

CARDIGAN TIDAL FLOOD RISK MANAGEMENT SCHEME

Appendix 6.2 – Fish Ecology Technical Note



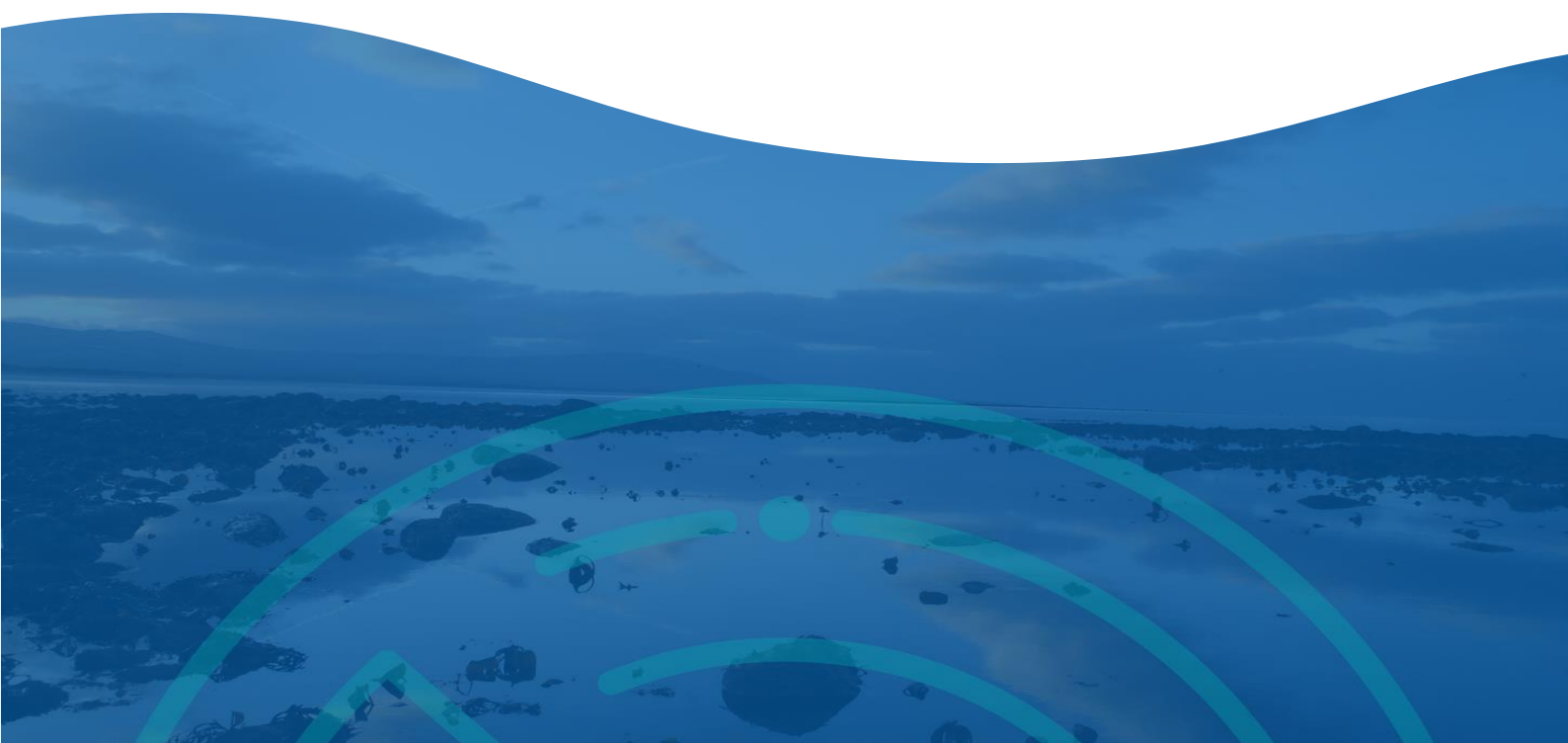
Cyfoeth Naturiol Cymru
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Binnies UK Ltd

Cardigan Tidal Flood Risk Management Scheme – Fish Ecology Technical Note



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1. Fish Ecology Technical Note

1.1 Introduction

Binnies UK limited has been commissioned by Natural Resources Wales (NRW) to undertake a Habitats Regulation Assessment (HRA) and Environmental Impact Assessment (EIA) in relation to a proposed tidal flood risk management scheme (FRMS) at Cardigan in the county of Ceredigion, south-west Wales. The Cardigan FRMS (herein referred to as the Scheme) is located towards the centre of the town of Cardigan along the north bank of the River Teifi (Afon Teifi). The Scheme is bound to the west by Castle Street and to the east by the A487 Pont Y Priordy.

The lower quayside areas of Cardigan are regularly inundated by the tide, which affects the Lower Strand and the Cattle Market areas. Low-lying residential and commercial properties are affected by a tidal return period of approximately 1:1 year annual event probability.

The extent of the Scheme is between Cardigan Bridge to the west and Gloster Row Car Park to the east, and covers land from the intertidal mudflats to the Strand. The distance between the existing river wall and the Strand varies between approximately 10 to 50m.

APEM have been commissioned by Binnies, to provide a Fish Ecology Technical Note to be provided as an Appendix to the Environmental Impact Assessment Report (EIAR) for the project. This technical note details the baseline environment, assessment of significance of effects, and where necessary, mitigation measures to avoid, reduce or minimise significant effects are proposed.

1.2 Policy, Legislation and Guidance

This technical note has been compiled with reference to the following legislation, conventions and policy:

- Infrastructure Planning (Environmental Impact Assessment (EIA)) Regulations 2017;
- Marine Coastal Access Act (MCAA) 2009;
- The Conservation of Habitats and Species Regulations 2017 (as amended);
- The Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019;
- The Marine Strategy Regulations 2010;
- The Ramsar Convention;
- Convention on the Conservation of Migratory Species (CMS) of Wild Animals (Bonn Convention) 1979;
- Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) 1979;
- Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) 1992;
- The Wildlife and Countryside Act (WCA) 1981 (as amended);
- The Water Environment (WFD) (England and Wales) regulations 2017;
- The Environment Act 2021;
- Salmon and Freshwater Fisheries Act (SAFFA) 1975 (as amended);
- The Eels (England and Wales) Regulations 2009;

- Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES) 1973;
- Invasive Alien Species (Enforcement and Permitting) Order 2019;
- Natural Environment and Rural Communities (NERC) Act 2006;
- The Merchant Shipping (Control and Management of Ships' Ballast Water and Sediments) Regulations 2022;
- International Convention for the Prevention of Pollution from Ships (MARPOL);
- Planning Policy Wales (Edition 11, 2021);
- NRW Area Statement; and
- The Ceredigion Local Development Plan.

The following guidance documents were used in this technical note:

- The International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN, 2025);
- Acoustical Society of America (ASA) Sound Exposure Guidelines for Fishes and Sea Turtles (Popper *et al.*, 2014); and
- The Chartered Institute of Ecology and Environmental Management (CIEEM) Guidelines for Ecological Impact Assessment in Britain and Ireland – Terrestrial, Freshwater, Coastal and Marine.

1.3 Methodology

1.3.1 Definition of study area

For this technical note, the study area comprises the area of the Afon Teifi including the Scheme, immediately adjacent to the Scheme and extending to within 5 km of the Scheme. This study area allows for the robust characterisation of mobile species, and is likely to encompass the Zone of Influences (ZoI) for both underwater noise and increases in suspended sediments.

1.3.2 Baseline information

The assessment of potential impacts of the Scheme on legally protected and notable species of fish has been informed by a desk-based review of existing ecological and environmental baseline data. No site-specific fish surveys were undertaken for this assessment. The main datasets used to characterise the fish community present within the study area are summarised in Table 1.

Table 1: Summary of desktop studies and datasets used to characterise the baseline environment.

Title	Source	Year	Author	Reference
National Biodiversity Network (NBN) Atlas ¹	NBN	2025	NBN	NBN, 2025
Celtic Sea Trout Project (CSTP)	CSTP	2016	CSTP	CSTP, 2016
Teifi Fish Survey Data	NRW	2007 – 2016 and 2021	NRW	NRW, 2021
NRW Freshwater Fish Surveys	Data Map Wales	2025	Natural Resources Wales	NRW, 2025

The National Biodiversity Network NBN Atlas includes verified and confirmed citizen science records and professional survey records of fish species throughout the study area. The Celtic Sea Trout Project (CSTP) includes survey data from a combination of electrofishing, angling, and netting based sampling primarily for sea trout and Atlantic salmon. The Teifi Fish Survey Data provides seasonal catch data of freshwater and estuarine fish within the Teifi Estuary around the Scheme and within the tributary rivers Cynllo and Mywldan upstream. NRW's freshwater fish survey data include species presence records from freshwater fish surveys conducted throughout Wales (including within the study area) by NRW and the former Environment Agency Wales, using a combination of electric fishing, netting and trapping.

1.3.3 Assessment methodology

Impacts are defined as changes arising from the Scheme, and the significance of effects by evaluating the sensitivity of the receptors and the magnitude of the impacts.

The criteria used to determine sensitivity, magnitude and significance of effect on fish receptors, have been informed by the CIEEM Guidelines for Ecological Impact Assessment in the United Kingdom and Ireland: Terrestrial, Freshwater, Coastal and Marine (CIEEM, 2022).

Sensitivity

Receptor sensitivity is defined as the degree to which a receptor is affected by an impact. The sensitivity of fish receptors has been characterised by three factors. All factors interact to determine a receptor's sensitivity to a given impact:

- Vulnerability – the vulnerability of the receptor relates to its capacity to accommodate change, i.e., the tolerance / intolerance of the receptor to change;
- Recoverability – the ability of the receptor to return to the baseline state before the Scheme impact caused the change; and

¹ Only records under the Creative Commons Attribution (CC-BY) license have been referred to and used. In line with the license conditions, records in the NBN Atlas under the Creative Commons Attribution Non-Commercial (CC-BY-NC) license have not been referred to or used.

- Importance – the importance of the receptor or feature is a measure of the value assigned to that receptor based on biodiversity and ecosystem services, social value, and economic value.

Considering the interaction between these factors (vulnerability, recoverability and importance), a receptor's sensitivity can be classified into the following four criteria:

- High – High vulnerability, very low recoverability and high importance;
- Medium - Moderate vulnerability, low recoverability and moderate importance;
- Low - Low vulnerability, moderate recoverability and low importance; and
- Very low - Very low vulnerability, high recoverability and very low importance.

Magnitude of Change

The potential magnitude of change on fish receptors arising from activities occurring as part of the Scheme is determined by the extent, duration, timing, frequency, and reversibility of their impact. Considering the interaction between these factors, an impacts magnitude can be classified into the following four criteria:

- High - The impact occurs over a large spatial extent resulting in widespread, long-term, or permanent changes in baseline conditions;
- Medium - The impact occurs over a medium spatial extent resulting in medium-term, or partial changes in baseline conditions;
- Low - The impact occurs over a small spatial extent resulting in short-term, or small changes in baseline conditions, or partially affects a small proportion of a receptor population; and
- Very Low - The impact occurs over a minor spatial extent resulting in very short-term, or minor changes in baseline conditions or partial affects to a very small proportion of a receptor population.

The assessment of the significance of effect on fish receptors has been determined by taking into account the sensitivity of the receptor and the magnitude of the impact. The method employed for this assessment is presented in Table 2. For the purposes of this assessment, any effects with a significance level of major or moderate have been deemed significant in EIA terms.

Table 2: Classification of significance.

Magnitude of Impact	Sensitivity of Receptor			
	High	Medium	Low	Very Low
High	Major	Major	Moderate	Minor
Medium	Major	Moderate	Minor	Negligible
Low	Moderate	Minor	Negligible	Negligible
Very Low	Minor	Negligible	Negligible	Negligible

1.4 Baseline environment and likely future evolution

The Scheme is located on the Afon Teifi, approximately 3 km upstream from the mouth of the river. Given the close locality to the marine environment, the areas adjacent to the Scheme are likely to experience variations in salinity levels. The width (wetted width) of the river at this location is approximately 50 to 100 m, likely varying based on tidal state and rainfall levels.

Fish communities, within estuarine environments, can broadly be categorised into the following functional groups (Elliott *et al.*, 2007):

- Diadromous species – Species which move between marine and freshwater environments at different stages of their life cycle;
- Marine species – Those typically found within marine environments, but may occur in estuarine environments in low numbers (marine stragglers) or high numbers during specific life stages (marine migrants);
- Estuarine species – Species well adapted to live their entire life cycle or large portions of within estuarine environments; and
- Freshwater species - Those typically found within freshwater environments, but may occur in estuarine environments in low numbers (freshwater migrants) or may be limited to the upper reaches of the estuary (freshwater stragglers).

Given the location of the Scheme, the fish assemblage is likely to be characterised by marine migrants (i.e. herring *Clupea harengus* and European seabass *Dicentrarchus labrax*), estuarine species (i.e. common goby *Pomatoschistus microps* and sand goby *Pomatoschistus minutus*) and diadromous species (i.e. Atlantic salmon *Salmo salar*).

1.4.1 Diadromous Fish

Diadromous fish species are those which move between the marine environment and freshwater at different stages of their life cycle, with anadromous species being those that migrate up rivers to spawn and catadromous being species which migrate down river to spawn in marine environments. The Afon Teifi is home to Atlantic salmon, brown trout *Salmo trutta* (including their anadromous form, sea trout) and European eel *Anguilla anguilla* (NBN, 2025; NRW, 2021), and lamprey of the genus *Lampetra* have been recorded in tributaries to the Afon Teifi (CSTP, 2025, NRW, 2025). With the exception of brown / sea trout, all of these migratory fish species are listed on Annex II of the EU Habitats Directive (Implemented into UK law via the Habitats Regulations) which makes provision for their protection through the designation of SACs, including the Afon Teifi SAC, in which the scheme is located within. There are no records of allis shad *Alosa alosa*, twaite shad *Alosa fallax* or European smelt (*Osmerus eperlanus*) within the study area (NBN, 2025; NRW, 2025; NRW, 2021) and therefore they have not been considered further.

Atlantic salmon

Atlantic salmon are anadromous, spawning in freshwater environments usually in November and December. They migrate to sea between 1 and 7 years old during the spring or early summer (CSTP, 2016), and they return back to the streams between June and November (Thorstad *et al.* 2016).

Atlantic salmon are protected by Appendix III of the Bern Convention and Annexes II and Annex V of the EU Habitats Directive (implemented into UK law via the Habitats Regulations). Salmon are also listed on Section 42 of the NERC Act 2006, The Salmon and Freshwater Fisheries Act 1975, the Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR) list of threatened species and as globally Near Threatened on the IUCN Red List of Threatened Species (IUCN, 2025).

NRW conducted monitoring between 2009 and 2016 and 2021 in the Teifi and identified 2 records of Atlantic salmon within the study area in 2007, approximately 1.5 km upstream of the Scheme (NRW, 2021). NRW and NBN Atlas contain records of Atlantic salmon in 2007, 2008, 2018 and 2024 in the Afon Teifi (1.5 km upstream) and Afon Piliau, a tributary to the Teifi, approximately 2 km upstream of the Scheme (NBN, 2025; NRW, 2025). The Afon Teifi is one of the most important Atlantic salmon rivers in Wales in terms of abundance and rod catches (CSTP, 2016).

Brown / Sea trout

Brown / sea trout are facultatively anadromous with some individuals or populations exhibiting anadromous behaviour (termed sea trout), while others spend their entire life history in freshwater environments (termed brown trout) (Aldvén and Davidsen, 2017). Sea trout migrate to sea between 1 and 5 years old during spring and early summer (Gargan *et al.* 2006; CSTP, 2016; Thorstad *et al.* 2016), with a large proportion of individuals remaining in close residence to the river mouth in shallow littoral environments (i.e. 68% within 4 km of river mouth (Eldoy *et al.*, 2015)).

The NRW Teifi Survey Data identified 6 records of brown / sea trout in 2007, 2010 and 2012 within the study area, approximately 1.5 km upstream of the Scheme and 3 km downstream, near the mouth of the river (NRW, 2021). NRW and NBN atlas contains records of brown / sea trout between 2003 and 2024 in the Afon Teifi (1.5 km upstream) and Afon Mwldan, a tributary to the Teifi downstream of the Scheme (NBN, 2025; NRW, 2025). Along with Atlantic salmon, the Afon Teifi is one of the most significant brown / sea trout rivers in Wales in terms of abundance and rod catches amongst other UK rivers (CSTP, 2016). Brown / sea trout are listed in Section 42 of the NERC Act and Protected under the Salmon and Freshwater Fisheries Act.

European eel

European eel spawn in the Sargasso Sea, arriving at the coast during the winter and early spring (as glass eels and elvers) and migrating upstream into freshwater in spring and early summer (Mann and Welton, 1995; Wright *et al.*, 2022). After spending a number of years in freshwater adult European eels (termed silver eels) begin their seaward migration between

late summer and early winter, migrating a distance of 5000 to 10,000 km to the Sargasso Sea to spawn (Lowe, 1952; Wright *et al.*, 2022).

Eels in the UK are protected by The Eels (England and Wales) Regulations (2009) and they are also included in Section 42 of the NERC Act 2006 and The Salmon and Freshwater Fisheries Act 1975. European eels are globally Critically Endangered on the IUCN Red List of Threatened Species and are also included in the OSPAR list of threatened species (IUCN, 2025).

Eels are widespread within study area. The NRW Teifi Survey Data identified 4 records of European eel across 2008 and 2014, within the Afon Mwldan, a tributary to the Teifi downstream of the Scheme within the study area, and also within the Afon Cynllo, a tributary around 18 km upstream to the east of the Scheme (NRW, 2021). NRW and NBN atlas has records of European eels within 2 km in Afon Teifi tributaries upstream and downstream of the Scheme from 2003 to 2024 (NBN, 2025; NRW, 2025).

Lamprey

Three species of lamprey occur within UK rivers; river lamprey (*Lampetra fluviatilis*), sea lamprey (*Petromyzon marinus*) and brook lamprey (*Lampetra planeri*). River and sea lamprey are anadromous, migrating upstream to spawn between October to December for river lamprey and April to May for sea lamprey (Maitland, 2003). Lamprey larvae spend 3 to 5 years in freshwater before migrating back down stream. For river lamprey this takes place between July and September, with adults usually being found in estuarine habitats. For sea lamprey downstream migration varies based on location with little being known about adult sea lampreys habitat requirements.

River lamprey are protected by annexes II and V of the Habitats Directive (implemented into UK law via the Habitats Regulations), Appendix III of the Bern Convention, Section 42 of the NERC Act 2006 and The Salmon and Freshwater Fisheries Act 1975. Brook lamprey, river lamprey and sea lamprey are designated features of the Afon Teifi SAC.

The NRW Teifi Survey Data identified records of lampreys (family Petromyzontidae) in 2008 and 2014, within the Afon Cynllo, a tributary around 18 km upstream to the east of the Scheme, however this was not recorded to genus or species level (NRW, 2021). NRW data indicates records of the lamprey genus *Lampetra* approximately 3 to 5 km upstream of the site in the Afon Teifi, and records in the Afon Piliaw, a tributary upstream and approximately 1.7 to 2 km from the Scheme (NRW, 2025). The NBN Atlas contains no records of lamprey within the study area.

Brook lamprey are an exclusively freshwater species, only undertaking limited migrations within freshwater environments. The transitional water body ends approximately 4 km upstream of the proposed works just north of Cilgerran which is where the tidal influence of the estuary ends. As such, brook lampreys are not considered to be present in the vicinity of the proposed works.

1.4.2 Marine and Estuarine Fish

Given the location of the Scheme, marine and estuarine species that are likely to occur are species adapted to living their entire life cycle or large parts of within low salinity environments (estuarine fish) and marine species utilising the area during specific life stages (i.e. as nursery or feeding grounds) (marine migrants).

The NRW Teifi Survey Data and NBN records include fish species such as brill (*Scophthalmus rhombus*), common sole (*Solea solea*), mackerel (*Scomber scombrus*) pollack (*Pollachius pollachius*), poor cod (*Trisopterus minutus*), pouting (*Trisopterus luscus*), red gurnard (*Chelidonichthys cuculus*), tub gurnard (*Chelidonichthys lucerna*), red mullet (*Mullus barbatus*), reticulated dragonet (*Callionymus reticulatus*), saithe (*Pollachius virens*), scad (*Trachurus trachurus*), turbot (*Scophthalmus maximus*), scaldfish (*Arnoglossus laterna*), solenette (*Buglossidium luteum*) and small-eyed ray (*Raja microocellata*). However, these species are more commonly associated with entirely marine environments and are therefore considered unlikely to be abundant adjacent to the Scheme. They have not been considered further.

Marine migrant species (those that occur in estuarine environments in high numbers during specific life stages) that are abundant within the study area include European seabass, Plaice *Pleuronectes platessa*, Atlantic herring, sand smelt *Atherina* sp., and sprat *Sprattus sprattus* (NRW, 2021). Estuarine species (those well adapted to estuarine environments that spend their entire or large portions of their lifecycles within estuarine environments) that are abundant within the study area include sand goby, common goby, thin-lipped grey mullet *Liza ramada*, thick-lipped grey mullet *Chelon labrosus*, golden grey mullet *Liza aurata* and flounder *Platichthys flesus* (NRW, 2021).

Whilst lesser sandeel *Ammodytes tobianus* and greater sandeel *Hyperoplus lanceolatus* are considered as occasional or rare occurrences within estuarine environments, both species were noted as abundant during surveys 1.5 km downstream of the Scheme (NRW, 2021). On a pre-cautionary basis, both species have been considered as likely to occur in close proximity to the Scheme on a pelagic basis (sandeels show pelagic behaviour when foraging and benthic behaviour when burrowed into sandy substrates overnight and over winter, benthic behaviour is likely to occur within entirely marine waters downstream from the Scheme).

Mullets

Thick-lipped grey mullet, thin-lipped grey mullet and golden grey mullet adults are found within marine, estuarine and/or freshwater environments, with sheltered harbours often being favoured (Barnes, 2008a; Henderson, 2015). Mullet generally migrate offshore to spawn, with juveniles returning to inshore, estuarine and/or freshwater environments (Pereira *et al.*, 2021; Ordeix and Casals, 2024; Froese and Pauly, 2025). All three species of mullet have been recorded in the Afon Teifi, approximately 1.5 km downstream of the Scheme (NBN, 2025; NRW, 2021).

European seabass

European seabass is a highly adaptable species known to inhabit a range of environments from open coastal waters to estuaries (Smith, 1990). Juvenile seabass are especially known to use shallow estuarine habitats as nursery grounds, where they may benefit from an abundance of prey and protection from predators (Pickett and Pawson, 1994). European seabass have been recorded in the Afon Teifi, within approximately 100 m of the Scheme (NBN, 2025; NRW, 2021).

Gobies

Gobies recorded within the study area include Common Goby *Pomatoschistus microps* (0.5 km downstream of the Scheme), Sand Goby *Pomatoschistus minutus* (0.5 km downstream), and Painted Goby *Pomatoschistus pictus* (1.5 km downstream) (NBN, 2025). Painted goby are only rarely found in estuarine environments (Barnes, 2008b; Froese and Pauly, 2025). Common goby and sand goby are both abundant and widespread across UK estuaries and brackish water environments, tolerating low salinities (Riley, 2003; 2007). Common and sand goby have no commercial value and are not of conservation importance. However, considering their abundance within the study area and their importance as prey items for a range of species, including larger fish species and birds, they have been considered further.

Pelagic fish

Pelagic fish recorded in the study area include Atlantic herring *Clupea harengus*, with numerous records between 2009 and 2021 (including records 0.5 km downstream of the Scheme), sprat, with numerous records between 2007 and 2021 (including records 1.5 km downstream), and lesser sand-eel and greater sandeel within 1.5 km of the Scheme, between 2007 and 2021 (NBN, 2025; NRW, 2021). Atlantic herring (listed on Section 42 of the NERC Act 2006), sprat, lesser sand-eel and greater sand-eel are important commercial and/or prey species within UK waters.

Flatfish

Flounder are widespread throughout the UK and are mostly considered an estuarine species, often migrating into estuaries and lower river reaches to feed and spawn (Henderson, 2015; Environment Agency, 2025). Flounder are known to utilise freshwater environments during early life stages (0 to 5 years old), during which time they undertake limited migratory movements, and can remain within such freshwater environments for several years before migrating downstream (Johnston, 1981; Beaumont and Mann, 1984; Bos, 2000; Le Pichon *et al.*, 2014). Flounder are of low commercial importance and are currently listed as Least Concern on the IUCN Red List (IUCN, 2025; Ford & Munroe, 2024). Flounder have been recorded in the study area less than 2 km upstream from the Scheme and less than 1 km downstream (NBN, 2025; NRW, 2025; NRW, 2021).

Plaice *Pleuronectes platessa* are listed on Section 42 of the NERC Act 2006 and are a highly commercially important species. They have a widespread distribution in UK waters with juveniles commonly utilising estuarine environment as nursery grounds (Henderson, 2015).

Plaice have been recorded in the Afon Teifi less than 1.5 km away from the Scheme (NBN, 2025; NRW, 2021).

1.4.3 Freshwater Fish

Native freshwater species known to occur in the study area (upstream of the Scheme) include three-spined sticklebacks *Gasterosteus aculeatus* and European minnow *Phoxinus phoxinus*. European minnows are more commonly associated with entirely freshwater environments, however, may occur in the upper reaches of the estuary (freshwater stragglers). Three-spined sticklebacks are commonly associated with freshwater environments, however, can occur in low numbers within estuarine environments (freshwater migrants), with some populations exhibiting anadromous behaviour. These species are not of conservation concern and/or are considered as occasional or rare occurrences within the estuarine environments adjacent to the Scheme. These species have therefore not been considered further.

Bullhead and spined loach are listed on Annex II of the EU Habitats Directive. There are records of bullhead in the Afon Teifi, approximately 1.5 km upstream of the Scheme in 2007 (NBN, 2025; NRW, 2025; NRW, 2021). Given that the scheme is situated in a transitional water body and that bullhead *Cottus gobio* are an entirely freshwater species, and that this species has not been recorded since 2007, it is likely that this species will not be present in the vicinity of the Scheme. There are no records of spined loach within the study area (NBN, 2025; NRW, 2025; NRW, 2021).

1.4.4 Designated sites

Designated sites within the study area with relevant fish features include:

- Afon Teifi Special Area of Conservation (SAC), designated for:
 - Brook lamprey;
 - River lamprey;
 - Sea lamprey (Present as a qualifying feature, but not primary reason for site selection);
 - Atlantic salmon; and
 - Bullhead.
- Cardigan Bay SAC
 - Sea lamprey (Present as a qualifying feature, but not primary reason for site selection); and
 - River lamprey (Present as a qualifying feature, but not primary reason for site selection).

1.4.5 Key Receptors

Table 3 identifies the receptors taken forward to the assessment within Section 1.5.

Table 3: Key receptors taken forward for assessment

Grouping	Receptor / Species	Justification
Diadromous Fish	Atlantic salmon	Likely to migrate through the study area. Globally Near Threatened on IUCN Red list. Listed on Annex II and V of the Habitats Directive. Protected by Appendix III of the Bern Convention. Listed in Section 42 of the NERC Act (Wales). Protected under the Salmon and Freshwater Fisheries Act.
	Brown / sea trout	Likely to migrate through the study area. Listed in Section 42 of the NERC Act (Wales). Protected under the Salmon and Freshwater Fisheries Act.
	European eel	Likely to migrate through study area. Protected by the Eels regulations. Listed in Section 42 of the NERC Act (Wales). Protected under The Salmon and Freshwater Fisheries Act.
	River lamprey	Likely to migrate through study area. Listed on Annex II and V of the Habitats Directive. Protected by Appendix III of the Bern Convention. Listed in Section 42 of the NERC Act (Wales). Protected under the Salmon and Freshwater Fisheries Act.
	Sea lamprey	Likely to migrate through study area. Listed on Annex II and V of the Habitats Directive. Protected by Appendix III of the Bern Convention. Listed in Section 42 of the NERC Act (Wales). Protected under the Salmon and Freshwater Fisheries Act.
Marine and Estuarine Fish	Thick-lipped grey mullet	Likely to inhabit study area.
	Thin-lipped grey mullet	Likely to inhabit study area.
	European seabass	Likely to inhabit study area. Species of commercial value within UK waters.
	Common Goby	Likely to inhabit study area. Important prey species.
	Sand Goby	Likely to inhabit study area. Important prey species.
	Atlantic herring	Likely to inhabit study area. Listed in Section 42 of the NERC Act (Wales). Species of commercial value within UK waters.
	Sprat	Likely to inhabit study area. Species of commercial value within UK waters.
	Lesser sand-eel	Likely to inhabit study area. Important prey species.
	Greater sand-eel	Likely to inhabit study area.

Grouping	Receptor / Species	Justification
		Important prey species.
	Flounder	Likely to inhabit study area. Species of commercial value within UK waters.
	Plaice	Likely to inhabit study area. Listed in Section 42 of the NERC Act (Wales). Species of commercial value within UK waters.

1.5 Assessment of effects

The impact of the construction and installation of the flood defence structures for the Scheme will directly affect receptors in and around the Scheme.

The sensitivity of the receptors identified in Section 1.5 have been assessed based on the following impacts:

- Underwater noise and vibration generated during construction activities;
- Changes in suspended solids (water clarity) during construction;
- Habitat loss;
- Water flow (tidal current) changes; and
- Pollution and accidental spills.

The Scheme will not result in physical barriers to migratory pathways, however barriers to migration as a result of underwater noise effects has been considered within the assessment of underwater noise and vibration generated during construction activities.

1.5.1 Underwater noise and vibration generated during construction activities

Vibropiling and augering works associated with the construction of the flood defence have the potential to generate and propagate underwater noise (as sound pressure motion) and vibration (as particle motion). Underwater noise and vibration can cause several effects on fish species including:

- Behavioural effects (e.g. reduced detection of predators/prey, inhibited communication between conspecifics, alteration in swimming behaviour);
- Masking effects (i.e. the reduced detectability of a given sound owing to the simultaneous occurrence of another sound);
- Temporary Threshold Shift (TTS) in hearing (short or long-term changes in hearing sensitivity that may or may not reduce fitness);
- Recoverable tissue injury (not resulting in mortality e.g. minor internal or external hematoma); and
- Mortality or potential mortal injury (immediate or delayed death).

The most recent and relevant guidelines for the purposes of the assessment of the impacts of underwater noise associated on fish are the Acoustical Society of America (ASA) Sound Exposure Guidelines for Fishes and Sea Turtles (Popper *et al.*, 2014). These guidelines provide

directions and recommendations for setting criteria (including injury and behavioural criteria) for fish.

The Popper *et al.* (2014) guidelines broadly group fish into the following categories based on their anatomy and the available information on hearing of other fish species with comparable anatomies:

- Group 1: Fish lacking swim bladders that are sensitive only to sound particle motion and show sensitivity to a narrow band of frequencies (e.g. lampreys, gobies);
- Group 2: Fish with a swim bladder where the organ does not appear to play a role in hearing. These fish are sensitive only to particle motion and show sensitivity to a narrow band of frequencies (e.g. Atlantic salmon); and
- Group 3: Fish that have special structures mechanically linking the swim bladder to the ear. These fishes are sensitive primarily to sound pressure, although they also detect particle motion (e.g. European eel). These species have a wider frequency range, and generally show higher sensitivity to sound pressure than fishes in Groups 1 and 2.

Species scoped into this assessment are categorised into the following hearing groups outlined in Table 4 below.

Table 4: Hearing abilities of fish species scoped into this assessment².

Hearing group	Receptor / Species
Group 1 (no swim bladder)	River lamprey, sea lamprey, flounder, plaice, common goby, sand goby, lesser sand-eel, greater sand-eel
Group 2 (swim bladder is not involved with hearing)	Atlantic salmon, brown/sea trout, thick-lipped grey mullet, thin-lipped grey mullet, golden grey mullet
Group 3 (swim bladder involved with hearing)	European eel, Atlantic herring, European seabass, sprat

Popper *et al.* (2014) sets out criteria for effects arising from different sources of noise. The criteria used within this assessment are associated with continuous noise (i.e. vibro-pilling and augering). Where insufficient data exists to determine a quantitative value, Popper *et al.* (2014) categorised in relative terms as high, moderate or low risk at three distances from the source: near (i.e. in the tens of metres), intermediate (i.e. in the hundreds of metres) or far (i.e. in the thousands of metres) (Table 5).

² Sources used to inform the categorization of the fish species: Chapman and Sand (1974), Hawkins and Johnstone (1978), Maklad *et al.* (2014), Sirri *et al.* (2016), Ladich and Schulz-Mirbach (2016) and Gugele *et al.* (2021).

Table 5: Risk of effects arising from noise exposure to categorised fish groups (Popper *et al.*, 2014).

Hearing group	Mortality and potential mortal injury	Recoverable injury	TTS	Masking	Behavioral
Group 1	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Group 2	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Group 3	(N) Low (I) Low (F) Low	170 dBrms 1µPa for 48hrs	158 dBrms 1µPa for 12hrs	(N) High (I) High (F) High	(N) High (I) Moderate (F) Low
Peak and rms sound pressure levels dB re 1 µPa; SEL dB re 1 µPa²-s. All criteria are presented as sound pressure even for fish without swim bladders since no data for particle motion exist.					

Those fish with an absence of a swim bladder (Group 1) or that have a swim bladder which is not involved in hearing (Group 2), are understood to be insensitive to sound pressure and are most likely to detect particle motion. Group 3 fish (those fish with a swim bladder that is involved in hearing) are understood to be able to detect both particle motion and sound pressure, and are more sensitive to sound than Group 1 and 2 fish species.

Most Group 1, 2 and 3 fish species are expected to be able to avoid noise sources before mortality and potential mortal injuries could occur. However, there might be some temporary physiological effects and behavioural responses. In relation to underwater noise produced during vibro-piling and auguring, Popper *et al.* (2014) indicates that there is a low risk of mortality and potential mortal injuries and recoverable injuries within the near (tens of metres), intermediate (hundred of metres) and far (thousands of metres) fields for Groups 1, 2 and 3. For behavioural effects there is a moderate risk in the near and intermediate fields, and low risk in the far fields for Group 1 and 2, and a high risk in near fields, moderate risk in intermediate fields and low risk in the far fields for Group 3.

Atlantic salmon, sea trout, European eels, river lampreys and sea lampreys are likely to migrate passed the Scheme and therefore underwater noise may impede upon or delay their migration. The piling and auguring works are scheduled to have a duration of approximately 2 months, however the time at which these activities will take place is currently unknown and therefore it is assumed, for the purposes of this assessment, that there will be temporal overlap with key migratory periods for these species. They have been deemed to be of medium vulnerability (can avoid injurious effects but migration may be delayed), high recoverability (migration may resume upon cessation of activities) and are of high to moderate importance. They have been assessed as high sensitivity. The piling and auguring works are scheduled to have a duration of approximately 2 months and are anticipated to be restricted to within the Afon Taifi. The magnitude has therefore been considered as low,

which for Atlantic salmon, sea trout, European eels, river lampreys and sea lampreys results in a moderate effect, which is considered to be significant.

All other Group 1, 2 and 3 fish receptors are expected to be able to avoid the impact before potential mortal injuries could occur, occupy nearby suitable habitats of the estuary or adjacent coastal waters and return upon cessation of the activities. They have been deemed to be of low vulnerability (reasonable capacity to avoid), high recoverability (return upon cessation of activities) and are of very low to moderate importance. They have been assessed as low sensitivity, which results in a negligible effect, which is considered to be not significant.

Proposed Mitigation

In water augering and piling should not be undertaken between March and November inclusive. Augering and piling are permitted between March and November only during periods when the tidal level is below the level of the piling works area. Between December and February, when these seasonal restrictions would not apply, in water activities can be undertaken during the daytime only.

In addition to the seasonal in water restrictions above, it is recommended that soft starts are used for piling activities. This involves the gradual and incremental increase in piling power until full operational power is reached and provides fish the opportunity to move away from the noise source before the onset of full power.

Residual Effects

The mitigation measures above for in water augering and piling, avoid the main migratory periods for Atlantic salmon, river lamprey (downstream migration), sea lamprey (upstream migration), European eel (upstream migration) and sea trout.

The European eel downstream migration occurs in late summer to early winter (April to December), the river lamprey upstream migration occurs between October and December and the sea lamprey downstream migration occurs between October and June, partially overlapping with the December to February period whereby in water activities may occur. However, such activities will be undertaken in day light hours, and the migration of European eel, river lamprey and sea lamprey occurs primarily at nighttime.

Considering the mitigation measures, the sensitivity of Atlantic salmon, sea trout, European eels, river lampreys and sea lampreys has been assessed as medium. Which results in a minor effect, which is considered to be not significant.

1.5.2 Changes in suspended solids (water clarity) during construction

Diadromous and estuarine fish species are expected to show a high level of tolerance to increased levels of suspended sediments, given their migratory routes, or the habitats in which they occupy, are areas with naturally high levels of suspended sediments which may vary across small temporal scales (i.e. tidal cycles, seasons). For example, the Severn Estuary, which is home to a range of diadromous and estuarine species, can regularly be exposed to suspended sediment concentrations of > 1000 mg/l (Bull, 1997), with concentrations varying by five-fold over a one-day period (Rijnsdorp and Stralen, 1985).

It is predicted that activities associated with the Scheme will produce temporary and short-lived increases in suspended sediment concentrations which would be quickly moved downstream and diluted by the river flow and tidal cycles. Suspended sediment concentration levels are not anticipated to exceed those naturally experienced in estuarine and riverine environments and any associated sediment deposition is anticipated to be minimal.

The sensitivity of all fish receptors is deemed to be low with the magnitude being deemed low, which results in a negligible effect, which is considered to be not significant.

1.5.3 Habitat loss

There will be permanent loss of intertidal habitat within the study area due to the works. The installation of sheet piling and construction of the sea defence wall and associated berm will result in the permanent loss of approximately 489 m² of intertidal mud habitat.

All of the receptors identified are highly mobile and none of the receptors are constrained to specific habitat types or areas. They are therefore likely to be able to use other areas of available habitat, either further upstream or downstream, for foraging and spawning.

The sensitivity of all fish receptors is deemed to be low with the magnitude being deemed very low (habitat loss will be localised and low in extent), which results in a negligible effect, which is considered to be not significant.

1.5.4 Water flow (tidal current) changes

The installation of the flood defence scheme will reduce the cross-sectional area of the river in the scheme area. This has the potential to increase water velocities in the area of the scheme. Hydraulic modelling of the proposed scheme has been undertaken to investigate the effect of the reduction in cross sectional area on water velocities (Binnies, 2023). The modelling concluded that the scheme would have negligible impact on local water velocities, and therefore the magnitude has been assessed as very low. Considering the negligible impact indicated by the hydraulic monitoring, changes in flow rate are not anticipated to cause significant effects upon fish receptors. Therefore, the sensitivity of all receptors is deemed to be low, which results in a negligible effect, which is considered to be not significant.

1.5.5 Pollution and accidental spills

The proposed works will involve the use of an excavator or piling rig within the intertidal zone. To reduce the risk of pollution, industry best practice will be followed in accordance with GPP5: Works and Maintenance in or Near Water, and a Pollution Prevention Plan will be established prior to commencement. Measures will be implemented to prevent accidental spills, including the use of biodegradable hydraulic oil where feasible and prohibiting refuelling activities at the work site.

Concrete pouring presents a potential pollution risk due to the leaching of uncured material and accidental discharge. To mitigate this, pours will be timed to coincide with low tide conditions, minimising direct contact with water during the curing process. Marine-grade concrete will be used to promote rapid curing, improve structural durability, and reduce the likelihood of washout and leaching.

The impact is predicted to occur over a small spatial extent and short-term duration (any pollutant will be quickly dispersed or contained). Additionally, with the implementation of the embedded measures mentioned above the impact has a very low likelihood of occurring. The magnitude has therefore been assessed as low.

All fish receptors are mobile and consequently have the ability to avoid polluted areas. These receptors are deemed to have a low vulnerability (reasonable capacity to avoid, adapt or tolerate the impact), a high to moderate recoverability and are of very low to moderate importance. They have been assessed as low sensitivity, which results in a negligible effect, which is considered to be not significant.

1.6 Summary of assessment

The significance of effects on the identified receptors to the impacts assessed are summarised below in Table 6.

Table 6: Significance of effects of the impacts assessed on the identified receptors.

Impact	Factored-in measures	Sensitivity of receptors	Magnitude of impact	Significance of effect	Additional mitigation	Residual effect
Underwater noise and vibration generated during construction activities	None	Low - high	Low	Negligible (not significant) – Moderate (significant)	In-water augering and piling not to be undertaken between March and November. Between December and February, when these seasonal restrictions would not apply, in water activities can be undertaken during the daytime only.	Negligible (not significant) – Minor (not significant)
Changes in suspended solids (water clarity) during construction	None	Low	Low	Negligible (not significant)	None	Negligible (not significant)
Habitat loss	None	Low	Very low	Negligible (not significant)	None	Negligible (not significant)
Water flow (tidal current) changes	None	Low	Very low	Negligible (not significant)	None	Negligible (not significant)

Impact	Factored-in measures	Sensitivity of receptors	Magnitude of impact	Significance of effect	Additional mitigation	Residual effect
Pollution and accidental spills	Industry best practice will be followed in accordance with GPP5: Works and Maintenance in or Near Water. Pollution Prevention Plan will be established prior to commencement. Use of biodegradable hydraulic oil where feasible and prohibiting refuelling activities at the work site. Concrete pours will be timed to coincide with low tide conditions. Marine-grade concrete will be used.	Low	Low	Negligible (not significant)	None	Negligible (not significant)

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