# Comunicating data science

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### Introduction

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Atlantic cod also known by its scientific name Gadus morhua is one of the most commercially important fish species in the world, with a long history of human exploitation dating back to the 10th century during by the Vikings Kurlansky (1998a).

This species has been an important source of food and income for coastal communities across the North Atlantic region, supporting a vast industry of fishermen, processors, and distributors for centuries. However, the sustainability of the Atlantic cod fishery has been increasingly threatened in recent years due to overfishing, habitat destruction, and climate change.

The warming of ocean waters, caused by increasing greenhouse gas emissions, has altered the biology, ecology, and behaviour of Atlantic cod, leading to declines in population and distribution. These changes have had significant impacts on the commercial fishing industry, which has relied heavily on Atlantic cod as a source of income and food for centuries.

In recent years, scientific research and policy efforts have been focused on understanding the impacts of climate change on Atlantic cod, and developing sustainable fishing strategies that take into account the changing environmental conditions.

This report aims to review the current state of knowledge on the impact of climate change on Atlantic cod, including the ecological and environmental factors that shape its distribution and abundance, considering some of the socio-economic implications of its decline, and the strategies for sustainable management and conservation in the face of climate change.

Through an analysis of the data regarding sea surface temperature increase and fishing, this report seeks to contribute to a more comprehensive and evidence-based understanding of the challenges associated with the Atlantic cod fishery in the era of climate change.

## Background and context

Atlantic cod fishing has a long and complex history that dates back to at least the 11th century. Cod was a vital food source for European colonizers and became one of the most important commercial fish species in the North Atlantic.

The first recorded European explorers to fish for cod in North America were the Vikings, who fished for cod off the coast of Newfoundland around 1000 AD. Later, in the 15th and 16th centuries, European fishermen established seasonal fishing camps along the New England nicknaming it Cape Cod Kurlansky (1998b).

As European fishing fleets grew in size and range, they began to explore deeper waters and more distant fishing grounds, leading to the development of large-scale commercial fishing operations. By the late 18th century, French and English fleets were competing for the rich cod fisheries of the Grand Banks and other areas leading to the modernization and a significant increase of cod fishing Kurlansky (1998c).

As such from its beginning of being an important food source, to its increased values in trade as a commodity and its increased in significance culturally due to it becoming a staple of many coastal diets and the naval development that produced experienced seamen and naval infrastructure that was required during the naval arms race of the colonial era.

## Objectives

The report aims to analyse the impacts of climate change on Atlantic cod fisheries in Iceland, Norway, Denmark and Scotland. The objectives of the report include evaluating the state of Atlantic cod fisheries from 1950 to 2010, identifying the scientific evidence linking climate change to changes in Atlantic cod's biology, ecology, and behaviour, identifying the key challenges facing the fisheries, and examining potential innovative management approaches to promote the resilience, adaptation, and sustainability of Atlantic cod fisheries.

The countries of Iceland, Norway and Denmark were chosen due to their availability of cod in their natural waters, the economy value of the fish and the long lasting traditions of cod consumption from the Viking era.

### specify why these countries

iceland, norway gdp

proof of cultural significance on these countries

Overall, the report aims to provide a comprehensive analysis of the ecological consequences of climate change on Atlantic cod fisheries and propose strategies for adaptation and mitigation. exhaustion of code fisheries (fishing quotas, alternative fishing, like fishlike code pangaceas)

#### Scope and limitations

The report is limited in scope to the impacts of climate change on Atlantic cod fisheries in Iceland, Norway, Denmark and Scotland from 1950 to 2010. The report does not cover other fish species or historical changes in Atlantic cod populations prior to the onset of climate change. The analysis is based on existing scientific research and data, which may be limited in scope or availability. While the report provides an analysis of the ecological impact of climate change on Atlantic cod fisheries, it does not advocate for specific management strategies or policy recommendations. The report aims to provide a comprehensive analysis of the issues and potential solutions within the knowledge and expertise limitations of the author.

fish data is only yearly and doesnt fully represent fishing seasons tempature sensitivy of measuring equipment may mean there are measurement erros which aren't accounted for

### TODO talk here about overfishing as a limitation that is hard to account for

## II. Climate Change and its Impact on Cod Fisheries

#### Causes and Effects of Climate Change

Climate change is primarily caused by the increase in greenhouse gases (GHGs) in the atmosphere, particularly carbon dioxide (CO2). Human activities, such as burning fossil fuels, deforestation, and agriculture, are the main sources of GHG emissions. These activities release large amounts of CO2 and other GHGs into the atmosphere, trapping heat and warming the planet.

Climate change is having a significant impact on plant and animal species, and these changes are having ripple effects throughout ecosystems. One of the most significant impacts of climate

change on ecosystems is that it is causing shifts in the behavior and distribution of species. As temperatures and precipitation patterns change, some species are migrating to cooler or wetter areas. For example, some fish species are moving further north or to deeper waters in response to warming ocean temperatures.

These shifts in the distribution of species can have significant implications for ecosystems. As species move, they may encounter new competitors, predators, or prey, which can have cascading effects on food webs. Additionally, if certain species decline or disappear entirely, it can impact the availability of food and other resources for other species. This can lead to changes in the abundance and distribution of species, and can have significant impacts on ecosystem health and function.

Changes in ecosystems can also have impacts on human livelihoods. For example, in the fishing industry, changes in the distribution of fish species can impact the abundance and availability of fish, which can impact the success of fishing operations. Similarly, changes in the distribution of tree species can impact the forestry industry by altering the availability of timber and other forest products. These impacts can have economic and social implications for communities that rely on these industries for their livelihoods.

III. The Effects of Climate Change on Cod Fisheries in Denmark, Iceland, and Norway A. Denmark Overview of Denmark's Cod Fisheries The Effects of Climate Change on Denmark's Cod Fisheries B. Iceland Overview of Iceland's Cod Fisheries The Effects of Climate Change on Iceland's Cod Fisheries C. Norway Overview of Norway's Cod Fisheries The Effects of Climate Change on Norway's Cod Fisheries C. Scotland Overview of Scotland's Cod Fisheries The Effects of Climate Change on Scotland's Cod Fisheries

V. Conclusion A. Summary of Findings B. Implications for Cod Fisheries and Fishing Communities C. Future Directions for Research and Action

This improves the world because goverments can take this data to plan for longevitie of cod supplies for future generations

```
adf.test(timeSeriesIceland)
```

```
    Augmented Dickey-Fuller Test

data:  timeSeriesIceland
Dickey-Fuller = -3.5896, Lag order = 9, p-value = 0.03369
alternative hypothesis: stationary
```

If the p-value of the test is less than 0.05, you can reject the null hypothesis that the time series is non-stationary and assume that it is stationary.

```r
arima_model <- auto.arima(timeSeriesIceland)

summary(arima_model)
```

```
Series: timeSeriesIceland
ARIMA(2,0,2)(0,1,1)[12]

Coefficients:
        ar1     ar2     ma1      ma2     sma1
      0.205  0.4741  0.5556  -0.0970  -0.8644
s.e.  0.250  0.1834  0.2509   0.0536   0.0244

sigma^2 = 0.1138:  log likelihood = -245.53
AIC=503.06   AICc=503.17   BIC=530.53

Training set error measures:
                         ME      RMSE       MAE        MPE     MAPE     MASE
Training set -0.0004178092 0.3334673 0.2625421 -0.2899174 4.317829 0.560623
                     ACF1
Training set -0.001528177
```

## References


Kurlansky, Mark. 1998a. *Cod*. Penguin Books.

———. 1998b. *Cod*. Penguin Books.

———. 1998c. *Cod*. Penguin Books.