Learning from the past and stepping into the future: Population dynamics of Atlantic cod (Gadus morhua) revealed by historical DNA

Marine fish biodiversity is often highly variable in space and time, and the additional impacts of human exploitation and climate change might greatly affect the survival of many organisms within the ocean. Dramatic changes in the abundance of many fish populations have been widely observed over time together with shifting distributional range. However, it is known that population diversity or biocomplexity underpins ecosystem functioning and productivity, and stabilizes ecosystem processes and services. Thus, preserving intraspecific genetic diversity is of paramount importance for successful management and conservation of marine fish.

The present thesis uses a spatiotemporal population genetic approach to examine historical dynamics of Atlantic cod populations (Gadus morhua) in Greenland and to elucidate how they have differentially responded to intense fishing pressure and environmental changes over the past century. Utilizing unique collections of archived fish samples, the overarching goals of this PhD project were to (1) examine the temporal stability of population structure of cod, (2) disentangle the population dynamics and how they have responded to intense fishing and environmental variability, and (3) understand important patterns of population connectivity. The thesis opens with a general introduction which briefly describes the historical and recent perception of world fisheries resources in human society (Chapter 1). The following chapters review relevant knowledge and methodological issues which have provided a critical rationale for addressing the research questions in this work. Chapter 2 emphasizes the importance of recognizing complex population structure in classical marine fish to reach effective management goals. Chapter 3 defines the most important drivers of genetic variation, and how these can generate detrimental demographic and evolutionary effects in marine fish populations. Chapter 4 presents the field of fisheries genetics, giving particular emphasis on genetic stock identification and retrospective genetic monitoring. Subsequently, a collection of manuscripts is provided. The different studies have revealed (Paper 1) complex and dynamic interactions of four genetically distinct populations of cod, (Paper 2) that the different populations exhibited dramatic spatiotemporal changes in abundance and distribution and responded markedly different to historical commercial fishing and recent increases of ocean temperatures, (Paper 3) historical fish tags as a useful source of DNA for conducting retrospective genetic analysis, and (Paper 4) long-distance natal homing in cod. Overall, this thesis provides unprecedented insights into the population dynamics of Atlantic cod at the northern margin of its distribution. It illustrates how temporally spaced DNA samples offer a unique opportunity for disentangling the effects of primary forces shaping marine fish populations accumulated over decades or even a century. Of particular note, Paper 1, 2 and 4 represent some of the first concrete examples of how spatiotemporal data delivered by geneticists can be successfully applied in current fisheries management schemes.

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