"FinE"

The overlooked evolutionary dimension of modern fisheries

Today, fishing is the dominant source of mortality in most commercially exploited fish stocks. According to the United Nation's Food and Agricultural Organisation (FAO), world capture fisheries have reached a ceiling, with three stocks out of four being maximally exploited or overexploited. This does not only change the abundance of exploited fish but also their traits and genetic composition, adding an evolutionary dimension to fisheries. Evolutionary changes in fish stocks must be of concern to managers, since they are bound to affect sustainable yield as well as the stability and recovery of stocks.

Removing the largest fish over several generations has gradually caused a **"Darwinian debt"**: the fish that remained in these populations became progressively smaller. In addition, maturation age has dropped, for example in Northern Arctic Cod it went down from 9-10 years to 5-6 years, which has reduced initial egg production by 50%. Moreover, eggs are smaller and have a lower survival and growth rate. Even behavioural traits like foraging and feeding rate have declined. All of these morphological and behavioral changes are the result of the fish's attempts to stay out of fishing gears.

Unfortunately, the speed at which these changes occur is much faster than previously believed. Moreover, as the changes are genetic, they don't immediately go away when fishing ceases: models suggest that each year during which current exploitation continues may require several years of evolutionary recovery.

The Specific Targeted Research Project on **Fisheries-induced Evolution (FinE)** is set up to **analyze the prevalence and consequences of fisheries-induced adaptive changes in exploited fish stocks** of particular relevance to fisheries management in the European Union. Its aims are to unravel the underlying mechanisms of change ranging from the phenotypic to the genetic level, to evaluate their consequences on population and fisheries dynamics, and to provide recommendations for evolutionary enlightened management.

FinE's overall objective can be broken down into three main lines of research:

1. **Phenotypic case studies** will aim at documenting phenotypic trends in life-history traits relevant for the demography and productivity of exploited fish populations, thus focusing on maturation, reproductive effort and growth. In order to assess the ubiquity of fisheries-induced adaptive changes, the following exploited stocks from European and North American water will be investigated:

- Atlantic cod in the Barents Sea
- Atlantic cod in Canada
- North Sea gadoids
- Flatfish
- Small pelagics
- Atlantic salmon
- Landlocked salmonids

Phenotypic fisheries-induced changes in these groups will consequently be compared and synthesised to dissociate observed phenotypic changes from a potentially underlying evolutionary component, which will allow for the assessment of

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"THE FINE PROJECT WILL DELIVER INSIGHTS AND RECOMMENDATIONS FOR ADDRESSING THE OVERLOOKED EVOLUTIONARY DIMENSION OF MODERN FISHERIES"

the degree of reversibility of the fisheries-induced changes.

2. **Genetics analyses** will aim to elucidate the genetic basis of fisheries-induced evolutionary changes suggested by phenotypic analysis. These studies will rely on the development of innovative molecular and statistical methodologies allowing tackling temporal adaptive genetic changes.

3. **Eco-genetic models** will be designed for

- evaluating alternative hypotheses advanced to explain observed data;
- assessing the ecological consequences of fisheries-induced evolution in terms of exploited stock dynamics, viability and recovery, as well as fisheries yield; and for
- comparing various management scenarios.

Because of the wide range of scientific experiences and approaches required for tackling these challenges, the FinE project aims at combining fields of expertise as diverse as population genetics and quantitative genetics, life-history theory, population dynamics, evolutionary theory and fisheries science.

To summarize, the FinE project will deliver insights and recommendations for addressing the overlooked evolutionary dimension of modern fisheries. Its dynamic approach to fish stocks as study systems in conjunction with a modern understanding of the effects of exploitation on patterns of growth, reproduction, population diversification, and their genetic underpinning, will greatly benefit both basic science and the development of management strategies capable of ensuring the sustainable exploitation of living resources.