Foras na Mara
Marine Institute

Post-Doctoral Fellowship: Proposal Outline

Topic	Multi-species food web modelling in Irish waters for fishery management in the context of climate change
Research Theme(s)	1) Climate Change 2) Biodiversity, Ecosystems and Food-webs
Background and Rationale	The scientific basis of Ecosystem Based Fisheries Management has been developing fast over recent years (Dickey-Collas et al. 2022). Operational EBFM remains much less developed (Skern-Mauritzen et al 2016; Karnauskas et al. 2021), although possibly some progress has been made recently (Marshal et al 2018). At the same time, it has become increasingly important to be able to understand the links between climate change and the distribution and productivity of the fisheries we are trying to manage (Link et al 2021; Ruiz-Diaz 2022). Both these papers propose approaches to help to operationalize EBFM in the context of routine fisheries management and in providing advice on how to adapt that management to potential changes due to climate change. We propose to develop three different approaches that could be used to link EBFM explicitly to climate change and that could lead to operational advice and fisheries management. These would be: 1. The explicit inclusion of ecosystem understandings and linked indicators to setting fishing mortality targets that take account of changes in the ecosystem, and in particular climate change related trends. 2. Develop the Ecosystem Overfishing concept, where system productivity and overall fish removals can be cross-linked. 3. Adapt existing ecosystem/multi-species models to explicitly include climate change driven changes in fish distribution and productivity, are able to disentangle the effects of fishing and climate change from each other.
Scope of Research (Scientific/ Technical Challenge)	The overarching aim of this fellowship is to develop multispecies/food web modelling for fisheries in Irish waters and apply it to the three key areas: • Ecosystem indicators in single species stock assessment, • Ecosystem overfishing, and • Climate change impacts on fish distribution and productivity.

	This fellowship should determine the interactions between fisheries management and the ecosystem, particularly in the context of climate change. The fellowship should address key research objectives as follows: • Develop the F_{eco} concept (Bentley et al 2021) for application in the Celtic Sea and other areas e.g. small pelagics in the California Current (Howell pers.comm.). This uses ecosystem modelling to modulate fishing mortality (F) advice and hence removals considering ecosystem drivers of productivity. A similar approach has also been taken for the Atlantic Menhaden fishery (Chagaris et al 2021). This would link the developing ecosystem modelling work with practical management advice along the lines suggested in Karp et al (2021). This would be through both ecosystem modelling and elements of Management Strategy Evaluation of scenarios of use for F_{eco} within the current single species management paradigm. We would also propose examining use of the F_{eco} approach in a wider, social-ecological system context, where the objectives of the stakeholders could be incorporated and tested. • Develop the Ecosystem Overfishing concept (Link 2021), taking a more system wide and holistic approach. This would build on the work in Link (2021), and apply the approach first proposed by Fogarty et al and on work within the Irish FishKOSM project (Kempf, J., PhD Thesis in prep.). There is evidence of ecosystem overfishing in both jurisdictions, but this can be strongly affected by the assumptions made in the calculations. In particular, the ratio of Primary Production that can make it to higher trophic levels, and the proportion of the production that is potentially harvestable at a specified trophic level. Irish work also suggests a higher than assumed energy transfer efficiency (around 15% rather than 10%) in the Celtic Sea which may affect its resilience to climate change. • Develop our understanding of climate change impacts on fish stocks and fisheries. Link et al (2021) identified the most important impacts as being changes in the location and changes in their productivity (e.g. Free et al., 2019). The MI funded a new project in 2020 under the Cullen Fellowship programme entitled Climate Change and Fish Distribution (CLIMFISH). This post-doctoral project set out to look for evidence of climate change driven distribution changes in fish distributions from survey data. The results to date have been inconclusive, with little evidence of the distribution or community changes hypothesized, and that have been seen elsewhere (e.g. Poloczanska et al., 2016). Recent complimentary work in the Celtic Sea (Kempf et al 2022) also showed that the main driver of changes in abundance of the main fish species was fishing pressure rather than any environmental influence. The likely explanation for these findings is that, to date, there is little evidence of climate change driven changes in

	temperature in the Celtic Sea. The distribution work is ongoing, and the MI project partners (Cóilín Minto and Louise Vaughan, at the Atlantic Technical University – Galway) are aiming to implement models in the VAST geostatistical modelling framework (Thorson et al., 2015). We would propose to continue developing these analyses, and to develop analyses of productivity changes in the Celtic Sea. Through the collaboration with NOAA we would plan to draw on their expertise to support this. The challenge is how to disentangle the impacts of fishing pressure and climate change on fish stocks, distributions and the wider fish communities, to allow projections of the likely changes driven by climate change in the future. This is a necessary step to allow us to provide advice on how to manage fisheries in an era of changing climate. **Rationale for a collaborative project** This proposal presents concepts for collaborative research between the MI and NOAA in the USA. It is designed to build on both NOAA and MI research work capitalizing on the experience of each. • The F_{eco} concept was largely developed in Europe, with a leading role by the MI and collaborators in the ICES WKIrish process. The work of Chagaris et al (2020) is complimentary, but as stated above there is also interest in the specific F_{eco} concept in the US. This aspect of the project could be seen then as Irish led. • The EOF concept was largely developed in the USA. The approach has since been applied to Irish fisheries with considerable success. This aspect of the project could be seen then as a parallel in the two jurisdictions. • Research into climate change driven changes in distribution and productivity is probably more mature in the Americas, with much clearer findings. In this case we would see the MI as learning from skills and understandings from NOAA.
Expected Impact(s)	The primary impact will be to further develop the knowledge needed to provide advice to fisheries managers (DAFM and EC) on the implications of climate change and other ecosystem drivers on the best possible management of fisheries. This approach, Ecosystem Based Fisheries Management (EBFM), is a stated aim in EU fishery and marine environment legislation (Common Fisheries Policy – CFP (EU 2013)) and the Marine Strategy Framework Directive – MSFD (EU 2008)). The fellowship will also build on the strong networking links between the MI and NOAA, particularly in the EBFM field.

	The fellow is also expected to engage with relevant national and international networks, and explore opportunities for collaboration and securing further European and international research funding, for example under Horizon Europe.
Outcomes	The principle outcome will be in provision of advice, firstly, on the likely impacts of climate change to fishery management in Irish waters, and secondly, any appropriate management measures that could be deployed. The project will provide the knowledge base for applying and using indicators such as Feco – for single stock management, EOF – for multi-species management, and indicators of changes in spatial distribution and productivity for key stocks. With the exception of Feco (only applied in the Irish Sea to date), none of these indicators and relevant management advice are currently available. The research is highly current and will result in numbers of peer reviewed papers, conference presentations etc. It will enhance the MI contribution to ICES and other WGs providing integrated advice at EU level. We would also propose developing policy briefings for both Irish and EU managers. It is expected that the research will be appropriate for leveraging further funding particularly from the EU Horizon Europe framework, but also under INTERREG. National funding under DAFM, SFI and IRC may also be possible for leverage.
Specific Collaboration	Dr. Jason Link, Senior Scientist for Ecosystem Management at National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service. jason.link@noaa.gov. The fellowship will be planned to include several extended visits to NOAA Woods Hole, Mass. to develop the collaborations, and to enhance the transfer of knowledge and techniques. Existing collaborations with ATU, Natural England, and the University of Strathclyde, UK, and of Rennes, France will be integrated into the project. The project fellow will also collaborate with the Ocean modelling team in OCIS, Marine Institute and will take part in appropriate ICES Expert Groups.
Location of Fellow	Marine Institute (Galway) and/or Higher Education Institute or Public Research Body (Republic of Ireland or Northern Ireland) The fellow will be primarily based in the Marine Institute dependent on accommodation and in discussion with the HEI involved. At the Marine Institute, the contact will be Professor Dave Reid (David.Reid@Marine.ie).

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Duration and Funding Available	4 years €100,000 per annum (i.e. total €400,000 maximum for duration of four years)
References	Bentley, J. W., et al. (2021). Refining Fisheries Advice with Stock-Specific Ecosystem Information. Frontiers in Marine Science 8(346). https://doi.org/10.3389/fmars.2021.602072 Chagaris, D., K. Drew, et al. (2020). Ecological Reference Points for Atlantic Menhaden Established Using an Ecosystem Model of Intermediate Complexity. Frontiers in Marine Science 7(1043). https://doi.org/10.3389/fmars.2020.606417 Dickey-Collas, M., J. S. Link, et al. (2022). Exploring ecosystem-based management in the North Atlantic. Journal of Fish Biology https://doi.org/10.1111/jfb.15168 EU (2013) EU. Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC Brussels: Official Journal of the European Union; 2013. EU (2008) DIRECTIVE 2008/56/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive) Fogarty, M. J., A. A. Rosenberg, et al. (2016). Fishery production potential of large marine ecosystems: A prototype analysis. Environmental Development. 17, (Supplement 1): 211-219. Free, C. M., Thorson, J. T., Pinsky, M. L., Oken, K. L., Wiedenmann, J., and Jensen, O. P. 2019. Impacts of historical warming on marine fisheries production. Science, 363: 979–983. Karnauskas, M., J. F. Walter Iii, et al. (2021). To EBFM or not to EBFM? that is not the question. Fish and Fisheries. https://doi.org/10.1111/faf.12538 Karp, M. A., J. S. Link, et al. (2023). Increasing the uptake of multispecies models in fisheries management. ICES Journal of Marine Science: https://doi.org/10.1093/icesjms/fsad001 Kempf, J., Breen, P., Rogan, E., & Reid, D.G. (2022). Trends in the abundance of Celtic Sea demersal fish: Identifying the relative importance of fishing and environmental drivers. Frontiers in Marine Science 9. https://doi.org/10.3389/fmars.2022.978654

	Link, J. S. (2021). Evidence of ecosystem overfishing in U.S. large marine ecosystems. ICES Journal of Marine Science 78(9): 3176–3201. Link, J. S., M. A. Karp, et al. (2021). Proposed business rules to incorporate climate-induced changes in fisheries management. ICES Journal of Marine Science 78(10): 3562–3580. Marshall, K. N., L. E. Koehn, et al. (2018). Inclusion of ecosystem information in US fish stock assessments suggests progress toward ecosystem-based fisheries management. ICES Journal of Marine Science 76(1): 1–9. Peterman, R.M., et al (2000) Comparison of parameter estimation methods for detecting climate-induced changes in productivity of Pacific salmon (Oncorhynchus spp.). Can. J. Fish. & Aq. Sci. 57:181–191. Poloczanska, E. S., Burrows, M. T., Brown, C. J., García Molinos, J., Halpern, B. S., Hoegh-Guldberg, O., Kappel, C. V. et al. 2016. Responses of marine organisms to climate change across oceans. Frontiers in Marine Science, 3. https://doi.org/10.3389/fmars.2016.00062 Ruiz-Diaz, R. (2022). Using an EBFM lens to guide the management of marine biological resources under changing conditions. Fish and Fisheries https://doi.org/10.1111/faf.12719