Home Office

NON-TECHNICAL SUMMARY

Tracking Twaite shad to evaluate seasonal distribution in Bristol channel Marine Protected Areas

Project duration

5 years 0 months

Project purpose

- (a) Basic research
- (d) Protection of the natural environment in the interests of the health or welfare of man or animals
- (e) Research aimed at preserving the species of animal subjected to regulated procedures as part of the programme of work

Key words

Twaite shad, Marine Protected Area, Acoustic tags, Marine distribution, Survival and deterrence

Animal types	Life stages
Other fish species	Juvenile, Adult

Retrospective assessment

> The Secretary of State has determined that a retrospective assessment of this licence is not required.

Objectives and benefits

Description of the projects objectives, for example the scientific unknowns or clinical or scientific needs it's addressing.

What's the aim of this project?

To compare the marine seasonal distribution, freshwater and marine survival rates of twaite shad (*Alosa fallax*) spawning in multiple rivers draining into the Bristol Channel, in order to extend basic scientific knowledge and inform management and regulatory decision making. To develop a cost effective acoustic fish deterrent to protect the species from future developments.

Potential benefits likely to derive from the project, for example how science might be advanced or how humans, animals or the environment might benefit - these could be short-term benefits within the duration of the project or long-term benefits that accrue after the project has finished.

Why is it important to undertake this work?

Fish which migrate into freshwater to spawn, such as Twaite shad may have to migrate past coastal and in-river developments to complete their life cycle. Developments such as weirs, barrages, tidal lagoons or major abstractions have the potential to impact on survival of both juvenile and adult stages.

This is particularly important for species such as shad (*Alosa fallax*), which spawn multiple times and may therefore be subject to cumulative impacts. The lack of data on marine migration and distribution, and hence potential impact, has impaired the ability of developers to assess impacts and propose suitable mitigation, compromising marine licence applications and potentially putting the fish populations at risk. The abstraction being built for Hinkley point C, and proposed tidal lagoons in Swansea Bay and elsewhere in the Bristol Channel are major developments where this work has significant current application.

This project will tag and track up to 600 Twaite shad from the Rivers Tywi and Wye, and compare the results with existing movement and survival data from fish tagged in the River Severn. The tags regularly emit a coded acoustic pulse which can be detected and decoded by fixed passive receivers, enabling individual movements to be followed. Adult fish will be tagged in freshwater, and their migration to sea followed, to develop quantitative survival, migration and availability data for a specific coastal location.

We also aim to develop a cost effective acoustic fish deterrent to deter twaite shad from entering marine structures such as abstractions or turbines. The first step will be to test threshold responses to a range of frequencies, for both adults and juveniles, in order to inform design of a field unit. This will involve laboratory trials of response to sound with up to 150 fish.

What outputs do you think you will see at the end of this project?

1. Quantitative data from strategic development areas such as Bridgwater Bay (Hinkley Point C abstraction) and Swansea bay (Tidal Lagoon)

2. Quantitative data on distribution and residence times of twaite shad in the Carmarthen Bay Marine Protected Area.

3. Qualitative data on coastal distribution and migration paths in the wider Bristol Channel area.

4. Comparison of river and sea survival rates for 4 rivers (includes the Severn and Usk where tagging is undertaken by other partners).

5. Comparison of similarities and differences in migration patterns with twaite shad tagged in the River Severn.

6. A behavioral audiogram of frequency/threshold responses to inform design of an acoustic fish deterrent

7. Detailed behavioural data in the immediate vicinity of a major marine abstraction; direct estimates of population level risk

Who or what will benefit from these outputs, and how?

Policy

Support for Marine Renewable development is an important element of Welsh Government policy. However lack of data on key marine species, particularly anadromous fish, is recognised as a strategic information gap for Marine Renewable energy and other developments such as major abstractions for power generation, by both regulators and industry (see for example ref 1 below.).

Tagging and tracking

Developers and regulators will be provided with valuable data as the study progresses. Information specific to the area will benefit local regulation (Natural Resources Wales) and inform evaluation of current and future development proposals as well as aiding understanding of the effectiveness of the MPA. The information will therefore provide both short and long term value. Results describing migration and behaviour patterns in inshore areas will have wider utility and will benefit assessments by other UK regulators (Environment agency, Marine Management Organisation, Natural England and Marine Scotland). The value regulators place on this data is reflected in significant financial commitments (tag and receiver purchase) to help support the work.

Local angling associations are keen that evidence is developed to ensure that both the fish population and fishery are protected through the regulatory process for marine developments. They will be directly involved in providing practical assistance with our fieldwork, including fish capture.

Industry partners are commissioning development and trials of battery powered high frequency systems based on previous work undertaken in this project. The behavioural data we collect around the intakes will be critical to their consenting process at Hinkley Point and will have much wider value.

Sound trials

A cost effective Acoustic Fish Deterrent for twaite shad is likely to be a critical mitigation requirement for future MRE (tidal range and tidal stream) developments and major abstractions in the Bristol Channel and Celtic Sea areas. This will benefit the fish populations themselves and support government policies in respect of green energy.

Reporting

A final project report will be published and made publicly available. The more important results will be published in peer reviewed journals. We would also expect to provide information regularly during the course of the project to the wider scientific community through conference papers and publications.

1. Marine Energy Wales. Tidal range: Critical Evidence gaps and how to address them. Workshop report, March 2022. http://www.orjip.org.uk/sites/default/files/u53/ORJIP%20OE%20MEW%20Tidal%20Range%20Workshop%202022%20V1.pdf

How will you look to maximise the outputs of this work?

We expect to produce reports, conference papers and peer reviewed publication.

We are already working closely and collaborating with regulators (Natural Resources Wales, Natural England, Environment Agency, and the Devon and Severn IFCA), to ensure results are incorporated into policy, fishery management decisions and regulatorydecisions, as well as industry partners and local conservation and angling interests.

Species and numbers of animals expected to be used

- Other fish species: Up to 600 fish.

Predicted harms

Typical procedures done to animals, for example injections or surgical procedures, including duration of the experiment and number of procedures.

Explain why you are using these types of animals and your choice of life stages.

Tracking

Twaite shad (Alosa fallax) are a highly protected anadromous species which are found in four UK rivers, all draining into the Bristol Channel. They normally spawn a number of times. They are highly protected, being primary species features of Special Areas of Conservation (SAC) in the Rivers Usk, Wye and Tywi, and primary species features of the Severn, Carmarthen Bay and Pembrokeshire Marine Protected Areas (MPA). Consequently they are particularly important for regulation of marine developments, including the cooling water abstraction for Hinkley Point C, Marine Renewable Energy

(MRE) developments (tidal range, tidal stream and offshore wind), as well as management of the impact of activities such as gravel abstraction and fishing.

We have previously undertaken marine tracking of twaite shad tagged in the river Severn under a separate Home Office licence. This has been a highly successful project and has enabled a good picture of marine migrations of shad spawning in the Severn to be developed. Early data from the work have already been used in a public inquiry looking at proposed modifications to the Hinkley point C (HPC) abstraction, and were referenced in the inspectors conclusions. More recent data have emphasised the potential risks posed by the HPC abstraction, and work already completed in 2023 under our own licence has demonstrated that those risks extend to the Tywi and Wye.

We do not yet know if Twaite shad spawning in the other rivers follow similar migration paths to those spawning in the Severn. This project aims to track fish from the Rivers' Tywi, Usk and Wye, in order to compare movements with the extensive Severn dataset to help understand the extent to which conclusions from Severn data may be transferable.

Sound trials

Additionally, the data that we have already collected demonstrates that adult twaite shad forage widely in the Bristol channel area and would be expected to be exposed to risk from tidal range and tidal turbine developments. They are highly protected and mitigation is likely to be required for future development applications to reduce the likelihood of them being drawn into turbine structures or abstractions. Given conditions (poor visibility, high tidal range etc) in the Bristol Channel and Celtic sea areas, acoustic deterrence is the most likely mitigation technique available. Acoustic Fish Deterrent (AFD) systems are already used to deter fish from entering intakes and these normally operate at low frequencies (<2kHz). While twaite shad may respond to a standard AFD twaite shad have unusual hearing when compared with most other fish species, hearing sound at up to 200kHz. As a result new deterrence systems operating at higher frequencies potentially offer higher protection levels and a more cost effective solution where they are the primary species needing protection. We therefore aim to run trials to establish response thresholds at different frequencies to understand deterrence requirements and optimal operating frequencies. Fish captured by rod and line will be temporarily transferred to licenced holding facilities and tank trials will be run for up to 15 different frequencies. In each trial a batch of 5-10 fish will be exposed to sound pulses of increasing amplitudes to establish hearing thresholds at each frequency. Individual trials will stop once a response to sound is observed to avoid damaging the hearing of the fish.

Typically, what will be done to an animal used in your project?

Acoustic tagging

Fish will be captured using rod and line. For fish which are being tagged and released, they will be anaesthetised and tagged with an acoustic tag through an incision approximately 1cm long (or less). The incision will be closed with a dissolvable suture and covered with a suitable covering to initially prevent the wound from infection during initial healing. Analgesia will be applied as appropriate.

After tagging adult fish will be held facing into the water stream until they are able to hold position and actively swim upstream. They will then be released to continue normal lives.

Sound experiments; establishing threshold responses

Adult fish used in sound experiments will be captured by rod and line, transferred to a licenced facility and held in 5m tanks in a recirculation system. Juvenile fish will be captured from the wild using seine nets. They will be allowed to recover for at least 48 hours after transfer before experimentation begins. Any fish showing signs of distress after that period will be excluded from experiments.

Experiments will aim to establish threshold response levels for each frequency tested by increasing sound levels until a group response is observed. Sound exposure will be achieved using purpose built equipment provided by our industry partners, with demountable professionally calibrated transducers.

Trials will be run with circulating water to encourage shoaling behaviour. We expect response to take the form of a 'scatter response' with shoaling breaking down. Initially a small number of trials will be run establish the best equipment set up, optimum numbers of fish per trial and length of stimulus pulses. These initial trials will also establish the nature of responses and identify objective response criteria to be used in subsequent trials.

Adult and juvenile fish will be tested in groups of 5-10 fish at each of up to 15 different frequencies, monitored by overhead video, with three replicate groups tested at each frequency. In each trial, stimulus will take the form of short sound bursts (exact length established in initial trials; indicatively 2-20 seconds). Trials will start at low amplitude, which will then be increased until a response is observed. At that point the trial will end to avoid extended stress and to avoid the risk of damaging the hearing of the fish. Fish will be allowed to recover between trials. Individual groups of fish will be exposed to a MAXIMUM of 10 trials per group, with a rest period of at least 3 hours between trials.

Once testing is complete all wild caught fish will be returned to the wild.

What are the expected impacts and/or adverse effects for the animals during your project?

Acoustic tagging

Experience has shown that fish rapidly recover from anaesthesia and surgery and are not expected to suffer any lasting long term harm as a result of the procedures under this protocol being carried out.

The procedures carried out in these protocols will be done under general anaesthetic and therefore fish will be subjected to no more than mild stress as a result of capture and handling. There may be some mild post-operative discomfort, but experience of staff carrying out the work will ensure that fish are only released when they are recovered and able to swim upstream against the flow.

A literature review has suggested there is a small risk that the fish could hear the tag. They are thought to be capable of hearing at 69kHz (the tag frequency), but the literature evidence suggests that the hearing threshold for these species is above the tag output. The same tags have been used extensively since 2018 with the same species in the River Severn (320 tagged), in our own studies in 2023, and in studies in the Netherlands and Ireland without any obvious problems or unusual behaviour. Recent tank trials with 69khz and 180khz tags undertaken by NRW in 2023 have not shown a scientifically clear response and our own trials in 2024 showed threshold responses at sound levels (160-165 db) exceeding tag output (146db). We therefore believe that any risks are low, and outweighed by the project benefits.

Sound experiments; establishing threshold responses

For fish used in sound experiments there will be some stress associated with capture and handling, as well as transient alarm during sound experiments. However our approach aims to minimise unnecessary sound exposure by terminating experiments once a response is seen. All wild caught fish will be returned to the capture location or released at a suitable downstream location, agreed by NRW.

Expected severity categories and the proportion of animals in each category, per species.

What are the expected severities and the proportion of animals in each category (per animal type)?

We expect the severity to be moderate for all fish tagged. The tagging approach is intended to minimise discomfort or damage to the fish.

For sound experiments, the expected response will be an alarm response, similar to that when the fish hears or sees a predator. While that may involve some stress, it is likely to be similar to a natural process, for example a stone falling into the water nearby. Our approach aims to minimise unnecessary sound exposure by terminating experiments once a response is seen, to avoid any damage to hearing. All wild caught fish will be returned to the capture location. We expect that experimental effects will be transient and mild.

What will happen to animals used in this project?

- Set free

Replacement

State what non-animal alternatives are available in this field, which alternatives you have considered and why they cannot be used for this purpose.

Why do you need to use animals to achieve the aim of your project?

Tagging

The project aims are to look at the behaviour and distribution of twaite shad (*Alosa fallax*) in the wild in order to gain information to manage and protect the species in the context of specific development areas. There are no practical alternatives to generate this data.

Acoustic responses

Understanding threshold levels and the most effective frequencies is important to design an effective deterrence system to protect the species. There is some existing very limited data from sound trials of twaite shad, but no clear systematic dataset to define the most effective response thresholds. We cannot find any realistic alternative which would provide confidence.

Which non-animal alternatives did you consider for use in this project?

Theoretical modelling has already been utilised to look at potential distribution and movements in relation to developments in the Bristol channel. This work has identified the species most at risk from developments, which include twaite shad. However all such work has to be grounded in empirical data to validate assumptions and parameterisation of models.

For studies of the response to sound we have looked at literature evidence but have been unable to identify sufficient data as per our previous response.

Why were they not suitable?

Work with fish tagged on the Severn has helped to inform the validation of modelling and predictions. However without these comparative studies we do not know whether these assumptions can be applied to fish spawning in other catchments.

Reduction

Explain how the numbers of animals for this project were determined. Describe steps that have been taken to reduce animal numbers, and principles used to design studies. Describe practices that are used throughout the project to minimise numbers consistent with scientific objectives, if any. These may include e.g. pilot studies, computer modelling, sharing of tissue and reuse.

How have you estimated the numbers of animals you will use?

Tagging

We need to use sufficient fish to provide robust estimates of survival and marine distribution to inform models which can then be used to predict impacts. We have drawn on survival and movement data from our collaboration with researchers tagging fish on the Severn to inform our sample sizes, together with initial work undertaken during 2023 and 2024 in this project. We have tagged 205 twaite shad under this licence over the two years to date, with high sea return rates (Ca. 90%) following tagging and spawning, and high detection rates at sea. Data collected in 2023 and 2024 show that detection rates from the Severn, Wye and Tywi at Hinkley Point C are high, ca. 20% of Tywi emigrants and more than 50% of emigrants from each of the Wye, Usk (tagged by NRW) and Severn (tagged by Hull and Bournemouth Universities). The abstraction rate at HPC is 132 cumecs (greater than the average flow of the Thames), and these four rivers contain the only UK spawning populations of twaite shad. There is therefore considerable *potential* risk to all 4 populations.

In 2025 we are looking to undertake fine scale tracking to look at detailed behaviour around the abstraction for Hinkley Point C, better understand the *actual* risk by looking in detail at presence and behaviour in the immediate area around the abstractions, and understand the likely effectiveness of deterrence measures which EDF are putting in place.

Although the proportion of fish detected in the wider area around the abstraction is high, the area of interest in the immediate vicinity of the abstraction intakes is relatively small. We have used our data from 2023 and 2024 to estimate the number of fish we need to tag to ensure sufficient detections to meet the project aims, and we consider that tagging up to 150 fish from each river is sufficient to obtain robust results in 2025. [NB : These numbers will be supplemented by tagging undertaken by other partners on the Rivers Usk and Severn. Their work is focussed on freshwater migration and barrier effects, under separate project licences, but we are co-ordinating our efforts and we have taken account of all tagging efforts to minimise the numbers required in this amendment).

Sound trials

For both adults and juveniles we aim to work with batches of 5-10 fish, with acclimatisation periods of 48 hours after capture and a minimum of 3 hours between trials. It is possible that there will be an initial reaction to capture and transport, including a risk of small numbers of mortalities (<5%) and any fish showing signs of distress at the end of the acclimatisation period will not be used in experiments and will be returned to the river.

One of our team has experience of this type of testing with a similar set up. These are shoaling fish and at the start of each trial we will aim to generate a circular flow in the tank, which we expect to encourage shoaling behaviour. Each trial will then comprise exposure of the fish to a series of increasing amplitude emissions of short duration (2-20 seconds) until a reaction is seen, which we anticipate may take the form of a breakdown of shoaling ie a scatter response. Fish will be left within the same tank after trials to minimise handling stress, with the transducers changed between trials so that each batch is tested with different frequencies. Batches will be randomly allocated to trials, with randomisation constrained to ensure different fish are used for each frequency.

Initial trials

Initial trials will firstly be undertaken to establish the best transducer and tank flow set up to encourage fish shoaling and to establish minimum numbers of fish required for shoaling to occur consistently.

We will then undertake trials to establish the stimulus times needed to establish a clear response, starting with 2 seconds sound pulses and increasing sound amplitude. Longer stimulus times will be used if two seconds is insufficient. This phase will also define objective response criteria for subsequent trials.

These initial trials will be used to ensure that tests are able to give clear results, to check that fish recover within 24 hours, and to check they provide reproducible results in subsequent trials. At the end of this initial testing we will review the data, confirm the experimental approach is (or is not) viable, and subject to viability, confirm the exact set up for experimental trials.

We expect to use up to 20 fish for these initial trials. No fish will be used for more than 10 initial trial sessions involving sound.

Experimental trials

We have assumed that for each life stage we will test up to 15 frequencies with three replicates for each frequency. That represents up to 45 individual trials per life stage. We will keep the number of

trials per batch of fish as low as possible (between 5 and 10) to reduce overall holding time for each fish to between 8 and 14 days prior to return to the river.

The exact number of fish required for experimental trials will be determined by the initial trials, with the parameters being the number of fish required to enable shoaling and the acceptable number of trials per batch of fish. For example limiting to 5 trials per batch we would require 9 experimental batches of fish to complete 45 trials, so between 45 fish (5 fish per batch) and 90 fish (10 fish per batch) plus fish for initial trials. At 10 trials per batch we would need between 23 and 45 fish.

What steps did you take during the experimental design phase to reduce the number of animals being used in this project?

Tagging

We are using an adaptive experimental design which is updated by empirical data derived from previous tagging years on an annual basis to determine numbers which need to be deployed in each year. Data for this assessment is currently available from the fish tagged on the Severn, as well as our own tagging on the Tywi and Wye in 2023 and 2024. This provides confidence that the number we intend to tag is the minimum necessary to achieve the objectives of the study with satisfactory levels of confidence.

Sound trials

As above we plan to conduct a number of trials on each batch of fish, with a period of acclimatisation between trials, to reduce the overall number of wild fish removed from rivers and exposed to the stress of handling. We expect the actual trials will result in no more than transient mild stress (ie a 'startle' reaction).

What measures, apart from good experimental design, will you use to optimise the number of animals you plan to use in your project?

As described in the previous response, adaptive review of prior data. Using that data to develop computer models which can be used in subsequent studies to reduce requirements for similar work.

Refinement

Give examples of the specific measures (e.g., increased monitoring, post-operative care, pain management, training of animals) to be taken, in relation to the procedures, to minimise welfare costs (harms) to the animals. Describe the mechanisms in place to take up emerging refinement techniques during the lifetime of the project.

Which animal models and methods will you use during this project? Explain why these models and methods cause the least pain, suffering, distress, or lasting harm to the animals.

The capture and tagging methods we are using with acoustic tags are well established, and have been refined for twaite shad during the published work undertaken on the Severn. The methods we are using are designed to allow the fish to return as rapidly as possible to normal behaviour with minimal long term effects.

For sound trials we will use progressively increasing sound levels at each frequency and will halt the trial as soon as an objective disturbance response is seen. The definition of an objective response will be determined in initial trials, and then used through the rest of the study. The use of progressively increasing levels until a response is seen aims to limit the volume of sound exposure and the period of any startle response, avoiding the likelihood of any damage to hearing.

Why can't you use animals that are less sentient?

Our objective in migration studies is to understand observe behaviour and distribution of Twaite shad under natural conditions, including in the sea. This cannot be achieved by other means.

Similarly fish hearing varies greatly between species and we need to use our target species to generate the threshold/frequency response curves.

How will you refine the procedures you're using to minimise the welfare costs (harms) for the animals?

Capture method

Rod and line is our preferred method and has been used in the Severn study and our own 2023 and 2024 studies with success and good survival rates (ca. 90% survival through tagging, spawning and return to sea on the Tywi and on the Wye). At least for the Tywi, this survival rate is directly comparable to river survival of fish returning to the river the year after tagging (26/30 returners, 87% survived spawning and left the river).

Choice of tags

We are using the smallest tags available consistent with the objectives of the project, including tag life and tracking in the marine environment.The tags we are using are specifically designed by the supplier (Innovasea) for work with the species and life stages we are using. They are tough and smooth to minimise any issues if ingested by a predator.

Tagging and recovery procedures

The anaesthesia technique we are using is well established. If tagging during dark hours light will be kept to a minimum to reduce stress. Aseptic surgery techniques and single use scalpel blades and suture needles will minimise risk of infections.

Each incision will be covered with a suitable temporary wound barrier to provide a temporary barrier, reducing discomfort and providing protection from infection. Sutures will be checked prior to transfer into recovery and holding tanks. Analgesia will be applied via subcutaneous injection.

Fish will be recovered and released by holding them facing into the current to maximise flow over the gills until they are capable of holding station and swimming against the current.

All procedures will only be performed by suitable trained and qualified individuals (ie PIL holder; training and competency record kept by NTCO)

Humane end-points and limits of severity

If internal damage to organs were to occur during surgery, the fish would not be allowed to recover and would be euthanized by a schedule 1 method.

If fish fail to recover from anaesthesia they will be euthanized by a schedule 1 method

Sound trials

Our protocol seeks to minimise stress and the initial trials to establish objective response will provide a better understanding of the most effective trial methodology and enable an adaptive approach.

What published best practice guidance will you follow to ensure experiments are conducted in the most refined way?

There are a number of published studies using these tags and techniques. However methods evolve continuously and we continue to share experience with others to develop best practice through conferences and direct conversations with other research groups who undertaking current licenced work with these species and our approach and protocols seek to take the best from each, consistent with our objectives.

For sound trials the methods we are proposing to use are similar to trials previously used successfully by one of our partners.

How will you stay informed about advances in the 3Rs, and implement these advances effectively, during the project?

We will continually review the literature. We will attend conferences, particularly those which bring together tracking researchers and species specialists. We will continue to network with others to share and learn from further developments, both as research understanding of the field develops and to improve our tagging methods to minimise any potential adverse effects. Where appropriate we will update our protocols and methods.