

**DAERA DIRECTED AGRI-FOOD AND  
BIOSCIENCES INSTITUTE (AFBI) RESEARCH  
WORK PROGRAMME 2019/20**

**Full Format Proposal Form/Project Extension  
Proposal Form**

(Includes the economic appraisal where public funding is  
£500,000 or less over the life of the project)

For SEIPD use only

Proposal Number 19/4/10

Agreement Date 4/12/20

**1. Title of project**

The information provided here **may be used** in DAERA publicity material

Scoping study for research on effects of climate change on fish and fisheries of Lough Neagh

|                       |                    |                     |             |
|-----------------------|--------------------|---------------------|-------------|
| <b>2a. Start Date</b> | 7 December<br>2020 | <b>2b. End Date</b> | 6 July 2022 |
|-----------------------|--------------------|---------------------|-------------|

**3. Contact details for DAERA's nominated policy lead**

| Policy lead-name | Branch           | Contact Telephone Number |
|------------------|------------------|--------------------------|
| [REDACTED]       | Inland Fisheries | [REDACTED]               |

**4. Contact details for AFBI's nominated project lead(s)**

| Project leader(s) name | Division(s) | Contact Telephone Number |
|------------------------|-------------|--------------------------|
| [REDACTED]             | SAFSD       | [REDACTED]               |
| [REDACTED]             |             |                          |
| [REDACTED]             |             |                          |

**5.1 Tick which PMB and Evidence and Innovation Strategy (EIS) Theme the proposal is relevant to – See the DAERA Evidence and Innovation 'Call' document for detail**

| Programme Management Board                           | (✓) | EIS Theme  |
|--|-----|--|
| PMB1 Performance in the market place                 |     |  |
| PMB2 Social & economic infrastructure of rural areas |     |  |
| PMB3 Animal and plant health and animal welfare      |     |  |
| PMB4 Sustainable environment                         | ✓   | Future climate change scenarios on the Northern Ireland fishing and aquaculture industry |

<sup>1</sup> Project Extension Proposals do not require Section 5 to be completed.

**6 (a).<sup>2</sup> Consult the DAERA Evidence and Innovation ‘Call’ document, and insert priority area relevant to this project**

**PMB 4 – Sustainable Environment**

The overall objective of PMB 4 is to address the environmental considerations which are major factors in health and wellbeing. Such issues include climate change, pollution, air / water quality, bio-diversity, waste management and protection of the landscape and natural resources. The main focus of evidence gathering and innovation support activity is to gain a better understanding of the issues surrounding environmental sustainability and climate change mitigation and the potential economic value attached to their effective management and exploitation. A better appreciation of the interaction between land/marine based industries and the natural environment and the regulatory compliance within and between these industries will help promote enhanced policy making and regulatory capabilities.

This proposal is for a scoping study to determine the research required to assess the present and potential impacts of climate change on the fish and fisheries of Lough Neagh in the context of an ecosystem already affected and in a state of flux due to nutrient enrichment and invasive species.

**6 (b). Describe how the project will address this priority area and explain the specific problem that needs to be addressed (please ensure that all scientific terms/abbreviations used in the document are explained)**

Climate change is acknowledged to be one of the primary threats to biodiversity and consequently to ecosystem services and associated provisioning services such as the commercial fishing industry on Lough Neagh. The consequences of increasing temperatures are relatively well understood for terrestrial and marine ecosystems and they generally involve latitudinal or altitudinal range shifts or increasing frequencies of seasonal mismatch between predator and prey population dynamics. A less documented but more damaging response to climate change is expected for freshwater systems, as geographic range shifts are restricted to a much greater degree when habitats are effectively enclosed by terrestrial and saline borders as is the case for many lake systems including Lough Neagh.

This project is aimed to be a first phase scoping study to further bring forward a comprehensively considered proposal or proposals (in a subsequent E&I call) with the primary groundwork already complete. Where data from regular monitoring programmes is readily available this must be compared against historical records to assess existing temporal trends. Where data is sparse, surveys to assess current baselines will need to be conducted. This project will further aim to assess the requirements needed to produce practical models to determine and forecast the impacts of climate change on key fish taxa for the Northern Ireland economy (pollan and eels). In doing this, the project will assess data availability and requirements of key prey items of eels and pollan; *Mysis salemaai* and chironomids.

In conjunction, the project will re-assess the status of the zebra mussel invasion of Lough Neagh, map the species' current and projected range expansion within the lake and assess the likely combined impacts of climate change and invasion in an ecosystem context, along with implications for important commercial fisheries.

---

<sup>2</sup> Project Extension Proposals do not require Section 6 to be completed.

**6 (c). What is the overall Objective(s) of this project? Describe how the project will address this Evidence and Innovation Need.**

Use Plain English and terms easily understood by a lay person. It is DAERA's intention to update stakeholders and the general public on the ongoing progress of its research programmes, therefore this information may be used in DAERA publicity material. To assist in doing this, please provide a short synopsis of **no more than 400 words** summarising the Objectives of this project.

The primary objective of this scoping study is to determine the key research required to characterise the impacts of climate change on the fish ecology of Lough Neagh.

- Temperature has increased significantly in the lake since 1995 and is likely to heavily influence the biology and ecology of key species, in particular pollan (*Coregonus autumnalis*) and European eel (*Anguilla anguilla*) which together support a commercial fishery in Lough Neagh.
- Bioenergetic modelling will be explored to assess its usefulness to future fishery management in Northern Ireland.
- Temperature and oxygen are two important factors known to affect every stage of the lifecycle and maturation rates of both eels and pollan. Data needs and additional resources such as automatic high frequency data availability will be investigated to characterise their use in improving stock models for these two commercially important threatened species. Temperature and oxygen high frequency monitoring data will be examined and its usefulness in future stock management assessed. High frequency summer temperatures will be compared against monthly means to investigate if higher resolution monitoring can further inform stock recruitment models for both eel and pollan.
- The status of key food items of these fish; and their food sources including chironomids and *Mysis salemaai* will be explored. Recent research has implied that abundances of both these prey items has declined in recent years. This study will assess if this is actually occurring. Effects of climate change on these prey items, such as increasing temperature, will be explored.
- The extent of zebra mussel invasion will be assessed. A survey in 2013 showed signs of colonisation and range expansion beyond the area believed to be the introduction site in 2005. A follow up survey aiming to re-map the zebra mussel range is timely, and required to identify the combined impacts of zebra mussel invasion and climate change on Lough Neagh.

**7. Research type - insert percentages to classify research into the following categories:**

| Research Type                            | Percent |
|--|---------|
| <i>Fundamental Research</i> <sup>3</sup> | 100     |
| <i>Industrial Research</i> <sup>4</sup>  |         |

<sup>3</sup> **Fundamental research:** Experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any direct practical application or use in view.

<sup>4</sup> **Industrial Research:** Research aimed at the acquisition of new knowledge and skills for developing new products, processes or services or for bringing about a significant improvement in existing products, processes or services. It comprises the creation of component parts to complex systems, which is necessary for the industrial research, notably for generic technology validation, to the exclusion of prototypes.



|  |  |
|--|--|
| <b>Experimental Research<sup>5</sup></b> |  |
| <b>Total</b>                             |  |

**8. What scientific knowledge already exists in relation to this Evidence and Innovation Need?**  
 In completing this section you should provide concise and relevant background information on related projects undertaken by the Agri-food and Biosciences Institute (AFBI) (past and present) **AND** research published by **other groups** locally, nationally and internationally. List title, year, and publication (if relevant). It is recommended that this section does not exceed three A4 pages.

Ireland and consequently Lough Neagh has a temperate marine climate strongly influenced by the North Atlantic Drift which prevents climatic extremes (Barrow and Hulme, 1997, Graham and Harrod, 2009). Climate change presents a further pressure on fish that are already subject to a series of natural and anthropogenic stressors including eutrophication, invasive species and arterial drainage schemes.

Climate directly and indirectly influences ecological processes (Friedland et al., 2000, Graham and Harrod, 2009). A range of complementary processes may act on a fish population. Water temperature has long been identified as a major influence on the ecology and physiology of fish (Maitland, 1972, Wheeler, 1983, Graham and Harrod, 2009). Temperature along with food availability are the most important factors that determine growth rates of fish. Decreasing temperatures slow metabolic processes, slow feeding rate and in turn decrease fish growth. Conversely as temperature increases, metabolism and energy demands increase to a point where inputs from food may be insufficient and fish have to utilise stored energy reserves thus decreasing their condition factor (Graham and Harrod, 2009). For these reasons temperature is considered a fundamental component of the niche of fish (De Stasio Jr et al., 1996, Graham and Harrod, 2009).

Other aspects of climate change will affect multiple environmental factors and in turn affect fish e.g. cloud cover / light penetration, storm surges, precipitation and altered river discharge. Climate change predictions for Ireland pinpoint changes in abundance and frequency of precipitation (Hulme et al., 2002), including increased periods of drought and these changes will affect fish communities in freshwaters.

The actual effects of climate change on fish are likely to be diverse (Graham and Harrod, 2009) and there is extensive literature examining this. The consequences are likely to be profound for fishes such as eels and salmonids that depend on the timing of seasonal events as migratory or spawning cues (Ottersen et al., 2004). AFBI freshwater scientists Kennedy and Crozier (2010) demonstrated that the timing of the smolt run on the River Bush was strongly linked to ambient river temperatures, the peak of the smolt run had shifted to an earlier date in recent years and that earlier running smolts were correlated to decreased overall subsequent survival rates as a consequence of thermal mismatch upon transition from freshwater to the marine environment.

Fishes may be susceptible to increased temperature regimes, due to their physiological requirement for cool-water environments and often complex life histories (Thomas et al., 2015). Increased water temperatures, particularly in nursery areas may impact negatively on fish survival and recruitment. Lough Neagh pollan expended circa 60% of their dynamic energy budget in a summer with a maximum recorded temperature of 21°C (Dabrowski, 1985). Harrod (2001) stated that this percentage is likely to increase at higher temperature. Harrod (2001) also reported that accurate predictions of the effects of warmer summers on pollan will require information on how food consumption, activity and respiration rates change with temperature.

*Mysis salemaai* (formerly known as *M. relicta*) is a euryhaline glacial relict and considered stenothermic (i.e. it can only survive within a narrow temperature range) and thus it is found in northern Europe (including Ireland) and northern Siberia (Audzijonyte and Vainola, 2006, Griffiths et al., 2015). Griffiths

<sup>5</sup>Experimental research: The acquiring, combining, shaping or using existing scientific, technological, business and other relevant knowledge and skills for the purpose of producing plans and arrangements or designs for new, altered, improved products, processes or services. This may include other activities aiming at the conceptual definition, planning and documentation of new products, processes or services.

(2007) provides a comprehensive list of studies which describe the sensitivity of *Mysis spp* to increasing water temperatures. In Griffiths et al. (2015) we reported that *Mysis* density in Lough Neagh had decreased by 96% between 1996 and 2012. Many Lough Neagh focused studies have described the importance of this species as a food item for key fish species (see: Kirkwood (1996), Bigsby (2000), Harrod (2001) and Vaughan (2009)). If climate change is driving the decline in the Lough Neagh *M. salemaai* population then their long term survival is in jeopardy and will affect the wider ecosystem, including commercially and conservationally important fishes.

Invasive species and their combined impacts with climate change provide a further stressor to the Lough Neagh system. Zebra mussels were first recorded in Ireland on the Shannon system in 1997 (McCarthy et al., 1997). By 1998 they were reported from the Erne system (Rosell et al., 1998) and they were first recorded on the hull of a boat in Kinnego Bay of Lough Neagh in 2005 (McLean et al., 2010). The zebra mussel is considered the most extensively studied and one of the highest impacting aquatic invaders (Gallagher, 2017). The zebra mussel is an ecosystem engineer (Rosell et al., 1998, Crooks, 2002, Maguire and Grey, 2006, Meehan et al., 2014, Zaiko et al., 2014), which directly or indirectly controls the availability of resources to other organisms by causing physical state changes in biotic or abiotic materials. Zebra mussels impact on all aspects of the food web and EU Water Framework Directive (2000) biological parameters, including phytoplankton community structure, macrophyte abundance and composition, benthic invertebrate communities and fish community structure (Baker et al., 1998, Maguire and Grey, 2006, Lucy, 2011, Karatayev et al., 2012, Gallardo and Aldridge, 2013a). The co-occurrence of climate change and the zebra mussel is likely to intensify and compound the pressures already exerted on commercially important fishes. Gallardo and Aldridge (2013b) used regional species distribution models (SDMs) to predict the effects of the expected climate in 2050 on zebra mussel impact on endangered species. They concluded that the zebra mussel would expand its range and where they are already present they would further proliferate at the detriment of endangered species.

- AUDZIJONYTE, A. & VAINOLA, R. 2006. Phylogeographic analyses of a circumarctic coastal and a boreal lacustrine mysid crustacean, and evidence of fast postglacial mtDNA rates. *Molecular Ecology*, 15, 3287-3301.
- BAKER, S. M., LEVINTON, J. S., KURDZIEL, J. P. & SHUMWAY, S. E. 1998. Selective feeding and biodeposition by zebra mussels and their relation to changes in phytoplankton composition and seston load. *Journal of Shellfish Research*, 17, 1207-1213.
- BARROW, E. & HULME, M. 1997. Describing the surface climate of the British Isles. *Climates of the British Isles*, 33-62.
- BIGSBY, E. 2000. *The interactions between Macro-Invertebrates, Fish, and Diving Ducks of Lough Neagh, Northern Ireland* D.Phil, University of Ulster.
- CARTER, C. E. 1978. Fauna of the muddy sediments of Lough Neagh, with particular reference to eutrophication. *Freshwater Biology*, 8, 547-559.
- CROOKS, J. A. 2002. Characterizing ecosystem-level consequences of biological invasions: the role of ecosystem engineers. *Oikos*, 97, 153-166.
- DABROWSKI, K. R. 1985. Energy budget of coregonid (*Coregonus spp.*) fish growth, metabolism and reproduction. *Oikos*, 45, 358-364.
- DE STASIO JR, B. T., HILL, D. K., KLEINHANS, J. M., NIBBELINK, N. P. & MAGNUSON, J. J. 1996. Potential effects of global climate change on small north-temperate lakes: Physics, fish, and plankton. *Limnology and Oceanography*, 41, 1136-1149.
- EU 2000. *Directive 2000/60/EC of the European Parliament and of the Council of 23.10.2000 establishing a framework for Community action in the field of water policy*, Brussels, European Union.
- FRIEDLAND, K. D., HANSEN, L. P., DUNKLEY, D. A. & MACLEAN, J. C. 2000. Linkage between ocean climate, post-smolt growth, and survival of Atlantic salmon (*Salmo salar* L.) in the North Sea area. *ICES Journal of Marine Science*, 57, 419-429.
- GALLAGHER, K. 2017. *Ecological Impacts of Freshwater Invasive Species*. PhD, Queen's University Belfast.
- GALLARDO, B. & ALDRIDGE, D. C. 2013a. The 'dirty dozen': socio-economic factors amplify the invasion potential of 12 high-risk aquatic invasive species in Great Britain and Ireland. *Journal of Applied Ecology*, 50, 757-766.
- GALLARDO, B. & ALDRIDGE, D. C. 2013b. Evaluating the combined threat of climate change and biological invasions on endangered species. *Biological Conservation*, 160, 225-233.
- GRAHAM, C. T. & HARROD, C. 2009. Implications of climate change for the fishes of the British Isles. *Journal of Fish Biology*, 74, 1143-1205.
- GRIFFITHS, D. 2007. Effects of climatic change and eutrophication on the glacial relict, *Mysis relicta*, in Lough Neagh. *Freshwater Biology*, 52, 1957-1967.



- GRIFFITHS, D., MACINTOSH, K. A., FORASACCO, E., RIPPEY, B., VAUGHAN, L., MCELARNEY, Y. R. & GALLAGHER, K. 2015. *Mysis salemaai* in Ireland: new occurrences and existing population declines. *Biology and Environment: Proceedings of the Royal Irish Academy*, 115B, 1-7.
- HARROD, C. 2001. *The ecology of a threatened fish: the pollan (Coregonus autumnalis) in Lough Neagh, Northern Ireland*. D.Phil, University of Ulster.
- HULME, M., JENKINS, G. J., LU, X., TURNPENNY, J. R., MITCHELL, T. D., JONES, R. G., LOWE, J., MURPHY, J. M., HASSELL, D., BOORMAN, P., MCDONALD, R. & HILL, S. 2002. Climate change scenarios for the United Kingdom: The UKCIP02 scientific report. *Climate Change Scenarios for the United Kingdom: The UKCIP02 Scientific Report*.
- KARATAYEV, A. Y., CLAUDI, R. & LUCY, F. E. 2012. History of *Dreissena* research and the ICAIS gateway to aquatic invasions science. *Aquatic Invasions*, 7, 1-5.
- KENNEDY, R. J. & CROZIER, W. W. 2010. Evidence of changing migratory patterns of wild Atlantic salmon *Salmo salar* smolts in the River Bush, Northern Ireland, and possible associations with climate change. *Journal of Fish Biology*, 76, 1786-1805.
- KIRKWOOD, R. C. 1996. *Interactions between fish, Mysis, and zooplankton in Lough Neagh*. D.Phil, University of Ulster.
- LUCY, F. 2011. Zebra mussels in Ireland-Fourteen years of invasive experience. *Journal of Shellfish Research*, 30, 528-528.
- MAGUIRE, C. M. & GREY, J. 2006. Determination of zooplankton dietary shift following a zebra mussel invasion, as indicated by stable isotope analysis. *Freshwater Biology*, 51, 1310-1319.
- MAITLAND, P. S. 1972. *A key to the freshwater fishes of the British Isles with notes on their distribution and ecology*, Freshwater Biological Association.
- MCCARTHY, T. K., FITZGERALD, J. & O'CONNOR, W. 1997. The occurrence of the zebra mussel *Dreissena polymorpha* (Pallas 1771), an introduced biofouling freshwater bivalve in Ireland. *Irish Naturalists Journal*, 25, 413-416.
- MCLEAN, S. P., EVANS, D. W., ROSELL, R. S., ROBERTS, D. & LIVINGSTONE, J. 2010. Establishment of the zebra mussel *Dreissena polymorpha* (Pallas, 1771) in Lough Neagh, Northern Ireland. *Biology and Environment- Proceedings of the Royal Irish Academy*, 110B, 55-59.
- MEEHAN, S., SHANNON, A., GRUBER, B., RACKL, S. M. & LUCY, F. E. 2014. Ecotoxicological impact of Zequanox (R), a novel biocide, on selected non-target Irish aquatic species. *Ecotoxicology and Environmental Safety*, 107, 148-153.
- OTTERSEN, G., ALHEIT, J., DRINKWATER, K., FRIEDLAND, K., HAGEN, E. & STENSETH, N. C. 2004. The responses of fish populations to ocean climate fluctuations. *Marine Ecosystems and Climate Variation*, 73-94.
- ROSELL, R. S., MAGUIRE, C. M. & MCCARTHY, T. K. 1998. First reported settlement of zebra mussels *Dreissena polymorpha* in the Erne system, Co. Fermanagh, Northern Ireland. *Biology and Environment- Proceedings of the Royal Irish Academy*, 98B, 191-193.
- THOMAS, S. M., GRIFFITHS, S. W. & ORMEROD, S. J. 2015. Adapting streams for climate change using riparian broadleaf trees and its consequences for stream salmonids. *Freshwater Biology*, 60, 64-77.
- TOMANKOVA, I., HARROD, C., FOX, A. D. & REID, N. 2014. Chlorophyll a concentrations and macroinvertebrate declines coincide with the collapse of overwintering diving duck populations in a large eutrophic lake. *Freshwater Biology*, 59, 249-256.
- VAUGHAN, L. 2009. *Trophic modelling of the Lough Neagh ecosystem, Northern Ireland*. PhD thesis, University of Ulster.
- WHEELER, A. 1983. *Kingfisher guide to freshwater fishes of Britain and Europe*, London, W1P 7AD, Kingfisher books LTD.
- ZAIKO, A., MINCHIN, D. & OLENIN, S. 2014. "The day after tomorrow": anatomy of an 'r' strategist aquatic invasion. *Aquatic Invasions*, 9, 145-155.

**9. What additional information will this project provide, over and above that described in Section 8 (i.e. describe in detail the 'gap' in existing knowledge that is being filled by this proposal)**

Due to the absence of a deep-water thermal refuge (Griffiths, 2007), pollan from Lough Neagh are likely to be under considerably greater pressure than their conspecifics elsewhere in Ireland. We have observed increasing water temperatures in Lough Neagh since 1995. The effects of increasing temperature on pollan will be investigated and future needs of the fishery will be scoped. Bioenergetic approaches will be investigated as a possible approach for management of climate change impacts (temperature/ prey availability) on pollan.

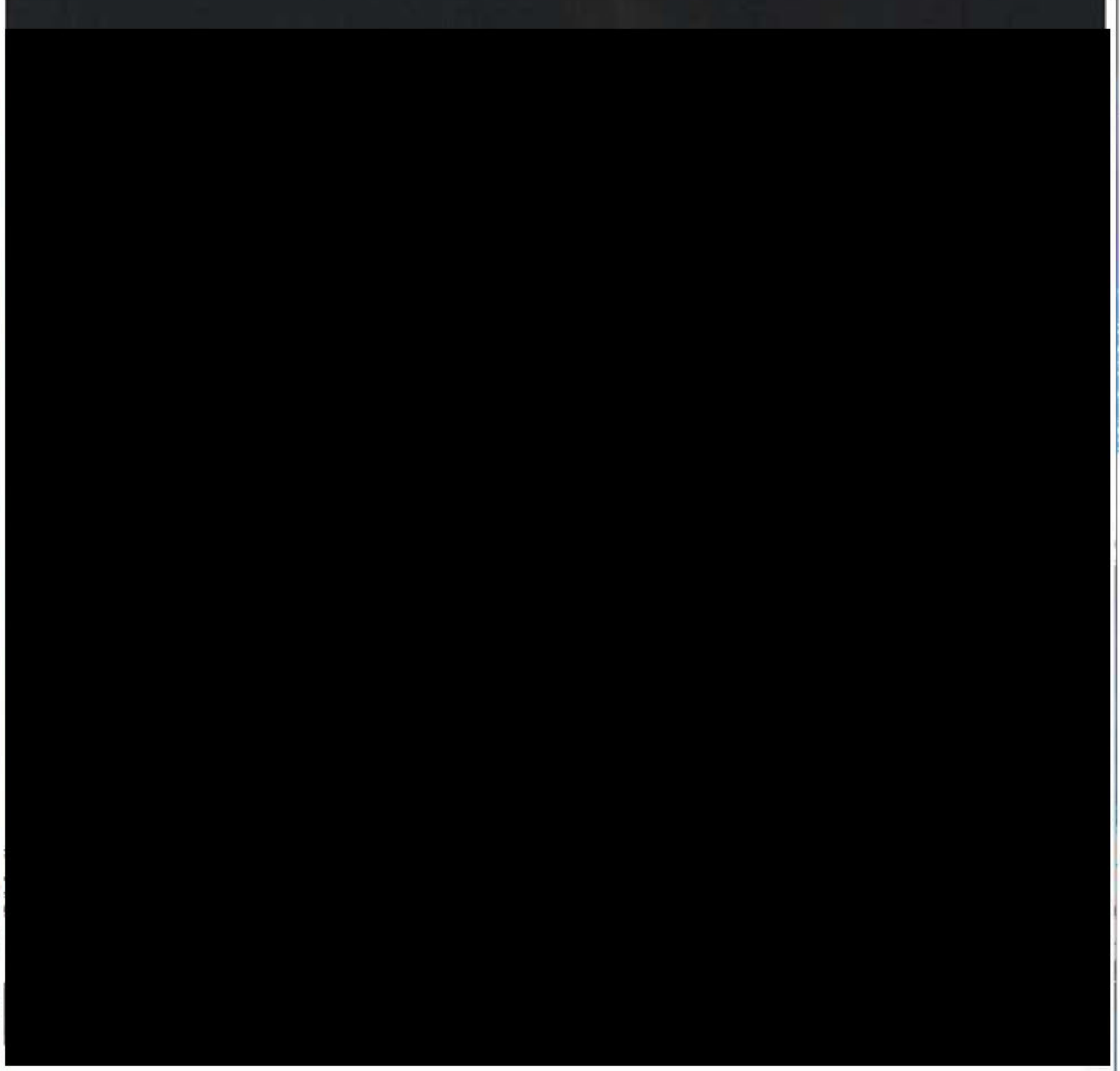
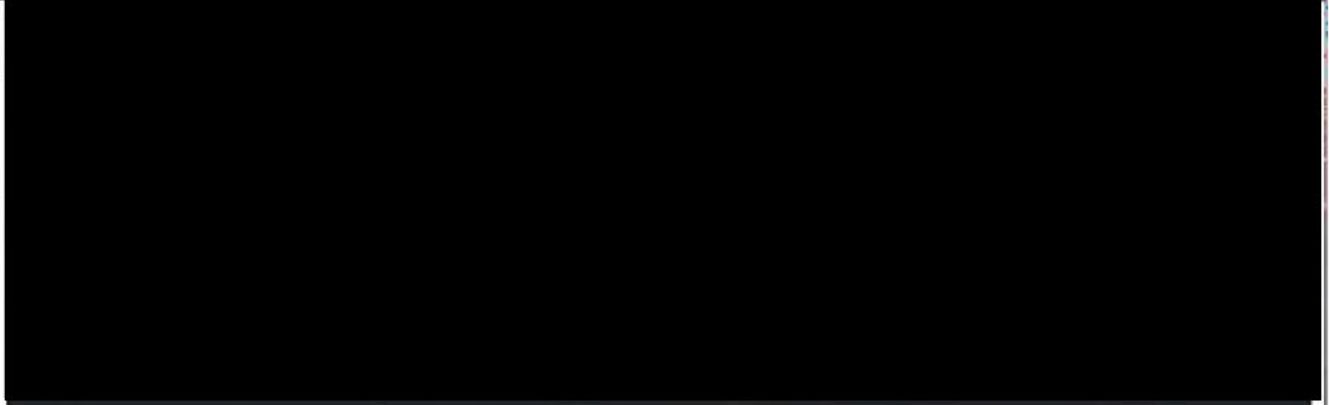
The water temperature during the first year of life in freshwater is an important influence on eel recruitment and increasing temperatures in the Lough will impact our ability to manage production expectations. Further, summer temperature is key in determining maturation from the brown to silver eel stage. Increasing summer temperatures will lead to a more rapid maturing of brown eels. European Regulations (1100/2007) state that we must have knowledge on the current status of the eel stock and that we must allow 40% escapement. In order to comply with these regulations we must have knowledge regarding the impacts of the observed and future increases in lake water temperature on current and potential future stock biomass.

High frequency monitoring data, specifically for the key parameters of temperature and oxygen will be recorded and their usefulness in improving predictive models for important fish species will be described. Data needs for incorporation to bioenergetics or stock/ recruitment models will be investigated.

In addition to direct impacts on fish, this project will look at the impacts of climate change on key prey items of fish; chironomids and *Mysis salina*. The benthic macroinvertebrate fauna of Lough Neagh is dominated by chironomids (Carter, 1978, Bigsby, 2000). The mean total density of macroinvertebrates has possibly reduced significantly c. 65% from 1998 to 2010 (Tomankova et al., 2014). Tomankova et al (2014) also reports that in terms of taxonomic composition, the relative contribution of *Tanyptodinae*, *Glyptotendipes* spp. and *Tanytarsini* declined, while the relative contribution of *Chironomus* spp. increased. This project will review these findings and evaluate if these changes are ongoing and how climate change can impact the benthic fauna and the future diet of fish.

Zebra mussels have not been surveyed in the Lough since 2013 and as outlined above are a major influence in any lake they invade. Recent anecdotal reports by fishermen (2019) suggest accelerating population expansion. A picture of current extent and biomass of zebra mussels in the Lough will help us estimate their impacts on trophic status and food availability for pollan and eels. Recent AFBI investigations of long term (100year) data on eel production in Lough Neagh already suggest a step change in eel lifetime survival rates since the introduction of roach in the 1970s and subsequent fish community domination by this species. The downward shift in eel productivity suggests potential competition between the fish species for key food items, requiring further investigation. The arrival and expansion of zebra mussels can only complicate this picture. Collation of existing data on the ecosystem components in one place, will be a key step toward reaching better understanding of possible futures scenarios

**10. Outline the Project Team's expertise/track record in this field and its capability to successfully complete the project proposed.** (This should include work on previous similar projects and reference any relevant research published by the group locally, nationally and internationally. List title, year, publication (if relevant).





## 11. Scientific Objectives and Tasks

Outline the key Objectives of the research and provide detailed main Tasks required to achieve each Objective (e.g analytical tests to be used; number of replicates). Insert target date (mth/yr) for achievement of Tasks and provide indicative duration (mths). Add additional lines as required.

|      | Objective  | Tasks required to achieve Objective (including indicative duration mths)   | Milestones (target date of achievement) |
|------|--|--|---|
| 11.1 | Literature Review  | A thorough review of the literature on the impacts of climate change on the ecology of Lough Neagh and its impacts on the commercial fishing industry. | August 2021                             |
| 11.2 | Baseline surveys of key prey species   | Baseline surveys to determine population densities of <i>Mysis salemaai</i> and chironomid larvae.   | Sept 2021                               |
| 11.3 | Update survey on Zebra Mussel range and expansion  | Determine the invaded range of zebra mussels in Lough Neagh and evaluate the population density at key sites.  | Sept 2021                               |
| 11.4 | Preliminary assessment of high frequency monitoring data for fish stock management   | Using data from automatic high frequency monitoring, investigate if oxygen and temperature data can be used to help manage the freshwater fisheries.   | May 2022                                |
| 11.5 | Investigation of bioenergetics or other modelling approaches that will inform us of the effects of increasing temperature on fish. | Review of data needs an applicability of modelling approaches.   | Feb 2021                                |
| 11.6 | Report and further proposal  | Write report and produce proposal for a second phase in depth study  | June 2022                               |

| <b>12. List the Deliverables and the date by which it will be achieved (mth/yr). Add additional lines as required.</b> |  |  |
|--|--|--|
|  | <b>Deliverable (e.g. paper to be published; report to be submitted; knowledge exchange opportunity) Include a brief description of deliverable if appropriate. Add additional lines as required.</b> | <b>Milestones (target date of achievement)</b> |
| <b>12.1</b>  | Comprehensive literature review pertaining to the impacts of climate change on the ecology of Lough Neagh and its impacts on the commercial fishing industry.  | August 2021                                    |
| <b>12.2</b>  | Baseline surveys of key prey species - Baseline surveys to determine up to date population densities of <i>Mysis salemaai</i> and chironomid larvae.   | Sept 2021                                      |
| <b>12.3</b>  | Survey of Zebra Mussel range and expansion - Determine the invaded range of zebra mussels in Lough Neagh and evaluate the population density at key sites.   | Sept 2021                                      |
| <b>12.4</b>  | Preliminary analyses of high frequency monitoring data and comparison with low resolution frequency monitoring for summer temperature. Outline usefulness in stock –recruitment model improvement    | May 2022                                       |
| <b>12.5</b>  | Review of Bioenergetics approach to fisheries modelling in Lough Neagh   | Jan 2022                                       |
| <b>12.6</b>  | Report and further proposal – produce technical report and an informed second phase proposal   | June 2022                                      |

| <b>13. Publications/ Knowledge and Technology Transfer. Please provide details of all planned publications, knowledge transfer opportunities/events over the duration of the project.</b> |                     |                         |                         |                         |                         |                         |
|---|---------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| <b>Output description</b>   |                     | <b>Target number</b>    |                         |                         |                         |                         |
|   |                     | <b>Year 1 (2020/21)</b> | <b>Year 2 (2021/22)</b> | <b>Year 3 (2022/23)</b> | <b>Year 4 (20XX/XX)</b> | <b>Year 5 (20XX/XX)</b> |
| Refereed scientific publications  |                     |                         |                         | 1                       |                         |                         |
| Non-refereed scientific publications  |                     |                         |                         | 1                       |                         |                         |
| Knowledge transfer/popular articles   |                     |                         |                         |                         |                         |                         |
| Knowledge transfer events   | to DAERA            |                         |                         | 1                       |                         |                         |
|   | to key stakeholders |                         |                         | 1                       |                         |                         |
|   | to the public       |                         |                         |                         |                         |                         |

| <b>14. List and detail collaboration with others, and explain what their role(s) will be?</b>   |                                    |
|---|------------------------------------|
| List any opportunities that have been identified within this proposal for collaboration with other research Institutions and/or Higher Education Institutes/Industry. Add additional lines as required. |                                    |
| <b>Institution/Company</b>  | <b>Lead Scientist/Collaborator</b> |
|   |                                    |
| <b>Detail of Collaboration (e.g. knowledge exchange, networking, co-funding, resource-sharing)</b>  |                                    |
|   |                                    |

|   |   |
|---|---|
| <b>15. Are there any Intellectual Property Rights (IPR) issues? Y/N</b> | N |
| <b>If yes, please provide details:</b>                                  |   |
| NA  |   |

**16. Project Risk Register - List the key risks relating to the completion of the project on time and within budget, the likelihood and impact of the risk, and briefly outline how these risks will be managed**

**NOTE:** Examples of risks include: key staff retirement; potential for staff to be redeployed (e.g. in emergency response); possible loss of technical support or of equipment resource; failure to complete field trials due to inclement weather; increases in consumables costs. Where risks likelihood/impact is identified as medium/medium, medium/ high, high /medium or high/high plans to mitigate the risk must be discussed and agreed with Policy Leads and AFBI Senior Management. Add additional lines as required. A Risk Manager **must** be named against each risk. Add additional lines as required.

| Risk no | Description of Risk   | Likelihood (High, Med, Low) | Impact (High, Med, Low) | How will this risk be managed?  | By whom?  |
|---------|---|-----------------------------|-------------------------|---|---|
| 1       | Pressures on lead or key staff                                  | M                           | M                       | Delegate workload and create cover over experienced staff members.        | AFBI, Head of Freshwater Science                          |
| 2       | Adverse weather preventing sampling                             | H                           | M                       | Mitigate by scheduling broad time windows.                                | Principal Investigator                                    |
| 3       | Failure to complete the project within the allocated time frame | L                           | L                       | Mitigated by setting a schedule at the outset and constant re-evaluation. | Principal Investigator                                    |
| 4       | Failure of strand leaders to deliver on agreed objectives       | L                           | H                       | Effective management and clear deadlines to be set and agreed at outset.  | Principal Investigator / AFBI, Head of Freshwater Science |

|   |   |
|---|---|
| <b>17. Project Proofing</b>   |   |
| <b>17.1 Does the project require an environmental assessment? Y/N</b>                       | N |
| <b>If Yes, please identify the person responsible</b>                                       |   |
| <b>17.2 Does the project require an animal welfare and ethics assessment? Y/N</b>           | N |
| <b>If Yes, please identify the person responsible</b>                                       |   |
| <b>17.3 Are there any specific licensing requirements associated with this project? Y/N</b> | N |
| <b>If Yes, please identify the person responsible</b>                                       |   |



### 18. AFBI's financial cost of project delivery (Full Economic Cost £'s)

Please note all research costs are now capital. A full breakdown of all costs associated with the project must be provided in the FFP Appendices.

It is expected that most research projects will be completed within a 3 year time period. Where the cost of an item/salary is likely to increase over time due to inflation, ensure that the increases are included in the cost projections).

|                                   | £<br>Year 1<br>2020/21 | £<br>Year 2<br>2021/22 | £<br>Year 3<br>2022/23 | £<br>Year 4<br>2023/24 | £<br>Year 5<br>2024/25 | £<br>Total     |
|-----------------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|----------------|
| <b>A) AFBI Costs</b>              |                        |                        |                        |                        |                        |                |
| <b>Direct Costs</b>               |                        |                        |                        |                        |                        |                |
| Staff costs                       | 19,760                 | 65,667                 | 17,807                 | 0                      | 0                      | 103,234        |
| Consumables                       | 0                      | 150                    | 50                     | 0                      | 0                      | 200            |
| Travel & Subsistence              | 0                      | 0                      | 0                      | 0                      | 0                      | 0              |
| Dissemination/Knowledge Exchange  | 0                      | 0                      | 0                      | 0                      | 0                      | 0              |
| Subcontract Research Costs        | 0                      | 4,500                  | 1,500                  | 0                      | 0                      | 6,000          |
| Animal Usage                      | 0                      | 0                      | 0                      | 0                      | 0                      | 0              |
| Other - give details              | 0                      | 0                      | 0                      | 0                      | 0                      | 0              |
| <b>Indirect costs</b>             |                        |                        |                        |                        |                        |                |
| Overhead charges                  | 25,060                 | 83,277                 | 22,582                 | 0                      | 0                      | 130,919        |
| Irrecoverable VAT on AFBI expense | 0                      | 1,246                  | 415                    | 0                      | 0                      | 1,662          |
| <b>Subtotal</b>                   | <b>44,820</b>          | <b>154,840</b>         | <b>42,355</b>          | <b>0</b>               | <b>0</b>               | <b>242,015</b> |
| <b>B) Non-AFBI Costs</b>          | <b>Year 1</b>          | <b>Year 2</b>          | <b>Year 3</b>          | <b>Year 4</b>          | <b>Year 5</b>          | <b>Total</b>   |
| Collection of samples/data        | 0                      | 0                      | 0                      | 0                      | 0                      | 0              |
| Dissemination/Knowledge Exchange  | 0                      | 0                      | 0                      | 0                      | 0                      | 0              |
| Other - give details              | 0                      | 0                      | 0                      | 0                      | 0                      | 0              |
| <b>Subtotal</b>                   | <b>0</b>               | <b>0</b>               | <b>0</b>               | <b>0</b>               | <b>0</b>               | <b>0</b>       |
| <b>C) In-kind contribution</b>    | <b>Year 1</b>          | <b>Year 2</b>          | <b>Year 3</b>          | <b>Year 4</b>          | <b>Year 5</b>          | <b>Total</b>   |
| Item 1-give details               | 0                      | 0                      | 0                      | 0                      | 0                      | 0              |
| Item 2 - give details             | 0                      | 0                      | 0                      | 0                      | 0                      | 0              |
| <b>Subtotal</b>                   | <b>0</b>               | <b>0</b>               | <b>0</b>               | <b>0</b>               | <b>0</b>               | <b>0</b>       |
| <b>TOTAL PROJECT COST</b>         | <b>44,820</b>          | <b>154,840</b>         | <b>42,355</b>          | <b>0</b>               | <b>0</b>               | <b>242,015</b> |
| <b>Co-Funding Income</b>          | <b>0</b>               | <b>0</b>               | <b>0</b>               | <b>0</b>               | <b>0</b>               | <b>0</b>       |
| <b>DAERA Funded Costs</b>         | <b>44,820</b>          | <b>154,840</b>         | <b>42,355</b>          | <b>0</b>               | <b>0</b>               | <b>242,015</b> |
| <b>DAERA Cost %</b>               | <b>100%</b>            | <b>100%</b>            | <b>100%</b>            | <b>#DIV/0!</b>         | <b>#DIV/0!</b>         | <b>100%</b>    |
| <b>Co-Funding Cost %</b>          | <b>0%</b>              | <b>0%</b>              | <b>0%</b>              | <b>#DIV/0!</b>         | <b>#DIV/0!</b>         | <b>0%</b>      |

[PLEASE INSERT FFP SUMMARY TABLE AS SHOWN IN FFP APPENDICES SPREADSHEET]

| 19a. How will the AFBI costs be funded? |          |                  |            |    |          |       |          |
|---|----------|------------------|------------|----|----------|-------|----------|
|   | DAERA    | Other Govt Depts | University | EU | Industry | Other | Total    |
| Funding (£'s)                           | £242,015 |                  |            |    |          |       | £242,015 |
| % of Cost                               | 100      |                  |            |    |          |       | %100     |
| Source of funding                       |          |                  |            |    |          |       |          |

| 19b. How will the non-AFBI research costs be funded? |       |                  |            |    |          |       |       |
|--|-------|------------------|------------|----|----------|-------|-------|
|  | DAERA | Other Govt Depts | University | EU | Industry | Other | Total |
| Funding (£'s)  |       |                  |            |    |          |       | £     |
| % of Cost  |       |                  |            |    |          |       | %     |
| Source of funding                                    |       |                  |            |    |          |       |       |

| 20. Justification of non-AFBI costs identified in section 18a above, and its funding (19b) above - For instance, there might be costs falling to CAFRE, Veterinary Service etc. for work carried out, or as a result of knowledge exchange programmes required. |  |                                    |   |     |   |  |
|---|--|------------------------------------|---|-----|---|--|
| Name of Organisation that will be involved in the work  | Describe briefly the work / service required | Total cost of work /service<br>£'s | Give a breakdown of cost incurred per annum |     | Which organisation will fund this cost? | Has it confirmed that it will be able to allocate funding to this work?<br>Y/N |
|   |  |                                    | Year of project (e.g. yr 1)                 | £'s |   |  |
|   |  |                                    |   |     |   |  |
|   |  |                                    |   |     |   |  |
|   |  |                                    |   |     |   |  |
|   |  |                                    |   |     |   |  |
|   |  |                                    |   |     |   |  |
|   |  |                                    |   |     |   |  |
|   |  |                                    |   |     |   |  |
|   |  |                                    |   |     |   |  |

**21. Describe how DAERA, and its stakeholders will benefit from the research**

Include both monetary benefits (e.g. increases in farm gross margins, or processing sector value added); and non-monetary benefits such as environmental, conservation, safety, welfare, customer confidence, social benefits etc. Social benefits/impacts might include reductions in poverty, improvements in equality etc.):

| <b>Beneficiary:</b>       | <b>Specific section / group:</b>                 | <b>How they will benefit:</b>  |
|---------------------------|--|--|
| <b>DAERA</b>              | Inland Fisheries/ NIEA                           | The outputs from this project will contribute to the evidence-base required for fisheries management plans. Outputs will help us meet Regulations 1100/ 2007 for eel stock management.   |
| <b>Consumers</b>          | General public                                   | Improvements in water quality via aesthetics and improved leisure, including recreational angling benefits.  |
| <b>Other Stakeholders</b> | Fishermen, their families and the General Public | Improvements in fisheries management- positive feedback to local communities and fishermen- encouraging greater public ownership, faith in management, and acceptability of future potential stock densities of commercial fish. |

**22. As far as is possible, it is important to quantify the likely benefits/outcomes<sup>6</sup> that should arise as a result of this Evidence & Innovation project, and where possible, calculate their monetary value. In describing the quantifiable benefits arising from the project below**

- explain your assumptions;
- show how you calculated the level of benefit;
- provide details of the expected timeline for the achievement of the benefit.

Under the EU Water Framework 'good ecological status' must be achieved in all waterbodies covered by the directive in Northern Ireland. Fish is a biological quality element in the Directive and is currently at good status. Climate change effects (temperature) may affect the oxygen/ food availability for the fish populations in the lake and this proposal seeks to address emerging issues to further investigate for Fisheries Management.

Failure to keep our good status for the fish element will result in monetary penalties from the EU commission, which NI will be required to pay until the situation is rectified. The size of these penalties will be decided by the European Court of Justice however, a recent example of the potential penalties imposed on the Republic of Ireland for failure to properly implement the Environmental Impact Assessment (EIA) Directive, resulted in a lump sum fine of €180,000 plus a daily fine of €19,000 until these regulations are correctly implemented.

<sup>6</sup> Outcomes - these are the eventual benefits to society that a project is intended to achieve.



|   |                   |
|---|-------------------|
| <p><b>23. When both monetary (Q22) and non-monetary benefits (Q21) are taken together, is it reasonable to assume that the benefits of the research will offset its costs? Y/N?</b></p>   | <p><b>Yes</b></p> |
| <p><b>24. If yes given for Q23, discuss why it is reasonable to assume that the benefits of the research will be sufficient to offset its costs</b><br/> E.g. where benefits are mainly 'monetary' in nature, take into account average 'benefit per farm' projections, and discuss what level of uptake in industry would be required for the benefits to offset the cost of the research, and conclude on whether this is achievable given uptake rates delivered from broadly similar research undertaken in the past.<br/> Where benefits are mainly 'non-monetary' in nature, provide information on the:</p> <ul style="list-style-type: none"> <li>• fit with DAERA objectives;</li> <li>• context data – e.g. the 'value added'<sup>7</sup> of the sector supported by the research at farm production, and food processing stages; number of employees, if relevant;</li> <li>• other relevant data (e.g. amount of interest from consumers/customers on the non-monetary benefits being generated; political drive to achieve these non-monetary benefits etc.);</li> <li>• Discuss why, in your view, the non-monetary benefits are sufficient to offset the costs of the research.</li> </ul> |                   |
| <p>If 'good ecological status' is not achieved in all waterbodies and Northern Ireland were to incur similar penalties as imposed on the Republic of Ireland for infringement related to the EIA Directive there would be an annual cost to the NI economy of £6.1 million/year until the situation was rectified.</p>  |                   |

|   |
|---|
| <p><b>25. Outline how it would be possible to measure robustly the monetary and/or non-monetary benefits actually achieved as a result of the research project</b><br/> Include information on:</p> <ul style="list-style-type: none"> <li>• how the relevant baseline information could be captured;</li> <li>• how the impact of the research could be measured.</li> </ul> |
| <p>Measuring the improvements in water quality due to the outputs of this project as opposed to other measures is extremely difficult. As such, robustly measuring the monetary benefits in terms of improvements in water quality and ecology in NI is uncertain. However, measures of the benefits can be obtained from associated indicators.</p>                          |

<sup>7</sup> The 'value added' of a sector is the monetary value of its overall contribution to the Northern Ireland economy. To estimate value added for agriculture production sectors, the aggregate gross margin figures are used. See "Aggregate Gross Margin Estimates for the Main Agricultural Sectors" in the DAERA Publication "Statistical Review of Northern Ireland Agriculture" <https://www.daera-ni.gov.uk/articles/statistical-review-ni-agriculture>

See "Value Added, by subsector" table in the DAERA Publication "Size and Performance of the Northern Ireland Food and Drinks Processing Sector" <https://www.daera-ni.gov.uk/articles/size-and-performance-ni-food-and-drinks-processing-sector> as this provides estimates of "value added" for subsectors at the processing stage.



The benefits of this research to the fishing and aquaculture industry in NI can be measured by the contribution it makes to fisheries management plans and targeting future effective use of public funds in future research areas.

The impact of this research can also be measured through its successful publication in high impact academic journals and the number of citations the papers received.

**26. Outline when would be the most appropriate time (i.e. year) to measure the monetary benefits actually achieved as a result of the research project?**

(e.g. for some projects, there may be a time-lag between the completion of the research project, and the benefits actually being delivered to industry, as knowledge exchange has to take place, and the industry adopt the new practices required. This question requires you to specify the year which is the earliest point in time that a meaningful estimate of the benefits should be possible.)

As this is a scoping project to identify further research required to examine the impacts of climate change on the fish ecology of Lough Neagh in the context of an impacted ecosystem this would be at least 3-5 years in the future and is not precisely definable at this stage.

**27a. Is there potential for any of the beneficiaries identified in Q21 above to contribute towards the cost of the research? If so, give details of relevant representative body that could be approached for funding/collaboration (and their responses, if they have already been approached).**

NA

**27b. List any other non-financial contributions to support the project from industry/others (e.g. meat samples; access to a membership database to use as a survey frame etc.)**

NA

**27c. If DAERA did not provide funding for this Evidence & Innovation project, to what extent, if any, might it be delivered by industry/private sector organisations; or the delivery funded by industry/private sector organisations or another public sector organisation?**

Impacts of climate change fall under the remit of DAERA / NIEA. These projects require a significant monetary and time resource which is unlikely to be conducted without government funding.

**27d. Pathway to Impact: A high level description of how the results will be impactful should be outlined. Where possible the roadmap to realise this impact should be highlighted here.**

The results of this project will feed into a further considered proposal that will have precise research objectives focusing on the impacts of climate change and invasive species on key commercial fishes. When the impacts are fully understood mitigating measures can be identified and applied.





**28. Project Evaluation Arrangements**

Who will be responsible for completing the evaluation of the project?

|       |              |                  |
|-------|--------------|------------------|
| Name: | DAERA Branch | Inland Fisheries |
|-------|--------------|------------------|

**29. When will the Post Project Evaluation Table at 31 below be completed?**

Date: 30<sup>th</sup> June 2023

**30. Project Evaluation Table (deliverables/outputs should be consistent with those identified in sections 12 and 13)**

|   | Expected     | Out-turn*                                       | Variance* | Reason for variance* |
|---|--------------|---|-----------|----------------------|
|   | Complete now | *to be completed at PPE date given at 29 above. |           |                      |
| Project costs                                   | £242,015     | £   |           |                      |
| Project funding                                 | £242,015     |   |           |                      |
| • DAERA   |              |   |           |                      |
| • Other Government Departments                  |              |   |           |                      |
| • Other University                              |              |   |           |                      |
| • EU  |              |   |           |                      |
| • Industry                                      |              |   |           |                      |
| • Other sources                                 |              |   |           |                      |
| Project deliverables/outputs versus projections |              |   |           |                      |
| • no of refereed scientific papers published    | 1            |   |           |                      |
| • no of non-refereed papers/articles published  | 1            |   |           |                      |
| • no of KTT/popular articles published          | 0            |   |           |                      |
| • no of KTT events held                         | 2            |   |           |                      |
| • no of people attending KTT events             |              |   |           |                      |
| • other deliverables/outputs (give details)     |              |   |           |                      |

| 30. continued – Evaluation of objectives | Expected  | Achieved?<br>(Y/N)                              | Why objective not achieved in full, if applicable? | Lessons learned |
|--|---|---|--|-----------------|
|  | To be completed now   | * to be completed at PPE date given in 29 above |  |                 |
| <b>Overall Policy Objective(s)</b>       |   |   |  |                 |
| <b>Scientific Objectives</b>             |   |   |  |                 |
| <b>Objective 1:</b>                      | Literature Review   |   |  |                 |
| <b>Objective 2:</b>                      | Baseline surveys of key prey species  |   |  |                 |
| <b>Objective 3:</b>                      | Update survey on Zebra Mussel range and expansion   |   |  |                 |
| <b>Objective 4 :</b>                     | Preliminary assessment of high frequency monitoring data for fish stock management  |   |  |                 |
| <b>Objective 5 :</b>                     | Investigation of bioenergetics or other modelling approaches that will inform us of the effects of increasing temperature on fish |   |  |                 |
| <b>Objective 6 :</b>                     | Report and further proposal   |   |  |                 |



## Data Protection and Freedom of Information Issues

The Department takes data protection and freedom of information issues seriously. It takes care to ensure that any personal information supplied to it is dealt with in a way which complies with the requirements of the Data Protection Act 1998. This means that any personal information you supply will be processed principally for the purpose for which it has been provided. However, the Department may also use it for other legitimate purposes in line with the Data Protection Act 1998 and Freedom of Information legislation. These include:

- Administration of the Common Agricultural Policy and other aid schemes;
- The production and safety of food;
- Management of land and other environmental controls;
- Animal health and welfare;
- Occupational health and welfare;
- Compilation of statistics;
- Disclosure to other organisations when required to do so; and
- Disclosure under the Freedom of Information Act 2000 or the Environmental Information Regulations 2004 where such disclosure is in the public interest.

**31. FoI Implications** (you should state here if any of the information provided in this form would be exempt from release under the Freedom of Information Act 2000, stating specific exemptions where possible)

### 32. This document was prepared with input from AFBI project leader(s)

| Name       | Date       |
|------------|------------|
| [REDACTED] | 19/11/2019 |

### 33. This document has been prepared and checked by policy lead(s) and is recommended for approval by the relevant PMB

| Name       | Date     |
|------------|----------|
| [REDACTED] | 27/11/19 |

### 34. This document has been accepted by me as the PMB Chair on behalf of the PMB and the project may proceed on this basis

| Name       | Date    |
|------------|---------|
| [REDACTED] | 29/5/20 |



**ANNEX 1: Benefit Evaluation Table  
(ONLY TO BE COMPLETED IF PROJECT IS SELECTED FOR BENEFIT EVALUATION)**

|  |  |
|--|--|
| <b>A1. Benefit Evaluation</b>  |  |
| Only some research projects will be chosen for a full benefit evaluation, and as it generally takes some time after project completion for benefits to be realised, this will most likely be undertaken as part of a "benefit evaluation" research project at some stage in the future. If this project is subsequently chosen, the following tables should be completed at the Benefit Evaluation date given in A2.3. |  |

|                                |                                    |
|--------------------------------|------------------------------------|
| <b>A1.1 Name of evaluator:</b> | <b>A1.2 Division of evaluator:</b> |
|--------------------------------|------------------------------------|

|  |  |
|--|--|
| <b>A1.3 Date Benefit Evaluation undertaken</b> |  |
| <b>Date:</b>                                   |  |

| <b>A1.4 Benefit Evaluation</b> | <b>Expected</b>               | <b>Achieved?<br/>(Y/N)</b>                                       | <b>Why benefit not achieved in full, if applicable?</b> | <b>Lessons learned</b> |
|--------------------------------|-------------------------------|--|---|------------------------|
|                                | (as per the Full Format Form) | * to be completed at Benefit Evaluation date given in A1.3 above |   |                        |
| Monetary benefits              | :                             |  |   |                        |
| Non-monetary benefits          | :                             |  |   |                        |
|                                | :                             |  |   |                        |
|                                | :                             |  |   |                        |

