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CYCLIC CLIMATE CHANGES AND MAJOR COMMERCIAL STOCKS IN THE ARCTIC REGION

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Abstract

Long-term dynamics of spring-spawning herring and North-East Arctic cod recruitment is reported to be in line with the several main Arctic climatic indices, such as Arctic air surface temperature (Arctic dT) and mean temperature of 200m water column along the “Kola Meridian” section (Kola meridian dT). Variation in the herring stock recruitment is shown to be in correlation with the Arctic dT and Kola meridian dT dynamics, while the cod recruitment follows these indices with a 8-10 years lag. Russian Arctic and Antarctic Research Institute (AARI) reports that for the last 100 years Arctic dT has displayed some 60-year regular fluctuations with maximums in the 1940s и 2000s, and suggests a descending trend in the Arctic dT in the near 10-20 years. Thus, in the next 10 years, commercial herring stocks are likely to decrease, while the cod commercial stocks to increase. The walleye pollock fishable biomass in the Bering Sea for the last 35 years was shown to vary in line with PDO (Pacific Decadal Oscillation), the main temperature index of the North Pacific. In particular, higher values of the walleye pollock fishable biomass were attributed to positive PDO anomalies, while the lower values of biomass was characteristic to the negative PDO anomalies. Analyzing both PDO and Solar activity dynamics for last 100 years, a negative PDO trend in the North Pacific may be forecasted. Therefore, a gradual decrease in the fishable walleye pollock biomass is likely to take place in

Introduction

Climatic borders of the Arctic are much broader than its geographical ones. Climatic zone of the Arctic Region is limited by location of the 10-degree July isotherm and includes the Barents Sea, the Norwegian Sea and the Bering Sea which are of great importance for the fishing industry in Russia, Norway and the USA. Total catch of walleye pollock, herring, cod, haddock and other fishes exceeds 2 million tons. Climate changes in the region affect the population of the main commercial stock that causes economic and social consequences.

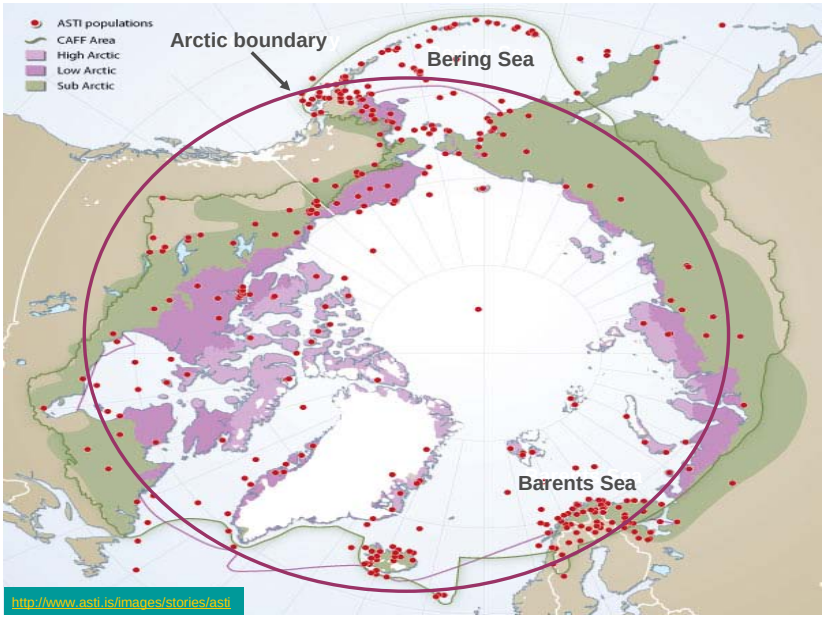

Fig.1. Geographical and climatic (10-degree July isotherm) borders of Arctic region

Materials and Methods

This work analyses data on herring and cod stock recruitment dynamics in three-year-olds according to ICES statistics (Anonymous, 2002, 2008). The data on Global temperature (Global dT) dynamics for the last 157 years were obtained from the Climatic Hadley Center official website: metoffice.gov.uk/hadobs; the 100-year dynamics of the Arctic air surface temperature (Arctic dT) was kindly furnished by Arctic &Antarctic Research Institute (AARI,) St.Petersburg, Russia (Frolov

et. al., 2007), and by International Arctic Research Center (IARC), Fairbanks, Alaska; http://research.iarc.edu (Polyakov, 2008). Time series of mean temperature of 200m water column along the "Kola Meridian" section (Kola Meridian dT) was obtained from Polar Institute of Fisheries and Oceanography website: http://www.pinro.ru/labs. The long-term trends were determined using smoothing techniques assumed in the modern statistics (Hardle, 1993) Correlation coefficients between recruitment dynamics and climatic indices trend were calculated by square modules of time-series data coherency spectra. The assessment was carried out using the classical periodogram and cross-periodogram averaging method (Brillinger, 1975; Bendat, Piersol, 1986; Lyubushin, 2007)

Results and discussion

Proceeding from the data by three main Arctic Centers: Headley Center (UK) , International Arctic Research Center (IARC, USA) and Arctic &Antarctic Research Institute (AARI, Russia), Arctic temperature oscillates with roughly 60-year period over the last 100 years, with a maximum in the mid 1940s, a minimum in the late 1960s and a new maximum in the 2000s. Kola Meridian dT trend correlates with Arctic dT trend. According to various sources, the long-term variability of the air temperature and the water column temperature are very similar (Fig. 2).

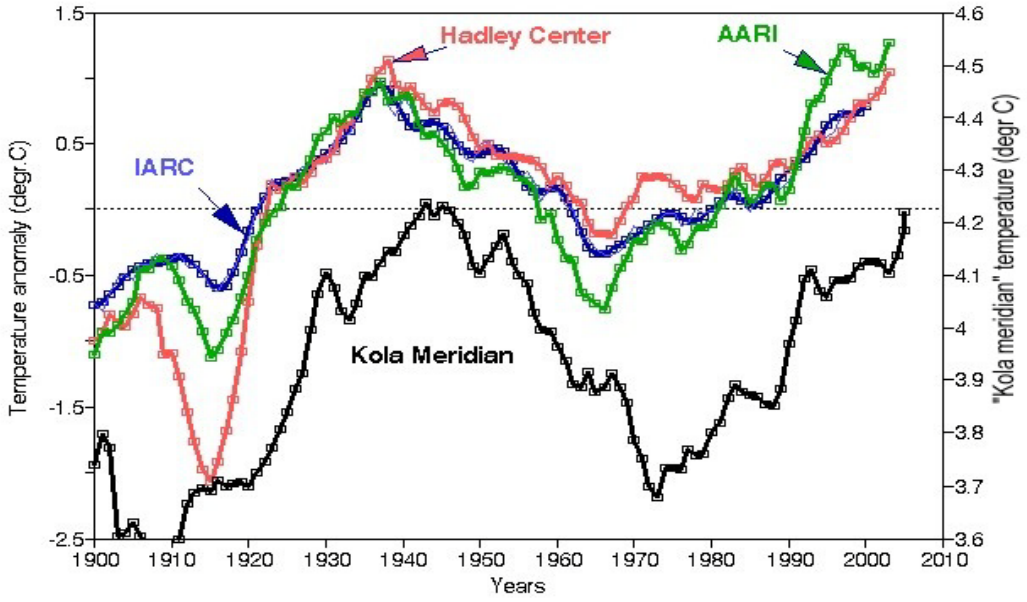

Fig. 2 Comparative dynamics of Arctic air and "Kola meridian" temperature, 1900-2008

The comparison of smoothed data on water column temperature dynamics and herring recruitment for more than 100 years shows their synchronous changes with a high correlation index (r=0.76). We believe that the long-term dynamics of the herring stock recruitment follows the air and water column temperature variation in the Arctic Region. Therefore, surface air and water temperature dynamics in the Arctic is likely to be the basic factor that controls herring stock recruitment over the region (Fig. 3).

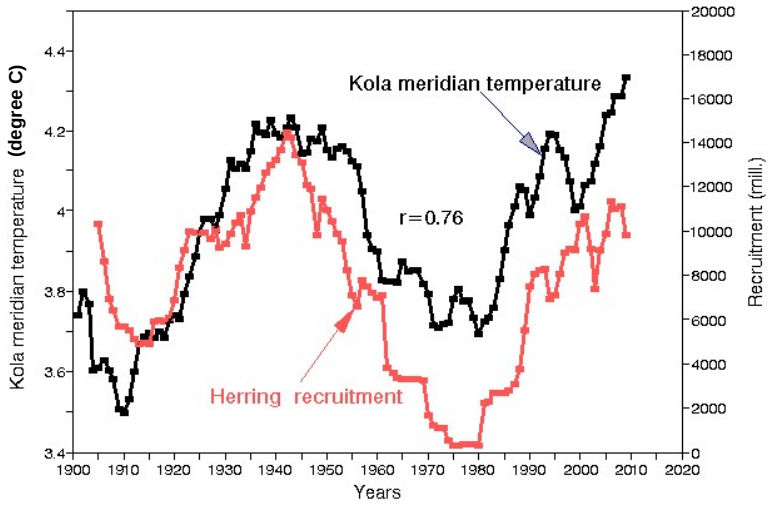

Fig.3. Comparative dynamics of “Kola meridian” temperature and herring stock recruitment, 1900-2008

In contrast with the herring population that varies synchronously with temperature change, the cod stock recruitment trend lags behind the Arctic dT and Kola Meridian dT. Shifting the cod recruitment curve by 12 years back results in its virtually complete coincidence with the aforementioned climatic indices (correlation coefficient is 0.74) (Fig.4)

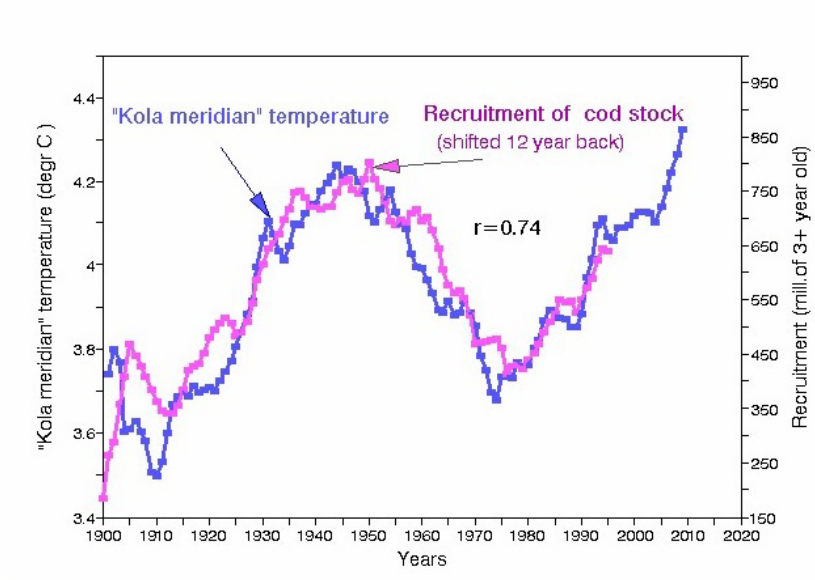

Fig.4. Comparative dynamics of “Kola meridian” temperature and recruitment of cod stock, shifted 12 years back (see text), 1900-2008.

The walleye pollock is the most abundant commercial species of North Pacific. Its maximum catch (7 mill.t) was observed in period of 1980s, corresponds with PDO (i.e. ocean surface temperature) dynamics (Fig.5).

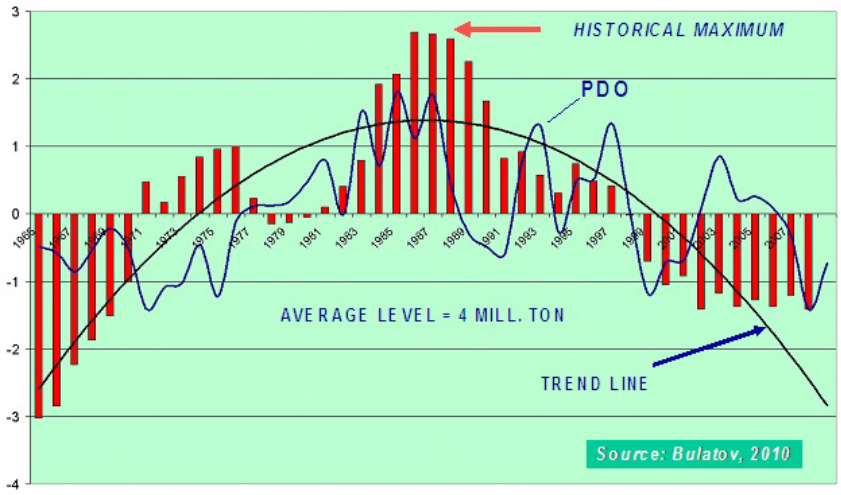

Fig.5. World pollock catch anomalies (bars, mill.ton) and PDO dynamics (line), 1965-2008

In the Bering Sea, the walleye pollock biomass shows a high annual variability. In 1980s, the high walleye pollock commercial stock coincided with positive PDO values. In the recent years, both PDO index (i.e. the ocean surface temperature) and the walleye pollock stock was decreasing (Fig.6)

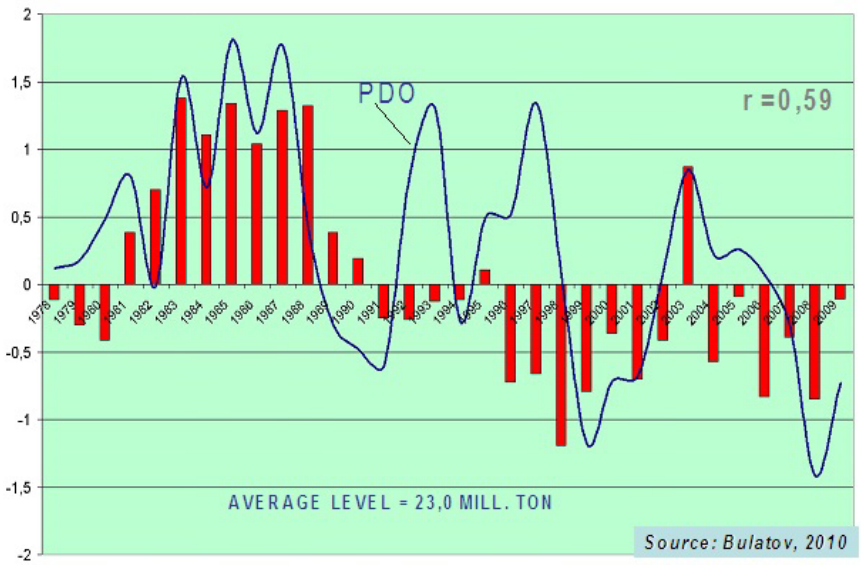

Fig.6. Bering Sea Pollock biomass anomalies (bars) and PDO dynamics (line), 1978-2009

To what extent are climatic changes in the Arctic Region and the North Pacific linked? Although these areas are distant from each other, periods of warming and cooling in the Atlantic Sector of the Arctic and in the North Pacific take place roughly simultaneously (Fig.7)

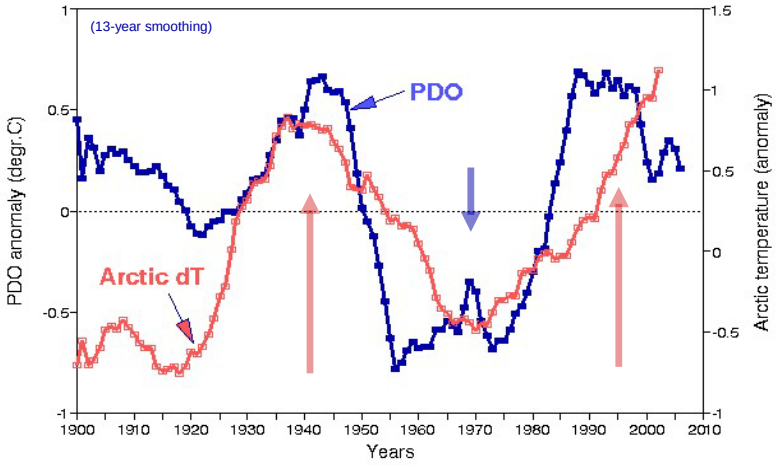

Fig.7. Comparative dynamics of Arctic air temperature and PDO, 1900-2009

The longest (150 years) time series of instrumental temperature observations have been recorded in the Gulf of Alaska area. Analysis of entire time series showed a long-term cyclic variation of the ocean surface temperature with the 59-year period (Fig.8)

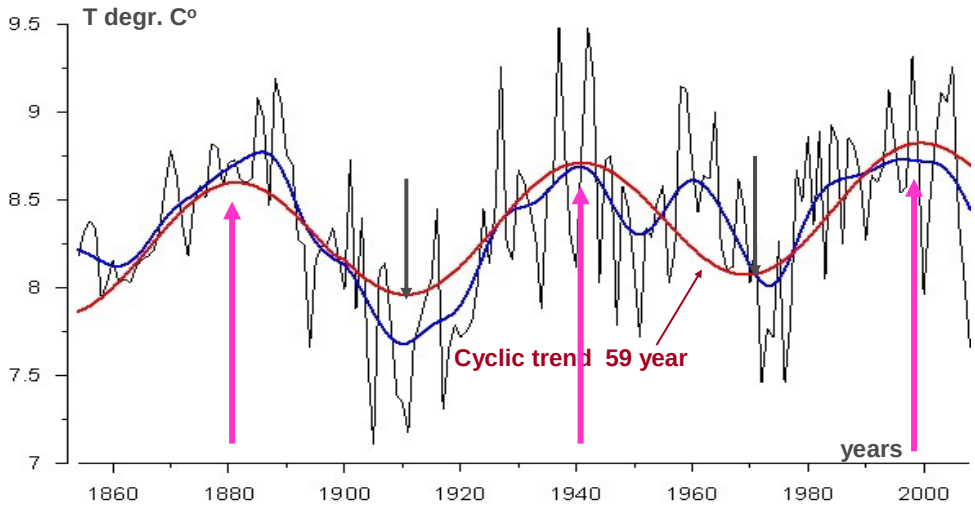

Fig.8 Cyclic trends of surface temperature in the Gulf of Alaska in 1854-2000 (W.Crawford, S.McKinnell, 2009)

Basing on the analysis of 100-year investigations, the Arctic &Antarctic Research Institute of the Russian Federation (AARI) anticipate that Arctic dT dynamics is subject to nearly 60-year fluctuations and forecast a gradual temperature decrease in the near 10-20 years (Fig.9).

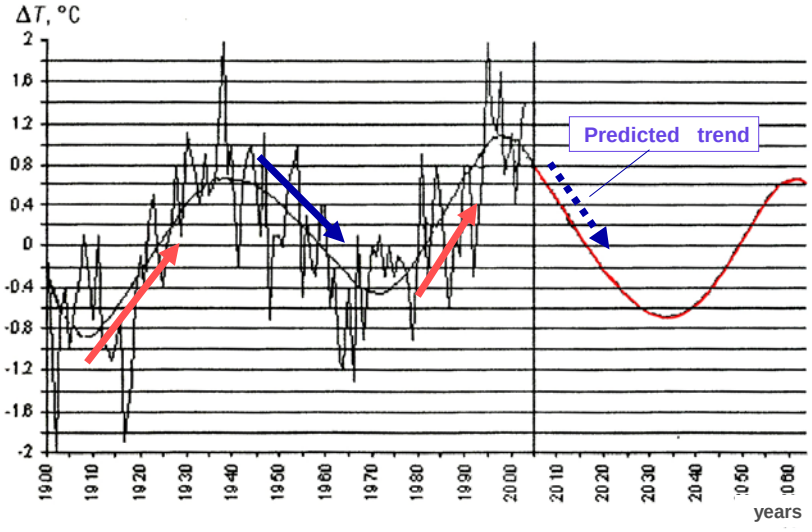

Fig.9. Arctic air temperature dynamics in 1900-2005 and its future trend according to Russian Arctic and Antarctic Institute(AARI) forecast

In the recent 100 years, the Total Solar Irradiation (TSI) dynamics is well correlated with PDO, showing roughly 60-year cyclic variation and indicating TSI and PDO (i.e. temperature) gradual decline after 2000s. Apparently, the next "cooling epoch" may be expected in the 2010s-2030s

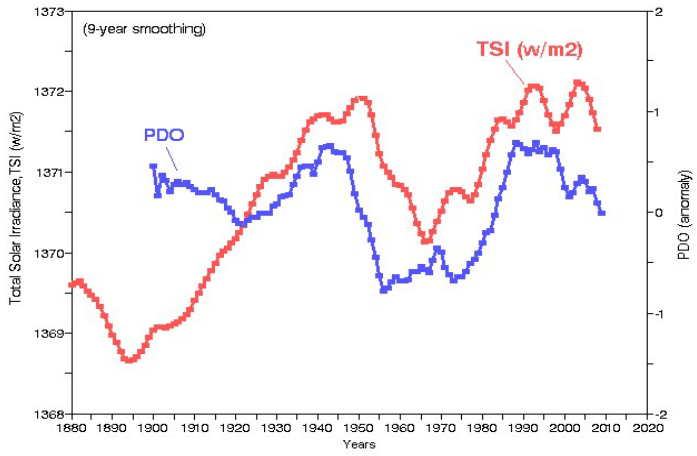

Fig.10. Comparative dynamics of Pacific Decadal Oscillation (PDO) and Total Solar Irradiation (TSI), 1900-2008

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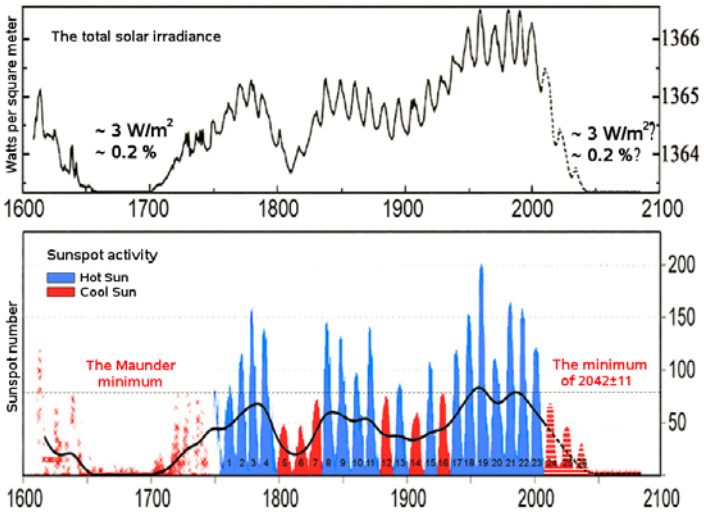
Recently, climate variations for successive several decades are estimated with a wide use of solar physics approaches and methods, in particular, the data on relation between air temperature changes and Total Solar Irradiance (TSI), Sunspot Activity and intensity of the so-called "Solar wind". Fig. 11 shows the epochs of high and low Solar Activity. On the evidence by solar physicists, a considerable decrease of the Sunspot Activity in 2010s-2030s, will be followed by the long-term "cooling down", period with an expected a decrease of the average surface air temperature by 0.5-0.7°.



http://solarscience.msfc.nasa.gov

Fig.11. Dynamics of the Total Solar Irradiance (TSI), Sunspot activity in 1600-2000 and forecast up to 2050s

Dr. Easterbrook, a known American climatologist, suggests one of three possible cooling down scenarios after 2010:

(i) a relatively low weak one as in 1945-1977;

(ii) (ii) a moderate one as in 1880-1915;

and (iii) a significant one analogous to the known climatic Dalton Minimum (1790-1820).

As can be seen from the Fig. 12, in the last 15 years, Global dT stops increasing or even slightly decreases that may denote probability of the initiation of the "cooling" climatic phase in 2010s-2030s (http://wattsupwiththat.com/2011/06/17/easterbrook-on-the-potential-demise-of-sunspots/).

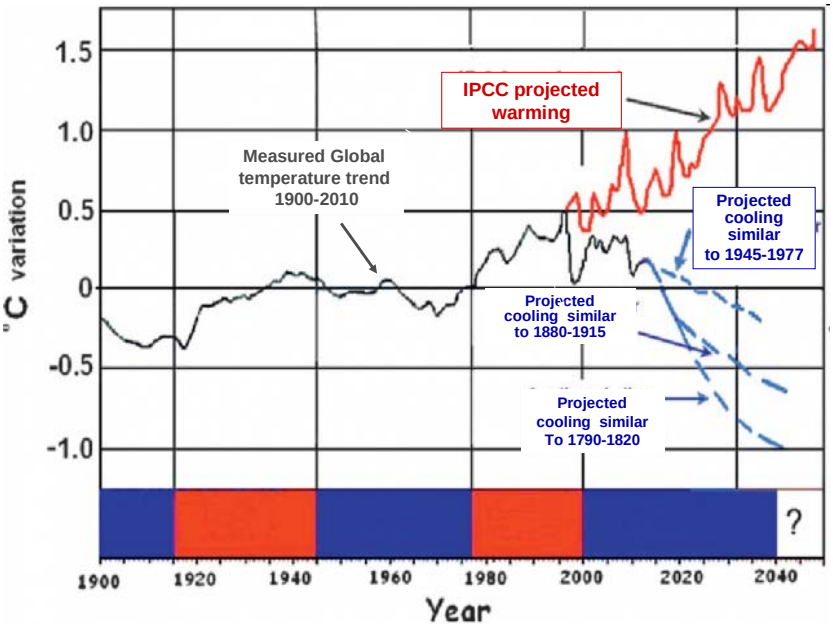


Fig.12. Three possible scenarios of lowering Global temperature in the next period 2010-2030s

Conclusion

According to the long-term forecast, a “cooling” period is expected in the Arctic and North Pacific regions in the nearest 10-20 years.

In the Atlantic Sector of the Arctic, on the background of temperature decrease, herring commercial stocks will likely to decrease in the near decade, while the cod biomass will likely to increase up to 2020s, and then will start decreasing.

In the Pacific Sector of the Arctic (the Bering Sea), a significant decrease of fishable walleye pollock biomass is expected in the next 10-20 years.

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