100 years of Defra data: What can we learn about climate change, fish, and fisheries?

Marine Theme Objective: State of the Marine Environment

What's the problem?

There is a need to develop sustainable fisheries exploitation strategies in the face of climate change. Defra, with Cefas are amongst the world's longest running fisheries research bodies and holds unique historical fisheries data which is potentially extremely valuable in examining climate change impacts. Such data are highly relevant for understanding the long-term effects of fisheries, pollution, and other human impacts on marine living resources. Yet despite this uniqueness, most pre-1970s data are not electronically available. This project aims to collate and digitise fish and fisheries data, collected over the past 100 years by Defra, Cefas, and predecessors. These data will then be used to examine changes in distributions of commercially important North Sea fish populations from 1913 inwards, in relation to climate change and fishing pressure. Moreover, the project will investigate long-term changes in stock structure, age and size compositions of key fish populations.

What are the aims of the project?

The aims of the project are:

- To digitise paper records of Defra's commercial fisheries 'Statistical Charts', covering the period 1913–1981 and providing extensive, spatially detailed information on distributions of UK fishing effort and fish populations.
- Based on the digitised data, to describe and map the long-term changes in the spatial distributions of key commercial fish populations in the North Sea, including plaice, sole, cod, haddock and whiting (Figure 1).
- To examine how changes in fish distributions may relate to climate change, fishing pressure, and/or other potential anthropogenic drivers.
- To create an inventory of the availability of Cefas' historical scientific survey data and to prioritise the datasets that will then be digitised within this project.
- To compare the data results with 'modern' survey data, to examine how the structure of fish populations has changed and to compare the present situation with historical trends.

Which policy areas will the research inform?

The work will help in defining reference conditions for a pristine, less impacted state of the environment. This is relevant for qualitative descriptors for determining 'Good Environmental Status' (Marine Strategy Framework Directive, Annex I). Furthermore, the research findings will inform our understanding of responses of fish populations have responded to climate change, improving process understanding and helping to predict future responses to climate change.

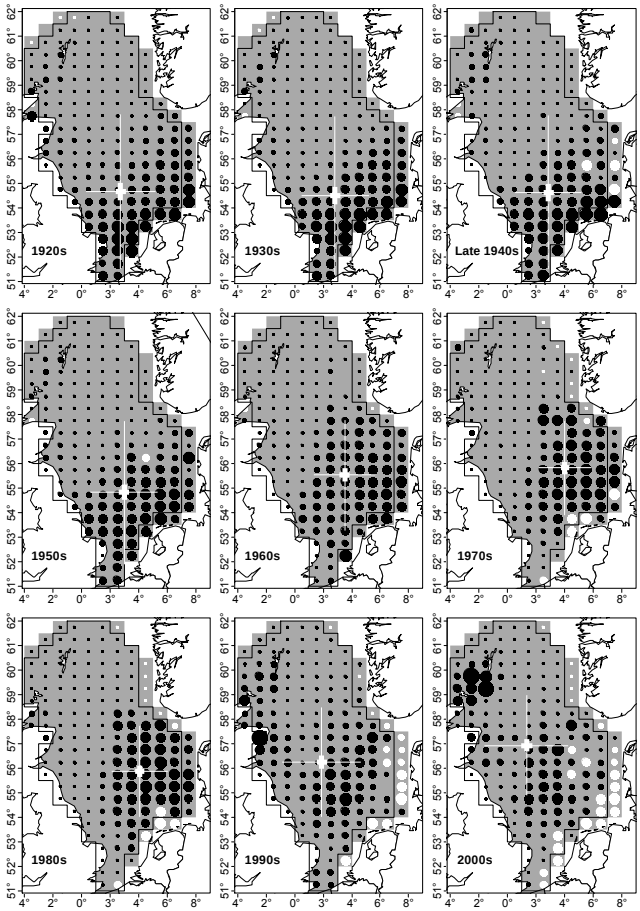

Figure 1: The distribution of North Sea plaice, 1920s to 2000s. The white cross shows, by decade, the 'centre of gravity' (longitudinal and latitudinal) of plaice distribution, which has shifted gradually over the course of the century and especially in recent decades has moved north-west. From Engelhard et al. (ICES Journal of Marine Science, in press).

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What are the results from the project and how will they be used?

As a key outcome, results from the project are showing that over the past 9–10 decades, fish populations of key importance to the UK have shown major distribution shifts within the North Sea. For plaice, shifts are illustrated in Figure 1, and shifts of similar magnitude have been mapped for sole, cod, and haddock. This is to our knowledge the first time that such spatially resolved distribution maps for a large marine area as the North Sea, over a period approaching a century, were compiled for any fish species.

To what extent is fish distribution shifts the result of depletions by fishing, or attributable to climate change (a northward shift being expected with warming temperatures)? For plaice, we found that the shift was attributable to climate change rather than to fishing. Conversely, both climate and fishing played a role in the distribution shift of sole. We came to these conclusions by first quantifying the shifts by calculating for each year the latitudinal and longitudinal 'centre of gravity' of sole and plaice distribution, and also the mean depth distribution (Figure 2). The 'centres of gravity' of these two species have shown very different trends in the past 50 years – plaice shifting northward (and westward) and to deeper waters, sole gradually shifting southwestward, and to shallower waters.

Next, we examined statistically (using general linear models) how climate change and fishing pressure can explain the distributional responses, and for sole this is illustrated graphically in Figure 3. Clearly, both higher temperatures and greater fishing pressure are associated with a southward distribution shift of sole (and also westward and to shallower waters, not illustrated here). In plaice, warmer temperatures led to a northward (and deepening) shift, but there was no link with fishing pressure.

Sole, a species with very high value, has been targeted by an intensive beam trawl fishery for half a century now, whereas plaice is merely a desirable by-catch species in this mixed flatfish fishery. As expected, results therefore show a strong link with fishing pressure in sole but not with plaice. The northward, 'deepening' shift in plaice is in line with expected responses of cold-water species to climate change. Sole, as a warm-water species, are known to suffer high mortalities during severe winters particularly in shallow waters, hence warming temperatures might allow these fish to survive better in shallow waters.

Fish distribution shifts are a topic of much debate, as stocks may move away from, or towards management or closure areas in place to conserve stocks, sometimes leading to disputes about fishing rights. The long-term Defra data have allowed this to be one of the first studies that disentangled the effects of climate change and fishing on fish distribution shifts, and this will help in predicting the future responses of fish stocks. In 2011, this work is to be extended to other species of high importance to the UK fisheries.

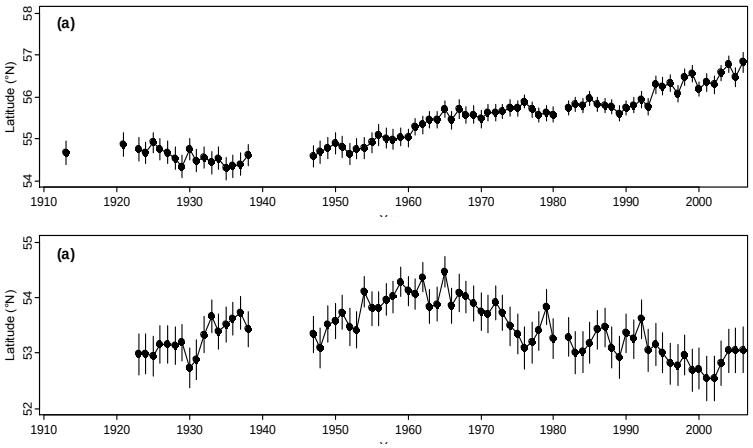

Figure 2. Changes in latitudinal 'centre of gravity' of North Sea plaice (top) and sole (bottom) distribution, over the course of the 20th and early 21st Century.

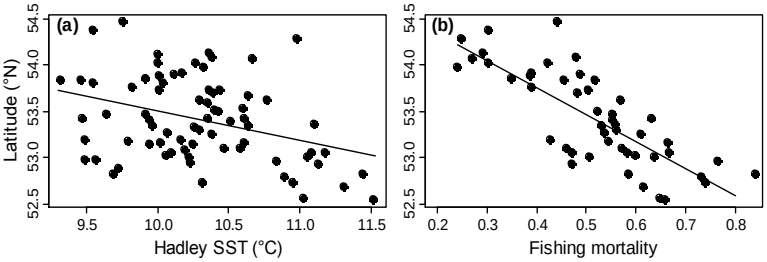

Figure 3. Mean latitudinal distribution of North Sea sole in relation to (a) Hadley sea surface temperature (SST) and (b) commercial fishing pressure on sole.

Where can I find further information about this and related research?

Cefas are responsible for delivering this research. For further information on the project, please contact Dr. Georg H. Engelhard (georg.engelhard@cefas.co.uk).

Alternatively, please contact Defra's Marine and Fisheries Science Unit: marinescience@defra.gsi.gov.uk

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