The spatial-temporal distribution of Arctic cod (Boreogadus saida L.) in the western Arctic Ocean and its response to the climate change

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Introduction

The Arctic Ocean and adjacent seas are strongly influenced by global climate. Recent analyses have revealed trends over the past 20-30 years of decreasing sea ice extent and sea level pressure in the Arctic Ocean coincident with warming trend. Fishes intimately associated with arctic freshwater and estuarine systems are of great significance to local human populations as well as significant keycomponents of the marine ecosystems. Accordingly, increasing interest in understanding the impacts of climate change on these components is very high. For fishes, climate change may strongly influence the distribution and abundance. These changes may have impacts on the nature and value of commercial fisheries.

Materials and methods

Data

The fish biological data is derived from the Data Warehouse of School of Fisheries and Ocean Science (SFOS), University of Alaska, Fairbanks.

Statistical analysis

Generalized additive models (GAMs) are a useful tool for exploratory analysis where the range of relationships can be extended to curves and nonlinear surface. In this study, GAMs were used to estimate and quantify the effect of several climate indices (predictors) and their interaction on the abundance of Arctic cod (dependent variable) expressed as a sum of smooth functions of the predictors. A Gaussian error model was used in the GAM analysis, with a link identity function.

Results

Temporal variation on abundance

The abundance of Arctic cod has a significant trend during 1950 to 2007. Non-influenced by global climate. Recent analyses of factors. So more data, especially the biotic data, should be involved in the modelling for these components is very high. For fishes, climate change may strongly influence the distribution and examined whether the distributions of Arctic cod are significant (Kruskal-Wallis, \( \chi^2 = 11, p < 0.001 \)). The correlation between the abundance and all response variations \( (\chi^2 = 35, \text{df} = 5, p < 0.001) \) (Figure 1). The abundance of Arctic cod is significantly lower than that in the previous decades. A relatively higher abundance can be found in the Bering Sea in 1980s and 1990s. In 1980s and 1990s, the survey locations are significantly lower than those in the previous decades. A relatively higher abundance can be found in the Bering Sea in 1980s and 1990s.

Spatial distribution of abundance

Temporal variation on abundance

The abundance of Arctic cod from 1950 to 2007 is shown in Figure 1. The abundance of Arctic cod is significantly lower in the Bering Sea, although the abundance is very low. Only one individual can be found in the area at most of survey period.

In 1970 to 1980, the higher abundance occurred in the Bering Sea, particularly off the waters of the Aleutian and the Bering Straits, the northern Canada and the Hudson Bay, and in the Beaufort Sea, particularly off the western waters of the Beaufort Sea and the Chukchi Sea. In the Hudson Bay, the abundance is still lower abundance can be found in the Bering Sea. In 1970s, the abundance is highest in the Chukchi Sea. In 1980s and 1990s, the survey locations are significantly lower than that in the previous decades. In 1980s and 1990s, the abundance is highest in the Bering Sea and the Chukchi Sea.

The response of abundance to the climate change

Table 1 shows the change of model's parameters when stepwise add response variations. The total deviance explained level of Table 1 can be found from:

http://www.esrl.noaa.gov/psd/data/climateindices/

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Further information

For equation 1, *g*(*) is the link function, \( \mu \) is intercept, \( \beta_j \) the non-parametric functions that describe the linking between \( *g*(*) \) and \( \epsilon \) explanatory variables.

For equation 2, the non-standardized square, \( \psi \) effective degree of freedom, \( \varphi \) variance. For Table 1, \( \psi \) deviance, \( \varphi \) degrees of freedom, \( \text{AIC} \) deviance explained, \( \text{AIC} \) pseudo-coefficient. The explanations of the other abbreviations in the table 1 can be found from:

https://www.esrl.noaa.gov/psd/guidesumanuals/glossary/