techniques and its outputs.

Creation of EMFs

- 13.2.3.14 The potential for electromagnetic fields (EMFs) to be generated within the water column from seabed cables will be determined and where necessary the levels identified. The assessment of potential effects will be based on the sensitivity of the different fish receptors present in or passing through the area to EMF's.

Waterborne noise and vibration from recreational activities

- 13.2.3.15 The types of recreational activity which may occur within the lagoon will be determined along with their potential to generate underwater noise and vibration above ambient levels in the area. An assessment on potential fish receptors will be undertaken based on an understanding of the sensitivity of the various species.

Impediment to navigation

- 13.2.3.16 Whilst during the construction phase safety zones will be present, during operation these will be reduced to key areas such as within the immediate vicinity of the turbines and sluices. Notwithstanding this the physical presence of the lagoon will act as a new structure which may inhibit existing passage of fishing vessels to fishing grounds. An assessment of this potential effect on fishing boats and charter vessels will be provided considering also, the findings of the Navigation and Marine Transport Assessment (Chapter 19).

Increased pressure on fish populations as a result of recreational angling

13.2.3.17 The new lagoon could provide attractive platforms for sea fishing and could therefore increase fishing mortalities above current levels. Subject to consultations with angling bodies, the likely angling usage will be estimated and mortality impacts estimated based on published catch-rate figures for the types of fishing involved.

13.2.4 Decommissioning

13.2.4.1 The potential effects from decommissioning will depend on the option progressed. Possible decommissioning scenarios are discussed in Chapter 6 Project Description. Potential effects are detailed in Table 13.4.

Table 13.4 Potential effects from decommissioning phase

Decommissioning			Estuarine / Marine species	Migratory species
Potential source of impact	Potential development impact	Potential effect		
Removal of turbines and sluice gates	Increases in suspended sediment and deposition	Smother spawning grounds	✓	
		Impact on larval/juvenile fish	✓	✓
		Injury and mortality	✓	✓
		Behavioural disturbance	✓	✓
Removal of turbines and sluice gates and associated vessel movement	Increases in underwater noise and vibration	Behavioural disturbance	✓	✓
		Injury and mortality	✓	✓
Habitat modification	Improved connectivity between the habitat within and outside the lagoon.	Increased access to spawning grounds	✓	✓
		Increased access to foraging grounds	✓	✓

Increases in suspended sediment and deposition

13.2.4.2 As with construction impacts, information will be provided on the decommissioning activities which could generate temporary increased suspended sediment levels. The potential effects of changes in suspended sediments above those predicted under the operational scenario, will be assessed.

Increases in underwater noise and vibration

13.2.4.3 The potential for decommissioning activities to generate underwater noise and vibration above operational levels will be investigated. An assessment of their

potential effect upon fish receptors will be determined in relation to the various fish species sensitivity.

Improved connectivity between the habitat within and outside the lagoon

- 13.2.4.4 Removal of the turbines and sluices will restore connectivity for fish and potentially eliminate steaming-time delays that the Project may have created for vessels in local waters. These effects will be assessed against the operational phase case.

13.3 Existing baseline data, consultation and need for survey

13.3.1 Overview of available data

- 13.3.1.1 Fish data for the near and far field zones will be sought from the following organisations:

- i. Natural Resources Wales
- ii. Environment Agency
- iii. CEFAS
- iv. DEFRA
- v. Natural England
- vi. Marine Management Organisation
- vii. Welsh Federation of Sea Anglers
- viii. Inshore Fisheries Units for South Wales
- ix. Freshwater angling clubs and associations
- x. Wildlife protection and conservation bodies
- xi. National Biodiversity Network
- xii. Local Biological Records Centre
- xiii. North Atlantic Salmon Conservation Organisation (NASCO)
- xiv. Local developers
- xv. Water companies and others undertaking environmental monitoring of the freshwater bodies

- 13.3.1.2 Additionally where relevant peer-reviewed literature, grey literature and evidence available from monitoring undertaken at other tidal power developments will be investigated.

Estuarine fish community data

- 13.3.1.3 The aim of the baseline characterisation will be to describe the species and lifestages that are present or pass through the area seasonally, and to describe their long-term fluctuations. This will be necessary so that any changes that may be caused by the construction, operation and ultimately any decommissioning of the lagoon can be assessed against the background of natural variability. The baseline characterisation will also consider the importance of the area as spawning and nursery habitat for wider marine and estuarine fish stocks in the Bristol Channel and Celtic Sea areas. Special attention will be paid to marine and estuarine

species that are listed for conservation importance or considered to be below safe biological limits.

- 13.3.1.4 One of the most comprehensive sources of data from which an understanding of fish communities and population dynamics in the Severn Estuary has been developed has been the long-term surveillance of fish and crustaceans collected from the cooling water intake screens of the various power stations sited on the Severn Estuary. Most important is the Hinkley Point site, for which there is a more or less continuous monthly record of captures going from 1981 to 2006, with sporadic earlier records. Data from Uskmouth, Berkeley and Oldbury-upon-Severn have also helped to broaden the picture. Further records are available from intertidal and subtidal Water Framework Directive (WFD) surveys carried out by the Environment Agency (EA) since 2007. Fish surveys have also been carried out for individual development projects, examples including the Second Severn Crossing, Bristol Port Expansion, Hinkley point C New Nuclear Build project, and various Severn tidal power projects, the most recent of which were the Severn Tidal Power Group studies (1989-1992) and the Severn Tidal Power Strategic Environmental Assessment (2008-2010).
- 13.3.1.5 In terms of commercial fishing for marine species, this is limited in the Severn Estuary owing to hostile tidal conditions and the fluid mud that characterises the subtidal in many areas, and the generally poor fish communities from a commercial point of view. Notwithstanding this landings records from fishing vessels >10 m in length are maintained by the Marine Management Organisation (MMO) on behalf of Welsh Government and access to this data will be sought.
- 13.3.1.6 Finally there have been numerous scientific papers containing species records and concerning various aspects of fish biology in the Severn Estuary and its sub-estuaries which further contribute to the body of knowledge.

Migratory fish community data

- 13.3.1.7 There are a number of long-term datasets available on stock trends of migratory fish populations within the major rivers flowing into the Severn Estuary, in particular those with a protected nature designation such as the SACs, for which there is a requirement to report on the condition status of populations on a 6 yearly cycle. For those species such as the salmonids for which there are recreational angling and net fisheries, annual records of catches are available. These are a valuable resource for assessing long-term stock trends. NRW and the EA for rivers in Welsh and English jurisdictions respectively, are the primary holders of such datasets.

- 13.3.1.8 Further information may be available on migratory fish populations within freshwater bodies. In particular for the smaller systems not regularly monitored by the regulatory authorities, this data may be available as a result of developments such as improvements to the M4 motorway. Wildlife protection and conservation bodies such as those associated with the Wentlooge Levels may also hold data on fish populations within these small and diverse waterbodies. The DECC Severn Tidal Power Scheme SEA collated and summarised extensive data sources for the Severn Estuary, Bristol Channel and associated rivers. All these data sources will be built on and updated for this present assessment.
- 13.3.1.9 Information sources on migratory fish populations within the Estuary itself will be similar to those discussed above for the estuarine/marine fish assemblage in particular that available from the power stations and Agency WFD monitoring.

13.3.2 Data gaps

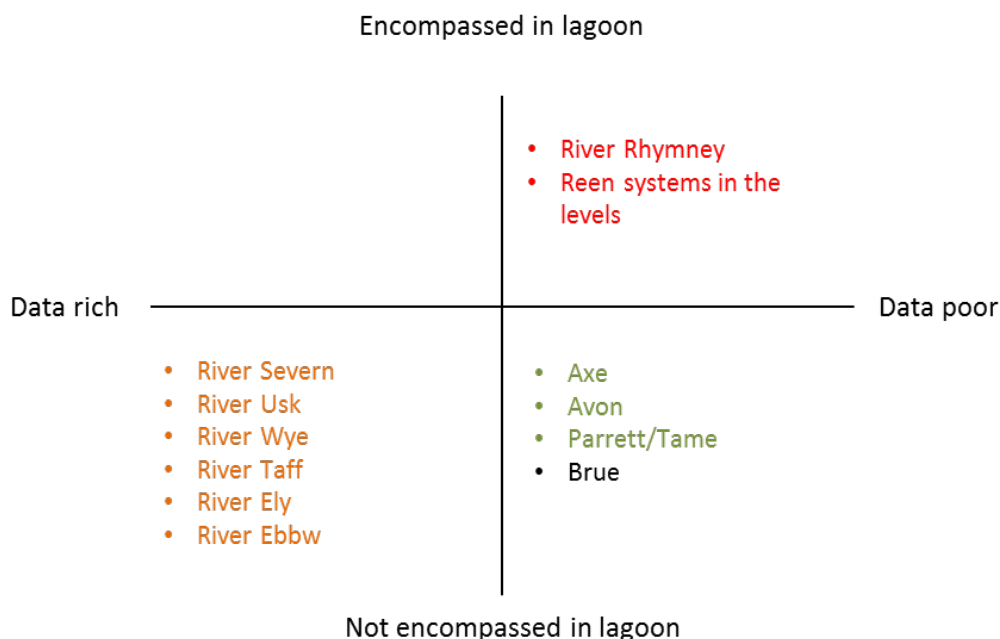
Estuarine fish community data

- 13.3.2.1 The data sources listed above provide for a good general description of baseline conditions in the Severn Estuary and levels of interannual variation but survey data specific to the lagoon locales are not available. The key gaps therefore with respect to the estuarine and marine fish component concern the distribution of marine/estuarine species and lifestages within the Project construction and operational footprint areas, their seasonal variations, and their particular importance (if any) to wider marine/estuarine stocks, e.g. as spawning, nursery or feeding areas.

Migratory fish community data

- 13.3.2.2 Following on from the overview of the existing situation detailed above, a preliminary review of likely available data sources has been undertaken for migratory fish within the near and far field zone. This data availability has been compared against the data requirements identified in relation to the potential impacts associated with the Project to identify key likely data gaps.
- 13.3.2.3 A matrix approach has been applied (Table 13.5) to identify watercourses considered to be of the greatest importance to the assessment for migratory species, i.e. those encompassed by or in very close proximity to the Project are ranked against those further afield. The next step considers the existing data likely to be available for the watercourses and ranks them from data rich to data poor. Watercourses in the highest priority/data poor quarter of the matrix are considered to be the priorities for additional sampling to characterise the migratory fish populations within the impact zones.

Table 13.5 Matrix summarising the likely availability of migratory fisheries data for freshwater bodies either encompassed or not encompassed (but potentially impacted) by the Project.



- High priority sites for additional data collection. Sites enclosed within the lagoon and likely to support migratory fish species but data considered to be absent or limited.
- High priority sites for characterisation and impact assessment. Known to be important sites for migratory fish species and within immediate proximity of the lagoon. Existing data likely to be available for characterisation purposes.
- Medium priority sites for characterisation and impact assessment but not within immediate proximity of lagoon. Migratory species likely to be present and some data available.
- Low priority sites for characterisation and impact assessment. Not known as important sites for migratory species and not within immediate proximity of lagoon.

13.3.2.4 The estuarine environment in the locale of the proposed lagoon is also known to be data poor for migratory fish species. While it is known that juvenile life stages of migratory fish species may utilise the estuarine habitat potentially for protracted periods, the evidence for this is limited, especially in relation to the specific areas around the proposed lagoon site.

13.3.3 Knowledge gaps

13.3.3.1 The DECC STP SEA identified a number of knowledge gaps which were considered to result in uncertainty in the assessment which in some cases would prevent a decision from being made with regard to potential impacts upon protected site designations and their qualifying features in particular. Much of this uncertainty focused upon the behaviour, residence time and habitat utilisation of migratory fish species within the Estuary. Modelling techniques were implemented to provide information on the behaviour and movement of migratory fish species, how they would interact with the proposed schemes and the number of potential passes through the turbines and sluices. In a number of cases however, information to support the behavioural input parameters was limited which retained uncertainty in the assessment process. The assessment of interactions of fish with the Project, in particular the number of passes through the turbines and sluices is essential for the quantitative assessment of impacts from these structures and subsequently the quantitative assessment of impacts at the population level. Uncertainty within this modelling assessment element therefore runs through the entirety of the quantitative elements of the assessment. There may therefore be a requirement to collect Estuary specific data to fill these knowledge gaps partially or in full to reduce the uncertainty of the assessment.

13.3.3.2 Specific knowledge gaps identified and of relevance to the assessment for the Project are as follows:

- i. The behaviour of adult salmon in the Estuary, in particular regarding straying from their natal river to enable determination of their transit time, direction of presentation to the proposed lagoon and potential number of presentations;
- ii. The residence of migratory fish in the Estuary and their habitat utilisation during this period in particular regarding sea trout, eels, juvenile shad and lamprey to determine the potential number of presentations to the proposed lagoon;
- iii. The migratory behaviour of some of the less studied migratory fish species in the Estuary such as lamprey, sea trout, shad and eels;
- iv. The habitat utilisation of the prey items of migratory fish species.

13.3.4 Data gathering and survey proposals

Estuarine fish community data

Intertidal fish fauna surveys

- 13.3.4.1 Multi-method surveys are proposed to characterise the inter-tidal marine fish fauna within the footprint of, and adjacent to, the Project and aid the assessment of habitat utilisation and residence of migratory fish species among others. The methodologies are based on standard Water Framework Directive (WFD) Transitional and Coastal Water (TraC) survey methodologies and are designed to describe the seasonal and annual community diversity within the inter-tidal waters potentially affected by the development of the lagoon.
- 13.3.4.2 The primary aims of the intertidal surveys are to characterise the juvenile lifestages of commercially important and keystone species, and to investigate the resident yellow eel population. The surveys have the following objectives:
- i. To characterise the fish fauna within the potential zone of impact;
 - ii. To provide an estimate of total catch rates per unit effort (CPUE); and
 - iii. To provide an estimate of CPUE and seasonal length-frequency distribution of selected species designated as Valued Ecological Receptors (VERs)
- 13.3.4.3 There is the potential for unsafe working conditions (e.g. deep intertidal mud and rapid tidal streams) to preclude certain areas from sampling. A site visit was undertaken in January 2015 and provisional survey locations were identified both within and outside the footprint of the Project as shown in Figure 13.3. It should be noted that these sites may change at the time of surveys if access or ground conditions dictate.

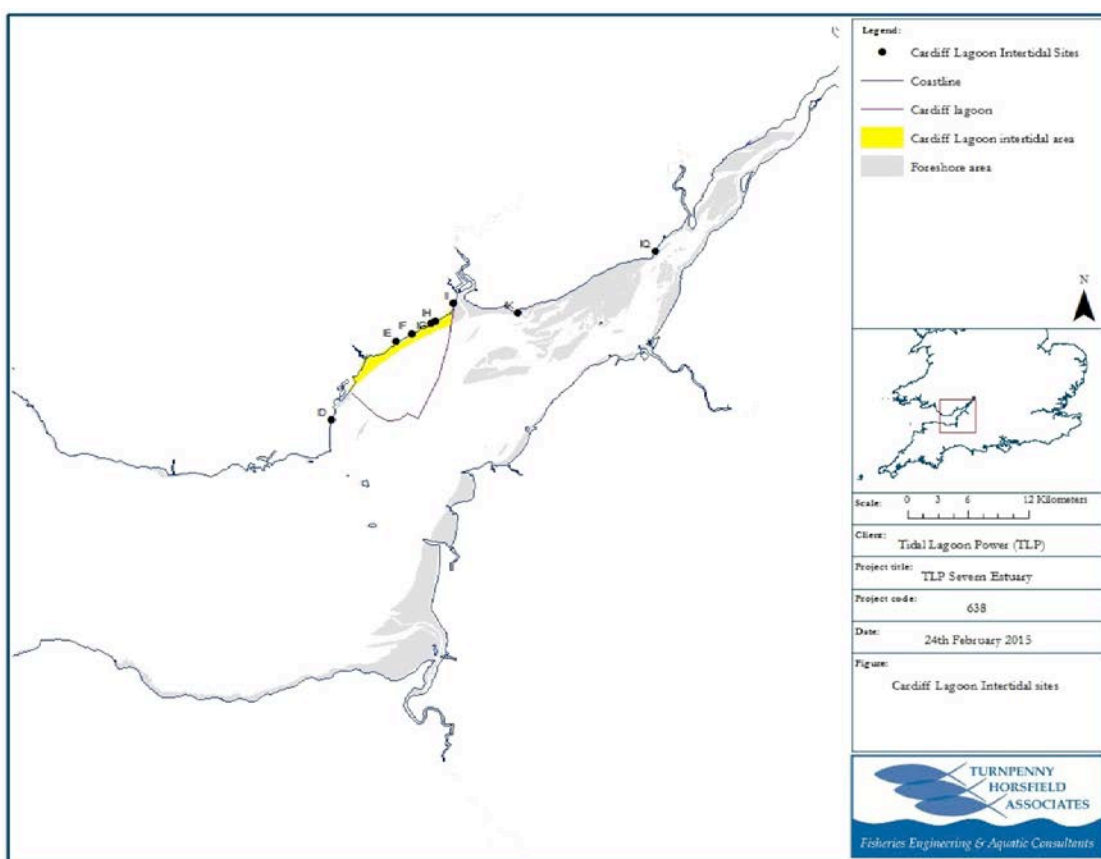


Figure 13.3 Map of indicative proposed intertidal survey sites

- 13.3.4.4 Surveys will be undertaken at quarterly intervals (typically January, April, July and October) to inform seasonal, inter-tidal habitat use. It is proposed to undertake two additional surveys during periods when migratory fish are likely to be present within the wider estuary, including out-migrating salmonids during the late spring/early summer (May/June) and juvenile shad in late summer/early autumn.
- 13.3.4.5 Core survey techniques will comprise of micro-mesh beach seines (approximately 25 m x 2.7 m with c. 3mm mesh), fyke nets (double ended fyke nets with cod end mesh <10mm), adult seine (43 m x 4 m with c. 14 mm mesh wings and a 6.5 mm mesh cod end) and actively fished trammel nets. It should be noted that certain standard intertidal monitoring techniques (such as Riley push-netting and 1.5m beam trawling) are not considered appropriate for the surveys due to difficult tidal (i.e. height and velocities) and ground conditions. Beam trawling is however, being carried out as part of the subtidal surveys (see below).
- 13.3.4.6 Techniques deployed at each site will be dependent on local environment and safe working conditions as well as regulatory consent, however nets will be similar at each station between surveys.

- 13.3.4.7 Replicates will be undertaken at survey stations within the footprint of the proposed lagoon along with reference sites outside the potential zones of impact. At each intertidal sampling station environmental parameters including water temperature, DO and salinity along with state of tide, time of deployment for each fyke/trap and time of recovery for each net will be recorded.

Subtidal fish trawls

- 13.3.4.8 The subtidal fish surveys proposed have been designed to provide the site-specific evidence necessary to assess marine and migratory species (and life stages) within the potential impact zone (near and far field influence areas).
- 13.3.4.9 The design includes a total of 4 subtidal transects within the proposed lagoon boundary (near field sites) and 2 additional distant transects (far field sites upstream and downstream from the lagoon). The proposed sampling locations are shown in Figure 13.4. On each transect, one sampling site will be located within the inshore shallow (<5m) subtidal area (sampled with the 1.5m beam trawl with 3 replicates) and two further offshore in the main estuary channel (5-12m and >12m, sampled with an otter trawl). The approach together with the use of specific gear for each location will enable the marine assemblages and their preferred estuarine habitats to be described as well as to identify any migratory fish species utilising the subtidal area. The proposed gear types are WFD-compliant; WFD UKTAG Biological Standard Methods⁴. The proposed design includes multiple sites and replicate samples within sites with sampling locations proposed along the estuarine salinity and depth gradients. Indicative sampling sites have been allocated on the basis of sites that are considered likely to be feasible for trawling, represent different habitat types and avoid sensitive habitat types. Sites selected are subject to change following discussions with the regulatory bodies and a pilot study given the difficult sampling conditions likely to be experienced in this area.

⁴ <http://www.wfduk.org/>

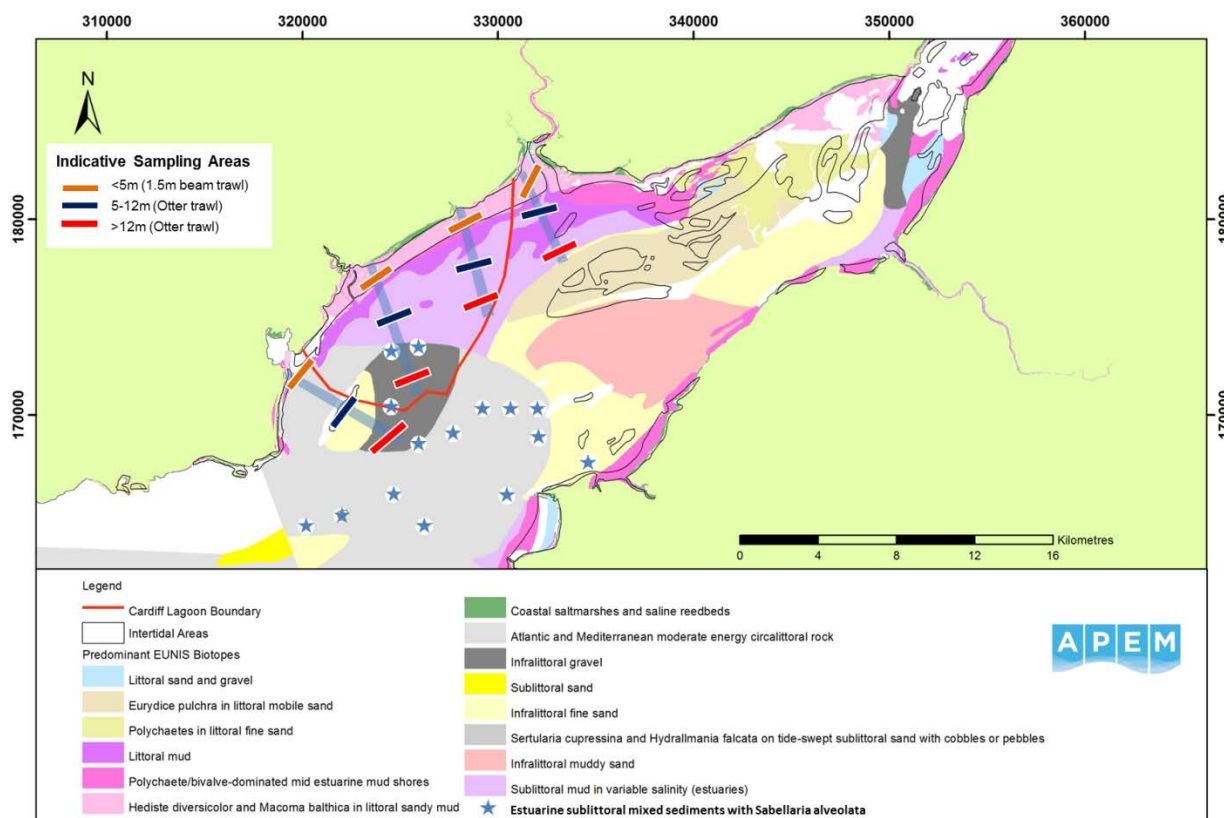


Figure 13.4 Map of indicative proposed subtidal fish trawls

13.3.4.10 Sampling will be undertaken on a quarterly basis to capture characterisation information for the four seasons, winter, spring, summer and autumn. A further two sampling occasions are additionally proposed to specifically target the potential presence of outmigrating salmonid smolts in the summer months of May/June and juvenile shad in late summer/early autumn. This additional sampling will aid in the assessment of migratory fish habitat utilisation and residence time within the Estuary.

Migratory fish community data

13.3.4.11 Two freshwater bodies/group of waterbodies have been identified by the data gap matrix analysis above as being of the highest priority for dedicated characterisation sampling for migratory species for the purposes of the EIA; the Rhymney River and the reen systems in the Wentlooge Levels. The Rhymney River, to be encompassed within the lagoon, is known to support a small run of sea trout and salmon but little is believed to be known regarding other migratory species such as lamprey and eels in particular. A number of migratory fish species are considered likely to utilise the reen systems of the Wentlooge Levels, during periods of their life cycle, in particular eels.

- 13.3.4.12 In addition to the freshwater bodies, migratory fish species are also likely to utilise the estuarine habitat itself during periods of residence within and transit through the Estuary.
- 13.3.4.13 Current knowledge on the presence and utilisation of migratory fish in these water bodies is considered likely to be limited, with some annual rod catch data for sea trout in the Rhymney available from the EA and NRW's annual Salmonid and freshwater fisheries statistics report. Catch data may also be available from various angling clubs. As the proposed lagoon will encompass the mouth of the river and the Wentlooge Levels as well as estuarine habitat, characterisation of the migratory fish assemblage utilising these environments has been identified as a requirement for a number of the impact assessment aspects. It is therefore proposed that dedicated targeted diadromous fish surveys are undertaken within these sites as part of the characterisation process to assess species composition and density and the proportion of different size cohorts (e.g. juveniles and adults).

Riverine electric fishing

- 13.3.4.14 Riverine electric fishing is only proposed for the River Rhymney to supplement the data on migratory fish populations that is currently anticipated to be available from routine monitoring by the regulatory authorities, rod catch data and any information available from other developments such as improvements to the M4 motorway.
- 13.3.4.15 Triple shock mixed species electric fishing will be undertaken at 5 pre-determined sites in different habitat types and stream orders over the course of the river to target juvenile salmonids, eels and other fish species present. A further 5 sites will be selected for lamprey specific sampling using the standard JNCC common standard monitoring technique within a 1m² netted quadrat. The data collected will provide information regarding species composition and density and the proportion of different size cohorts within the River.

Reen electric fishing

- 13.3.4.16 The reen/ditch systems are extensive within the adjacent shoreline of the proposed lagoon due to the presence of the Wentlooge Levels but are only connected to the Estuary in a few places. An initial scoping exercise has been undertaken to determine the waterbodies within the Levels that have a connection with the Estuary which will be encompassed by the lagoon structure. At least 4 waterbodies have confirmed connections with a potential 5th also under consideration as shown in Figure 13.5.

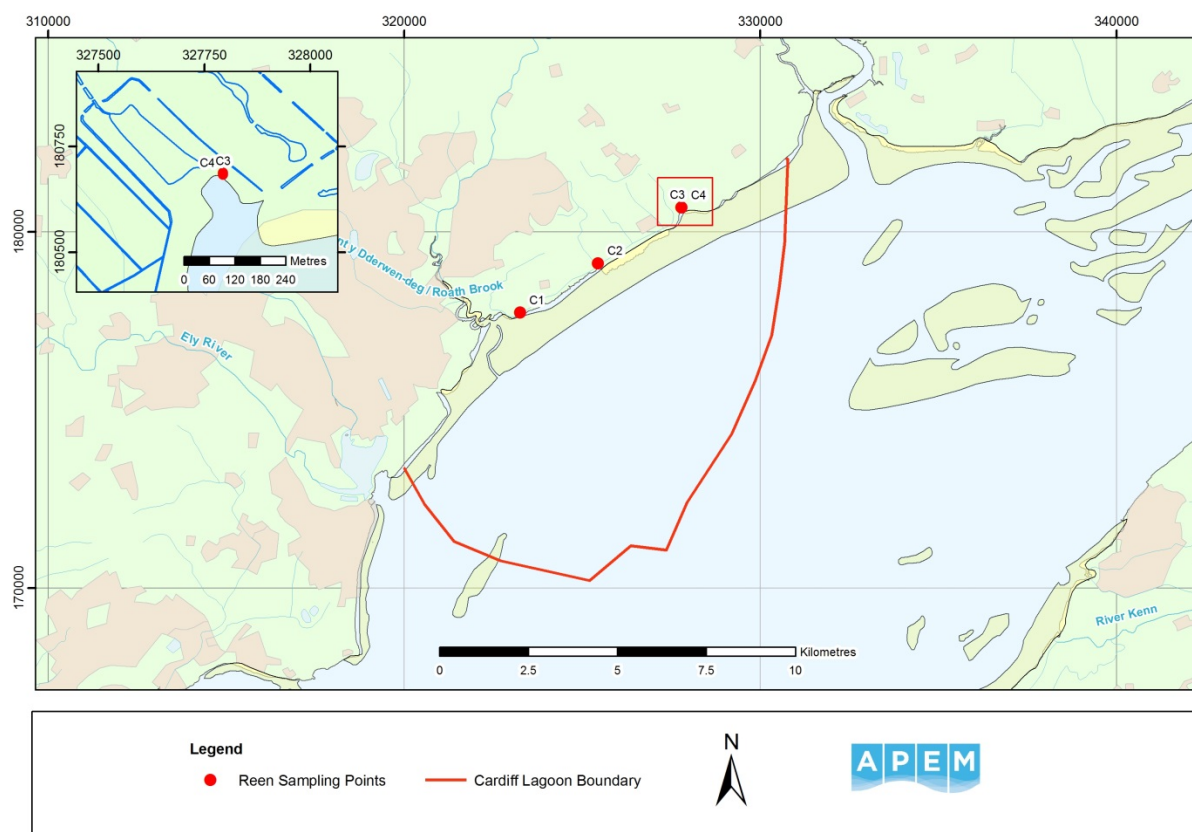


Figure 13.5 Map of identified reen/ditch system connections with the Estuary within the boundary of the Project

13.3.4.17 Electric fishing within the reen/ditch system would focus on those with a connection with the Severn Estuary to provide an indication of eel and other fish species presence/absence. An understanding of the connectivity within the Levels and potential wider distribution of migratory fish species will be undertaken via a desk based study. Electric fishing protocols will follow the same as those defined above for the riverine sampling. Sampling will be undertaken at 2 sites within each of the 4-5 identified waterbodies.

Reen fyke netting/stow netting

13.3.4.18 To gain a better understanding of the eel usage of the Wentlooge Levels reen/ditch as a whole, the outmigrating silver eel population will be monitored at the point of the connection in to the Estuary at the same 4-5 waterbodies as identified above (Figure 13.5). Either two 1m high D-ring fyke nets or stow nets will be fixed in the centre of the channel at each site with the mouths facing upstream and the leaders positioned at an angle of approximately 45°. The net specification will comply with that specified in the EA's guidance to monitoring elver and eel populations (The Eels Manual GEHO0211BTMY-E-E). Monitoring will concentrate on 1 sampling site per identified waterbody over a period of 1 night on a total of 6 occasions during the main migration period from approximately September to November.

Reen elver artificial habitat collection devices or traps

- 13.3.4.19 There are two possible sampling techniques that could be employed for the assessment of elver passage in to the reen/ditch systems. Traps could be placed at the point at which the reen/ditch connects with the Estuary, which is usually controlled in some manner to prevent the intrusion of seawater at high tide whilst allowing drainage of freshwater i.e. via a sluice gate or other barrier. Trap designs compliant with the EA's guidance for monitoring elver and eel populations (The Eels Manual GEHO0211BTMY-E-E) would be used. Where present it may be possible to incorporate such traps with existing elver passes at the sites. Such an elver pass has been identified at at least 1 of the selected waterbodies for sampling.
- 13.3.4.20 An alternative or supplementary technique to the traps, trialled in other countries is to use artificial habitat collection devices within the reen/ditches or at their entry point in to the Estuary. The sampling device consists of an array of split rope fibre. The devices are placed at the designated sampling point and left for a set sampling period, they are then retrieved and the contents emptied into a collection bin for processing.
- 13.3.4.21 As with fyke netting, the same number of waterbody sampling points are proposed with 1 sampling site per system. Monitoring with either of these devices would take place over 3 or 4 night periods at any one time over the course of 6 weeks during the main migratory period from approximately February to April.

13.3.5 Consultation

- 13.3.5.1 Consultation with statutory and non-statutory stakeholders will be maintained throughout the assessment process. Statutory consultees with respect to fish and fisheries interests include NRW, Welsh Government, NE, EA, Cefas and the MMO.
- 13.3.5.2 Non-statutory consultees will include representatives from conservation and fishing-related sectors, including Rivers Trusts, Angling Trust, Fish Legal, angling clubs and associations and their representatives, commercial fishers associations, fishery property owners, fishing tackle shops, charter boat operators and universities.

13.4 Proposed assessment methodology

13.4.1 Generic assessment overview

- 13.4.1.1 Generic assessment criteria applicable to fish and shellfish, commercial fishing and recreational fishing are presented below. More specific criteria, such as the value of receptors within each area assessed, are given separately. The impact assessment approach will be based on guidance from the Institute for Ecology and Environmental Management Guidelines for Marine Impact Assessment (IEEM, 2010) and the Ecological Impact Assessment (EcIA) guidance set out by the Institute of Ecology and Environmental Management (IEEM, 2006).
- 13.4.1.2 The implications of the following EIA regulations and legislation will be taken into consideration when compiling the EIA:
- i. Conservation of Habitats and Species Regulations (SI 2010/490);
 - ii. Offshore Marine Conservation Regulations 2007 (SI 2007/1842);
 - iii. Wildlife and Countryside Act 1981; and
 - iv. Water Framework Directive (Directive 2000/60/EC).
- 13.4.1.3 To determine the significance of possible impacts, standard EIA criteria will be taken into account:
- I. Magnitude of the impact;
 - II. Spatial extent of the impact;
 - III. Duration of the impact;
 - IV. Likelihood of occurrence; and
 - V. Confidence in accuracy of predicted impact.
- 13.4.1.4 Confidence in the predictions of the assessment will be assigned according to a three point scale based on expert judgement (High, Probable, Uncertain).
- 13.4.1.5 Potential impacts will be identified for the three phases of the Project: construction, operation and decommissioning. In addition, any potential in-combination impacts of the Project with other plans and projects in the area will be assessed.
- 13.4.1.6 For each of the assessments, the potential impacts will be examined and the significance of the effect identified. Impacts that are 'Moderate' or 'Major' are regarded as being significant for the purposes of the Infrastructure Planning (Environmental Impact Assessment) Regulations 2009 (the 'EIA Regulations').

13.4.2 Fish and shellfish assessment overview

Definition of valued ecological receptors

- 13.4.2.1 The value attributed to ecological features is dependent on both their overall biodiversity/ecosystem services as well as their social and economic value within a relevant geographic framework (IEEM, 2010).
- 13.4.2.2 The potential value of an ecological receptor is generally determined from its conservation designations. The value criterion for sites of local value or species not formally designated is more difficult to define.
- 13.4.2.3 Table 13.6 identifies the criteria that will be used to determine the ecological significance of Valued Ecological Receptors (VERs) within the area relevant to the proposed lagoon. Multiple criteria may apply when identifying VERs

Table 13.6 Geographic frame of reference and associated sensitivity used to determine the value the ecological receptors in the Project study area.

Value of VER	Criteria Which Defines Value
International / Very High	Regularly occurring species protected under international law.
National / High	Species protected under national law. UK BAP priority species (including grouped action plans) that have nationally important populations within the study area. Species which have primary spawning/nursery areas (high intensity) within the study site.
Regional / Medium	UK BAP priority species (including grouped action plans) that have regionally important populations within the study area i.e. are locally widespread and/or abundant. Species which have secondary spawning/nursery areas (low intensity) within the study site. Species that are of commercial value to the fisheries which operate within Swansea Bay.
Local / Low	Species common throughout the UK and present within the study area. Species considered to enrich the ecological resource within the locality (keystone species).

- 13.4.2.4 The VERs identified at the scoping stage within the area relevant to the proposed lagoon are shown in Table 13.7. Their importance is based on their conservation value, distribution and status within the area of potential impact, spatial extent of spawning and nursery areas, and migratory activity. Their importance as a commercial or recreational species is also taken into consideration. Some features provide key ecological function to other features rather than being of conservation interest themselves.

Table 13.7 Fish and Shellfish Valued Ecological Receptors (VERs) within the Project study area and their relative geographical importance.

VERs	Value
Migratory fish species	
Atlantic salmon, European eel, allis shad, twaite shad river lamprey and sea lamprey	International importance
Sea trout	National importance
Estuarine/marine & commercially important fish species	
Common sole	National importance
Herring	Regional importance
Sandeel	Local importance
Other demersal and pelagic species	Mixed regional and local importance
Commercial shellfish	Regional importance

Assessment of significance of effect on VERs

- 13.4.2.5 To consider and evaluate impacts, a two stage process will be adopted involving:
- i. Establishment of a magnitude value for impacts on VERs. This will be based on an understanding of their sensitivity, together with the temporal and spatial characterisation of the impact. A six-point scale will be used (Table 13.8); and
 - ii. Significance based on the area/value of receptor and magnitude of the impact. A “significance descriptor” will be derived from a matrix.

Table 13.8 Criteria used to classify the magnitude of impacts on fish and shellfish.

Potential consequence of impact on VER	Magnitude
The impact would have a serious, non-reversible effect over the integrity of the VER. Activities predicted to occur and affect the VER continuously over the long term or during sensitive life stages.	High
The integrity of the overall VER would not be affected but there may be some effect on the overall conservation objectives for that species within a given geographical area. There is the potential for activities to regularly disrupt the receptors, over the medium to short term and during sensitive life stages.	Medium
Species are subjected to a limited adverse effect. Disturbance to the population size is within parameters of natural variability. Activities are likely to be intermittent and irregular over the medium to short term.	Low
A small observable effect is predicted. Disturbance is expected to fall within natural variability. Impacts are limited to the area in the immediate vicinity of the development.	Negligible
Although it is not always possible to state categorically that there will be no impact on a receptor the term 'neutral' will be used where the level of exposure is considered to be less than the tolerance of the receptor, therefore an impact is unlikely. Or there will be no impact at all on the species in question.	Neutral
The change is likely to prove beneficial to the VER.	Positive

13.4.2.6 Separate value and magnitude tables will be used as appropriate for the different fisheries under consideration (see Tables 13.9 and 13.10).

13.4.3 Commercial fisheries assessment overview

13.4.3.1 Guidance on the commercial fisheries assessment will be taken from the National Policy Statement for Renewable Energy Infrastructure EN-3 and additional publications from DEFRA (2004). Possible impacts arising from renewable projects on commercial fisheries include the following:

- I. Complete loss of, or restricted access to, traditional fishing grounds during construction, operation and decommissioning;
- II. Safety issues for vessels;
- III. Interference with fishing activities;
- IV. Increased steaming times to fishing grounds;
- V. Obstacles or obstruction on the seabed as a result of the construction work; and
- VI. Any further concerns raised by local fishermen and fishing organisations.

Definition of commercial fisheries receptors

- 13.4.3.2 For commercial fisheries, the main ports where the principal receptors are expected to be will be identified along with any overseas fishing interests.
- 13.4.3.3 The following table (Table 13.9) identifies the criteria to determine the value of commercial fishery receptors within the area of the Project.

Table 13.9 Potential value of commercial fishing receptors in the Project study area.

Value of Receptor	Criteria Which Defines Value
Very High	Internationally valued fishing fleets contributing significantly to the EU economy
High	Nationally valued fishing fleets contributing significantly to the Welsh economy
Medium	Regional fishing fleet which contributes significantly to adjacent countries
Low	Small fishing fleet contributing at the local economy scale

Assessment of significance of effects on commercial fisheries receptors

- 13.4.3.4 To consider and evaluate impacts, a two stage process will be adopted involving:
- i. Establishment of a magnitude value for impacts on commercial fishing receptors. This will be based on an understanding of their sensitivity, together with the temporal and spatial characterisation of the impact. A six-point scale will be used (Table 13.10); and
 - ii. Significance based on the value of receptor and magnitude of the impact. A “significance descriptor” will be derived from a matrix of these.

Table 13.10 Criteria used to classify the magnitude of impacts on commercial fisheries.

Potential consequence of impact on VER	Magnitud
Commercial fishing activity on traditional fishing grounds will be severely affected by the Project and/or associated construction activities. Permanent (>3 years) interference to fishing grounds will occur.	High
Commercial fishing activity on traditional fishing grounds will be significantly affected by the Project and/or associated construction activities. Long-term (6 months to 3 years) interference to fishing grounds will occur.	Medium
Commercial fishing activity on traditional fishing grounds will be affected by the Project and/or associated construction activities. Medium-term (1 to 6 months) interference to fishing grounds will occur.	Low
Commercial fishing activity on traditional fishing grounds will remain largely unaffected the Project and/or associated construction activity. Intermittent and temporary interference to fishing grounds will occur.	Negligible
Although it is not always possible to state categorically that there will be no impact on a receptor the term neutral will be used where the level of exposure is considered to be analogous to natural variation.	Neutral
The change is likely to prove positive to the status of the fishery.	Positive

13.4.4 Recreational fisheries assessment overview

Definition of recreational fisheries receptors

13.4.4.1 The principal receptors for recreational fisheries will be identified.

13.4.4.2 The following table (13.11) identifies the criteria which will be adopted to determine the value of recreational fishery receptors within the geographic framework pertinent to the Project.

Table 13.11 Potential value of recreational fishing receptors in the Project study area

Value of Receptor	Criteria Which Defines Value
National/High	Nationally valued recreational fishery contributing significantly to the Welsh economy
Regional/Medium	Regionally valued recreational fishery contributing to the economy of several counties
Local/Low	Locally valued recreational fishery supporting the local economy

Assessment of significance of effects on recreational fisheries receptors

- 13.4.4.3 To consider and evaluate impacts, a two stage process will be adopted involving:
- i. Establishment of a magnitude value for impacts on commercial fishing receptors. This will be based on an understanding of their sensitivity, together with the temporal and spatial characterisation of the impact. A six-point scale will be used (13.12); and
 - ii. Significance based on the value of receptor and magnitude of the impact. A “significance descriptor” will be derived from a matrix.

Table 13.12 Criteria used to classify the magnitude of impacts on recreational fisheries

Potential consequence of impact on VER	Magnitud
Recreational fishing activity on traditional fishing grounds and adjacent watercourses will be severely affected by the Project and/or associated construction activities. Permanent (> 3 years) interference to fishing grounds will occur.	High
Recreational fishing activity on traditional fishing grounds and adjacent watercourses will be severely affected by the Project and/or associated construction activities. Long-term (> 6 months to 3 years) interference to fishing grounds will occur.	Medium
Recreational fishing activity on traditional fishing grounds and adjacent watercourses will be severely affected by the Project and/or associated construction activities. Permanent (> 1 to 6 months) interference to fishing grounds will occur.	Low
Recreational fishing activity on traditional fishing grounds and adjacent watercourses will remain largely unaffected the Project and/or associated construction activity. Intermittent and temporary interference to fishing grounds will occur.	Negligible
Although it is not always possible to state categorically that there will be no impact on a receptor the term neutral will be used where the level of exposure is considered to analogous to natural variation.	Neutral
The change is likely to prove positive to the status of the fishery.	Positive

13.4.5 Methods proposed to assess specific effects

Modelling and survey requirements from other EIA topics

- 13.4.5.1 Fish and fisheries assessments will be informed by data streams and modelling outputs from other topic areas within the EIA. Key interfaces are listed in Table 13.13.

Table 13.13 Modelling outputs to inform fisheries assessment

EIA Topic Area	Modelling/Survey Outputs Required	Application within Fisheries Assessment
Coastal Processes and /or Water Quality	High resolution hydrodynamic model within 5-10 km of turbine house, the turbine house (5-10 m) and with Q10 fluvial flow from all pertinent rivers. Low resolution wide field model 100-200 km from the scheme. Modelling over a full spring/neap tidal cycle. Identification of areas of sediment deposition or scouring. Identification of changes in flow conditions including freshwater exchange and discharge. (Chapter 8 Coastal Processes, Sediment Transport and Contamination)	Required as input to the fish IBM Turbine Encounter Model. Required for assessing habitat change. Required for assessing impacts to migratory cues and passage routes.
Noise Assessment	Estimates of underwater noise source levels from construction activities and turbine operation, and transmission loss values (Chapter 20 Marine Noise and Vibration)	To assess effects of underwater noise on fish.
Coastal Processes and / or Water Quality	Contour plots of estimated suspended solids levels increases relative to background levels for construction and operational conditions, and exceedance curves for naturally occurring suspended solids levels. Sediment modelling outputs for deposition/erosion. Modelling of phytoplankton blooms and their potential for effects on fish deoxygenation. (Chapters 8 Coastal Processes, Sediment Transport and Contamination and 9 Water Quality Processes)	To assess risk of increased suspended solids levels on fish spawning, survival and behaviour.
Benthic Ecology	Information on the intertidal habitats to be encompassed within the lagoon. Data on potential fish prey items and their habitat utilisation. (Chapter 12 Intertidal and Subtidal Benthic Ecology)	To aid in the assessment of the utilisation of areas to be encompassed by the lagoon and enable an assessment of impacts upon prey items.

IBM encounter modelling

- 13.4.5.2 Individual-based models (IBMs) of fish behaviour allow the movements of different fish species and lifestages within river or tidal water bodies to be modelled according to behaviour rules specific to the species and lifestage. For instance, the way that a returning adult salmon or sea trout reacts to cues in its immediate environment (e.g. water currents, chemical odours, depth contours) will differ from that for a salmon or sea trout smolt leaving the river to enter its marine life phase. The potential value of IBMs in predicting outcomes of various behaviours when confronted with the new environment of e.g. a tidal lagoon were first explored as part of the Severn SEA study (Willis & Teague, 2011). IBM models were further developed for assessing potential impacts on a wider variety of fish species and lifestages of the proposed Swansea Bay Tidal Lagoon (<http://www.tidallagoonswanseabay.com/environmental-impact-assessment.aspx>). For the proposed Cardiff scheme, as for Swansea, IBM modelling techniques will be used to assess the probabilities of key fish species/lifestages encountering the lagoon's turbines and sluices. This is a critical and essential input into the turbine injury modelling described below.
- 13.4.5.3 Fish species /lifestages to be modelled will include (as a minimum):
- i. Migratory species: Atlantic salmon, sea trout adults and smolts, European eel including elver and silver eel, twaite shad, river lamprey, sea lamprey.
 - ii. Marine/estuarine species: whiting, sprat, Dover sole, bass.
- 13.4.5.4 Additional species may be added subject to fish survey findings and stakeholder consultations.
- 13.4.5.5 The IBM models rely on good primary information on fish migration speeds, orientation cues, depth preferences, etc. This will be provided from literature review, case studies and fish telemetry (tracking) studies carried out in the Severn Estuary and Bristol Channel by TLP as discussed further below. As identified above, there are significant gaps in present knowledge of how fish utilise and migrate through the Estuary, their residence within different parts of the Estuary which will affect their likelihood of encountering the turbines one or more times. Outputs from the proposed fish surveys and tracking studies will be used to develop and refine fish behaviour rules within the IBM fish species/lifestage-specific models.

Migratory fish tracking

- 13.4.5.6 Predictions made within the Individual Based Models on the interaction of migratory fish with the Project will be calibrated by both active and passive acoustic telemetry. Tracking studies at the appropriate resolution will be used to inform and validate the basic rule sets used to populate the fish behavioural models. Outputs will include swimming speed, direction, track tortuosity, coastal habitat usage and behaviour associated with the tidal cycle. Hydrodynamic models will be used to decompose the vectors of movements and thus can isolate swimming behaviour. Active tracking will be undertaken from coastal vessels using

mobile real time direction finding, this will be supplemented by the deployment of fixed data logging receivers that may provide information such as spatial coverage. Definition of any tracking studies required will be progressed with statutory consultees, key stakeholders and manufacturers. Undertaking such studies safely in a high-energy estuarine environment will not be a simple matter and before a fish tracking plan is fully developed for the Severn Estuary, methods will be trialled in the more moderate tidal conditions of Swansea Bay during 2015. Initially these will concentrate on salmon and sea trout smolts and silver eel, with additional species in subsequent seasons.

Turbine fish injury modelling

- 13.4.5.7 Fish which enter or leave the lagoon with the flow of seawater may pass either through the lagoon's sluice gates or via the turbines themselves. As discussed previously turbines will be of a variable-speed, 'fish-friendly' design and most fish will pass through the turbines unharmed. A proportion may be injured by blade contact or pressure and turbulence effects. The STRIKER™ 4 turbine fish injury model will be used to predict fish injury rates from this cause. STRIKER™ 4 was developed specifically for tidal turbine applications and employs laboratory biological response data developed in earlier Severn tidal power investigations, brought up to date using data from the latest USA Department of Energy findings from the Advanced Hydro Turbine (AHT) project. New features will be added to STRIKER™ 4 to represent stochastic variation in key variables, modelled using Monte Carlo methods.
- 13.4.5.8 Fish species and lifestages modelled will be as for IBM modelling.
- 13.4.5.9 Once a turbine supplier has been selected, detailed data on turbine geometry, fluid dynamics and operating characteristics will be obtained and fed into the model.

Fish population modelling

- 13.4.5.10 Each of the impacts and their assessment techniques discussed above assess the point estimate effects upon the different fish species rather than population level effects. Robust assessments of potential impacts at the population level are proposed to assess the potential impacts on protected fish species in particular to assess impacts upon integrity of SAC designated waterbodies. It is therefore, intended that predictive modelling of the impacts on the relevant fish species stocks are undertaken. The presentation of impacts at population level offers greater confidence in the developments quantitative impacts, particularly when the outputs are probabilistic and set against the observed natural variation in the fish populations.
- 13.4.5.11 The proposed modelling will aim to quantitatively evaluate the potential impacts of the Project upon migratory fish populations through:
- i. Direct injury/mortality through turbine entrainment;
 - ii. Indirect mortality through;

- iii. Increased predation;
 - iv. Delay through physical barrier effects or false orientation cues; and
 - v. Fitness changes through altered feeding opportunities or changed prey species, that might alter growth rate and thus maturation timing and fertility.
- 13.4.5.12 The predicted quantitative impacts will be incorporated into age/stage matrix life cycle projection models for each target species that predict the future characteristics (e.g. abundance, trends, age composition, fitness indices), of the population as a whole once the simulations have reached a stable age distribution for a given set of scenarios. In this context 'population' refers to that of a whole river.
- 13.4.5.13 Fish species/lifestages and associated waterbodies to be modelled will include:
- I. Salmon and sea trout for the Rivers Severn, Usk, Wye and Taff/Ely. Less detailed assessments may also be possible for the River Rhymney, Parrett, Brue and Axe as required;
 - II. Shad for the Rivers Usk, Wye and Severn;
 - III. River and sea lamprey for the Rivers Usk and Wye; and
 - IV. Eels for the Rivers Severn, Usk, Wye and Parrett.
- 13.4.5.14 The models will rely on the availability and suitability of fish stock data and life history parameters for the species and rivers under consideration. Outputs will provide a prediction of the future trends and composition of the relevant fish populations with and without the lagoon scenario, with estimates of uncertainty.

13.5 References

- Cardiff Harbour Authority. (2012). Conservation strategy for Cardiff Bay. (http://www.cardiffharbour.com/content.asp?nav=3,43,93&parent_directory_id=1&id=92&d1p1=1).
- Claridge, P.N., Potter, I.C., & Hardisty, M.W. (1986). Seasonal changes in movements, abundance, size composition and diversity of the fish fauna of the Severn Estuary. *Journal of the Marine Biological Association of the United Kingdom*, **66**, 229-258.
- Elliott, M., Whitfield, A.K., Potter, I.C., Blaber, S.J., Cyrus, D.P., Nordlie, F.G., & Harrison, T.D. (2007). The guild approach to categorizing estuarine fish assemblages: a global review. *Fish and Fisheries*, **8**, 241-268.
- Environment Agency. (2013). Salmonid and Fisheries statistics for England and Wales. (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/383598/Report2013.v2.pdf).

Henderson, P.A. (2007). Discrete and continuous change in the fish community of the Bristol Channel in response to climate change. *Journal of the Marine Biological Association of the United Kingdom*, **87**, 589-598.

Henderson, P. A., & Bird, D. J. (2010). Fish and macro-crustacean communities and their dynamics in the Severn Estuary. *Marine Pollution Bulletin*, **61**, 100-114.

Maitland, P.S., and Lyle, A.A. (1990). Practical conservation of British fishes: current action on six declining species. *Journal of Fish Biology*, **37**, 255-256.

Potter, I.C., Claridge, P.N., Hyndes, G.A., & Clarke, K.R. (1997). Seasonal, annual and regional variations in ichthyofaunal composition in the inner Severn Estuary and inner Bristol Channel. *Journal of the Marine Biological Association of the United Kingdom*, **77**, 507-525.

Potter, I. C., Claridge, P.N. & Warwick, R.M. (1986). Consistency of seasonal changes in an estuarine fish assemblage. *Marine Ecology Progress Series*, **32**, 217-228.

Potts, G.W. and Swaby, S.E. (1993). Review of the status of estuarine fishes. English Nature Research Report No. 34, Marine Biological Association/English Nature, 278 pp.