

## **Cullen Scholarship: Biological changes in key commercially exploited fish in the light of Climate & Ocean Change (PhD Award)**

### **Background**

Under Ireland's Statutory National Adaptation Framework published in 2018, the Department of Agriculture, Food and the Marine are developing sectoral adaptation plans for Agriculture, Forestry and Seafood. This proposal is linked to that, and particularly the Seafood adaptation plan.

Key to developing such an adaptation plan is an understanding of the impacts of climate change on commercial fish species and consequently on the fisheries that exploit them. Reviews in this field (Heath et al 2012, and Wright et al 2020) have indicated a number of likely key changes supported by scientific studies. The key pressures identified were temperature changes and acidification. The main impacts cited were distribution and growth changes. Changes in fish distribution, both spatially and temporally, are being addressed in the post-doctoral research project "Climate and Fish Distribution" based at GMIT, and programmed to start in 2020. This project includes components examining growth changes, but predominantly in herring.

One of the key impacts identified by Wright et al (2020) was that temperature changes are demonstrably affecting fish growth and age at maturation. Rising temperatures also decrease oxygen solubility and increase metabolic costs and there is now considerable debate as to whether this is limiting the maximum size that fish species can attain. This phenomenon is known as the Temperature–Size Rule (TSR; Atkinson, 1994). Recent research has also indicated that changes in fish size may not all be negative, and that increased size can also occur, and that these changes can happen rapidly (Audzijonyte et al. 2020). The authors went on to say "*The rapid and variable responses of fish size to warming may herald unexpected impacts on ecosystem restructuring, with potentially greater consequences than if all species were shrinking*".

This PhD proposal is designed to complement the GMIT postdoctoral award, but focus on the thermal responses of the fish species. This will also link with the analysis of biogeographic changes in that project, as in addition to changes in size at the individual level, the average size of the fish community may also be declining due to the increasing number of Lusitanian (southern) species entering our waters, which tend to be smaller and have shorter life spans (Montero-Serra et al., 2015 van Walraven et al., 2017).

A further key impact of climate change on fish has been identified as phenology changes, or the timing of fish development stages in relation to the timing of other cyclic and seasonal natural phenomena (Wright et al 2020). This remains a much debated subject, but one of the key knowledge gaps is on the timing of spawning – earlier spawning would naturally lead to phenology changes. The project will therefore also include a study of what if any changes in spawning time can be identified for key commercial stocks in Irish waters.

This project will further build research and advisory capacity on climate and ocean change impacts on fish and fisheries, providing new insights into key commercially exploited fish species in Irish waters on life histories and phenologies. It will add significant value to the Climate and Fish Distribution project (GMIT) and support the Irish scientific advice on possible changes in the sector due to impacts of climate change on key fish species under the DAFM Climate Adaptation Plan.

### **Proposal**

We propose a structured four-year PhD project on a full-time basis to address commercial fish biogeography (life history metrics by region) and phenology (shifts in timing of key events such as maturation).

The project will aim to:

1. Document possible changes in key life history metrics linked to temperature impacts on fish size. These will include: length distribution; age at length, age and size at maturation & the proportion mature fish, condition factor, size and age of the first exploited year class. The study will focus on cod, haddock, herring, and possibly a flatfish species depending on data availability. Data will be sourced from national and international databases from surveys, landings and observer reports. It will be interrogated for three critical areas for Irish fisheries: The Irish Sea, Celtic Sea and Atlantic waters. Analysis will initially be based on statistical modelling, but if appropriate will be extended to mathematical ecological modelling possibly including the Ecopath with Ecosim (EwE) models available for the Irish and Celtic Seas
2. Investigate the MI otolith archives for cod, haddock and herring to reconstruct a digital record and database of growth, both for individuals and at the population level.
3. Link the life history metrics (Task 1) and the growth trajectories (Task 2) with the likely climate and ocean drivers, principally temperature, but others as appropriate. The project will collaborate with OSIS and the A4 Maynooth project to assess the appropriate drivers, the scale and resolution and suitable models for combining biological data with ocean drivers. The aim will be to project findings forward using ICCP climate scenarios to evaluate likely future changes.
4. Undertake a pilot study on key fish species otoliths, identified in Task 2, using microchemical analyses (Stable isotopes, trace element laser ablation, novel methods to detect stress events). To test the feasibility of identifying whether there has been a decadal change in feeding or breeding history indicative of a range or behaviour shift. Novel methods, such as those used on human hair, might facilitate the identification of stress events and/or spawning events.
5. Undertake a literature review, introduction, summary chapter and a discussion on the findings of the project and their possible implications for the future of important Irish fish stocks and their associated fisheries.
6. Data Sources: Irish and international databases from surveys, landings and observer reports especially those held by ICES & STECF, e.g. DATRAS for bottom trawl surveys, as well as assessment working group reports. Marine Institute fish otolith archives will be used.

## **Outcome**

The main expected outcome from the project will be an understanding of what changes can be described in the growth, maturation and phenology of key Irish fish stocks and a projection of these based on standard CC scenarios. Our hypotheses are that Climate and Ocean change will result in important changes to the biology, behaviour and phenology of our key exploited marine fish species. The working hypothesis is that we will expect to see changes in fish size, growth rate, and maturation in recent years and link those to the likely drivers, probably temperature changes. Ideally, we will establish a time series of the main metrics e.g. size at age that will illustrate trends and likely future paths.

It is expected to:

- Create strong links with the CLIMFISH distribution GMIT project and the A4 Maynooth project.
- Publish at least three peer-review papers
- Produce a PhD Thesis
- Add significant value to the data and the fish otolith archive in the Marine Institute
- Input to the advisory process on the DAFM Climate Adaptation plan for the Seafood Sector.

### **Links to MI Strategy**

This proposal falls principally under Strategic Focus Area 3 - Research & Innovation, which links strongly with Strategic Focus Area 2 – Forecasting Ocean & Climate Change, particularly in terms of the drivers for, and the impact of Climate Change on fish and fisheries. In turn, this links to Strategic Focus Area 1 – Scientific Advice & Services, specifically in providing advice for the Seafood Climate Change Adaptation plan.

### **Specific Requirements**

The scholar should have a primary degree in a natural or ocean science, and ideally a masters level degree in an appropriate field. The scholar should have an interest in both the biological science and in mathematical and statistical modelling. An interest in, and a knowledge of the oceans, fish and fisheries would be a great benefit.

The scholar will likely be based in Newport, but significant amounts of time will be required in MI Galway and GMIT Galway as well as their host Higher Education Institute.

### **Financial Details**

Scholarships will be up to €25,000 per annum (maximum funding of €100,000 over four years). This amount comprises a maintenance award of €16,000 (Irish Research Council rate) to the student as well as payment of fees to the host higher education institution (HEI). The maximum fees payable to the HEI will be €6,000 per annum. The scholarship award also includes a budget of up to €3,000 per annum for eligible research costs (travel & subsistence, publication costs, consumables and other costs e.g. laptop) for the sole use of the student, and are payable on a reimbursement basis direct to the host institution where the postgraduate student (scholar) is registered. There are no overheads payable on the scholarship. Publication costs are intended to cover publications on which the scholar is listed as first author and are published under Open Access.

### **Marine Institute Co-Supervisor(s)**

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