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WALLEYE POLLOCK BIOMASS DYNAMICS IN THE BERING SEA: POSSIBILITY OF LONG-TERM FORECASTING

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WALLEYE POLLOCK BIOMASS DYNAMICS IN THE BERING SEA: POSSIBILITY OF LONG-TERM FORECASTING

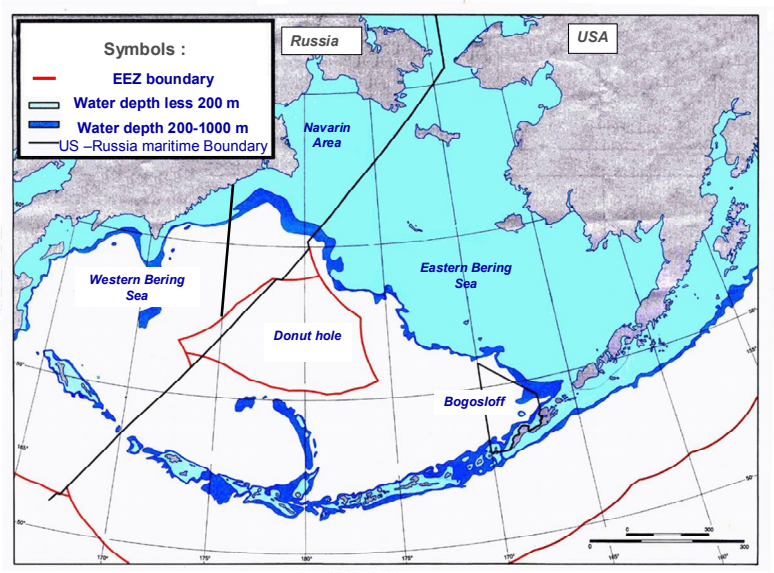
Abstract

A 100 year time series of the major indices were examined: air temperature in the Arctic (Arctic dT), Pacific Decadal Oscillation (PDO), Aleutian Low Pressure Index (ALPI) and Total Solar Irradiance (TSI) index. All climatic indices and TSI show common cyclic dynamics of 60-65 year periods with peaks in 1940s and 2000s and minimum in the 1960-1970s. The historical maximum of the total biomass of walleye pollock was observed in the mid 1980s (32 million tons), which was followed by a notable decline in biomass. According to working hypothesis the downward trend in the total pollock biomass will continue up to historic minimum in 2020-2030.

Slide 1

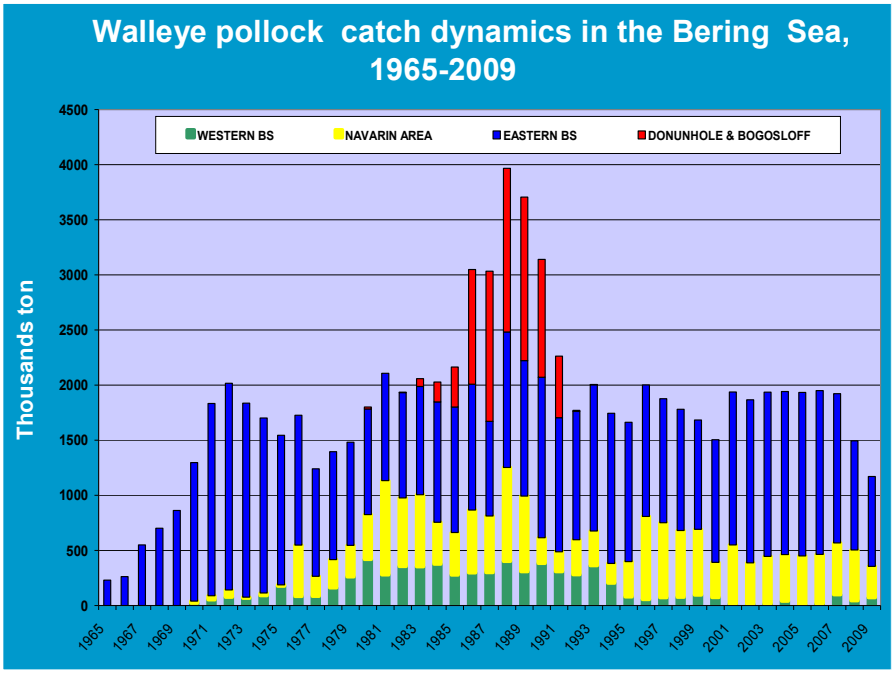
Slide 2.

The Bering Sea is the northernmost body of water in the Pacific. Its area is 2.3 million km2; the shelf occupies 1 million km2. This slide shows subdivisions in the Bering Sea. Formally, the sea is not a part of Arctic though it does not differ from the seas of Arctic zone in terms of climate.



Slide 3.

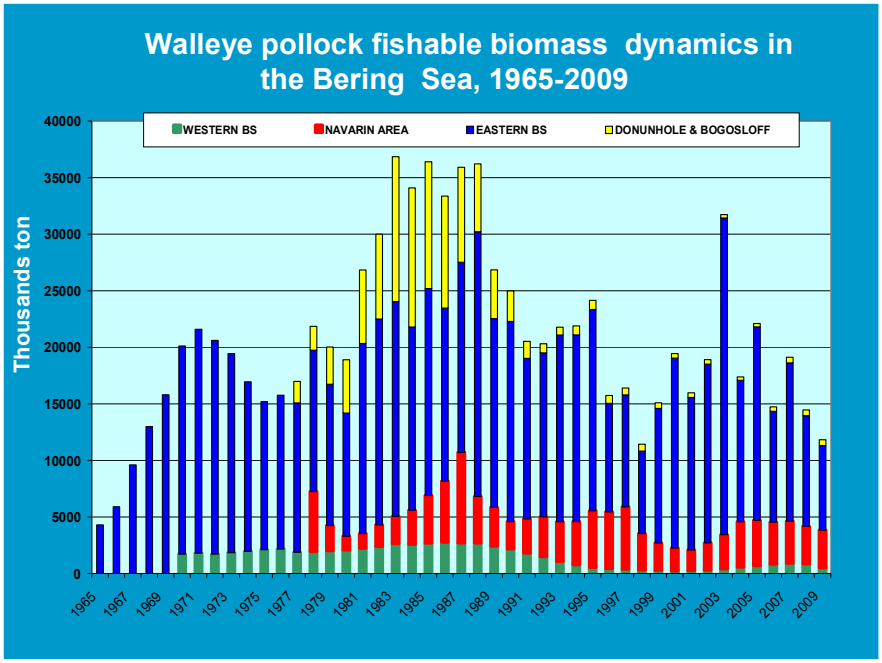
Pollock is one of the most important species for the global fisheries. The major fishing grounds for pollock are located in the Bering and Okhotsk Seas. Historically the large scale fisheries for pollock in the Bering Sea date back to over 40 years. Since then three peak catch periods were recorded: the early 1970s, 1980-1990s and 2001-2007s. The record catch of 4 million tons occurred in 1989; catches of about 2 million tons were quite frequent during the other years. The minimum catch of 1.2-1.5 million tons was taken in 1977, 2001 and 2009. The leading region for pollock fisheries is the eastern Bering Sea (US EEZ); Navarin region in the Russian EEZ is important too. During some years (1985-1991) the Donut hole high seas area of the sea was a place of significant fisheries; the 1989 catch there amounted to 1.5 million tons. The western Bering Sea is the least important for pollock fisheries.



Slide 4.

There were three periods when the biomass of Bering Sea pollock was at a high level: early 1970, 1982-1990, 2003-2007; the fishable stock either reached or exceeded 20 million tons then. The main stocks of pollock are concentrated in the eastern Bering Sea (US EEZ).

Navarin region and the West Bering Sea are by far less abundant. The acute rise in pollock biomass observed in the Donut hole in the 1980s has not repeated itself.



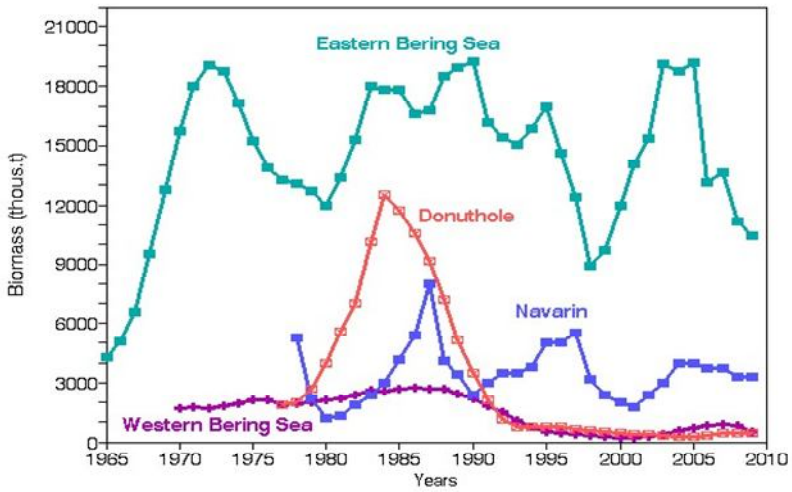
Slide 5.

The multiannual changes in pollock biomass occurring in different regions have different rates. Four lowest biomass values have been recorded in the east of the sea: 1965, 1980, 1999 and 2009. Except 1965, the lowest stock values was between 9 and 12 million tons while the maximum biomass reached 19 million tons while the up and down ratio was 2:1.

There was a totally different situation with pollock stocks in the Donut hole. The maximum of 12 million tons reached in 1984 was followed by as fast a decline in biomass. Beginning from the early 1990s there was a depression which is still going on.

In Navarin region there were three peaks as well: 1987, 1997, 2005. Numerically they were much lower (4 million tons or more).

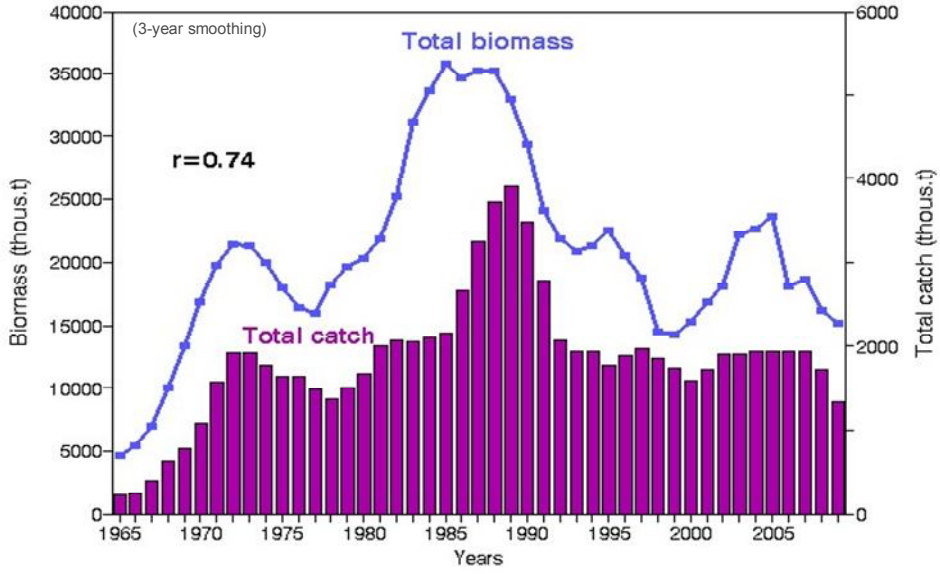
Comparative dynamics of walleye pollock biomass in different regions of the Bering Sea 1965 - 2009



Slide 6.

Comparison of pollock stock and catch dynamics for the whole Bering Sea shows their relationship. Correlation analysis made it possible to find out their statistically reliable dependence. It can be assumed that the catch which changes proportionally to stocks was not the cause of their decline or growth.

Comparative dynamics of the Bering Sea walleye pollock
total biomass and catch 1965-2009



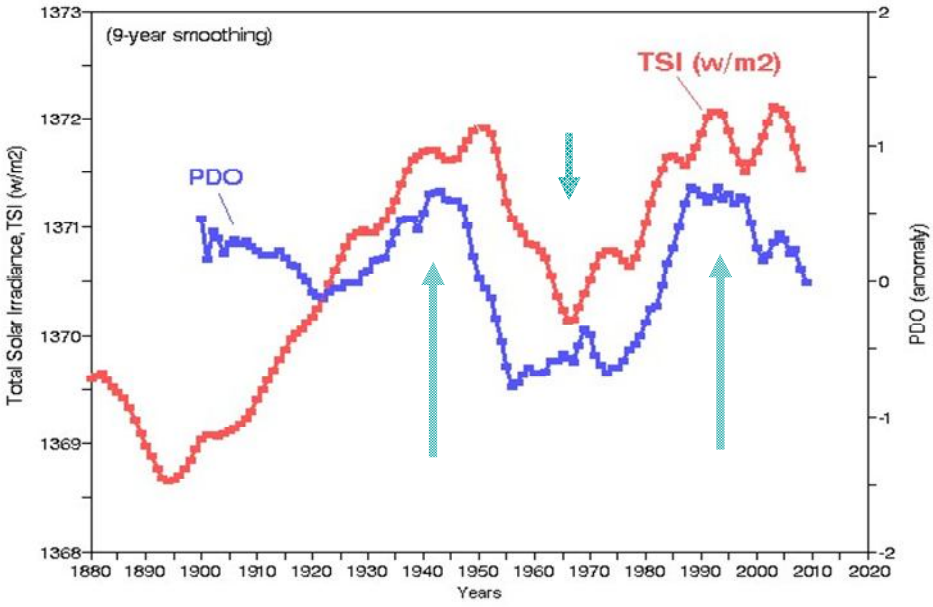
Slide 7.

Temperature conditions have a considerable impact on the development of pollock in early life history, on the rate of its further growth and success of reproduction, shaping strong or weak generations. Temperature is main limiting factor for possible reproduction, development and growth of pollock.

The main climate indicator of the mean surface temperature in the North Pacific including the Bering Sea is the Pacific Decadal Oscillation (PDO). Slide 7 presents data on comparison of the widely used climate index PDO with the index of Total Solar Irradiation (TSI). Similarity of the long-range dynamics of these indices allows us to regard the changes in solar intensity as one of the major factors causing temperature variations in the North Pacific.

The maximum values in the 20-th century were in 1945-1950 and in 1990-2005. The lowest were in 1955-1975. The year 2005 was followed by a new downward phase of TSI and PDO.

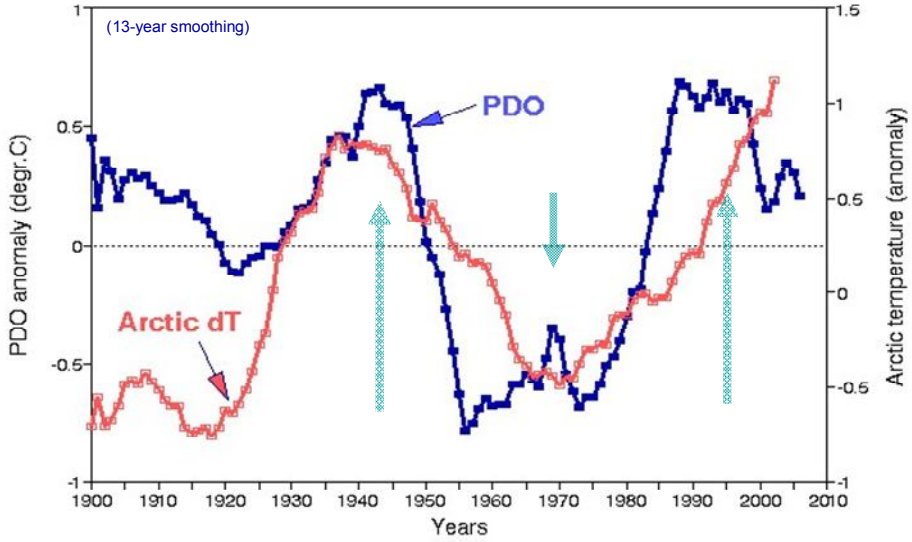
Comparative dynamics of Pacific Decadal Oscillation (PDO)
and Total Solar Irradiation (TSI) 1900-2008



Slide 8.

Comparative analysis of centennial dynamics of PDO and air temperature in Arctic (Arctic dT) in 1900-2005 shows similarity of temperature changes occurring in Arctic and North Pacific. There were two periods of warming in Arctic in the 20-th century with an interval of about 55-60 years.

Comparative dynamics of the Arctic dT and PDO
1900 - 2008

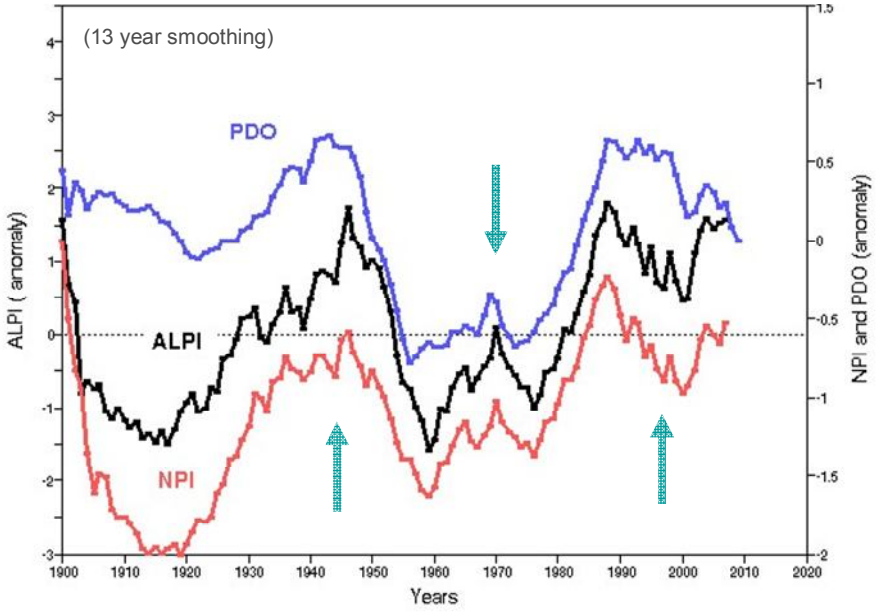


Slide 9.

Century-old dynamics of the main climate indices for the North Pacific: PDO, ALPI (Aleutian Low Pressure Index) and NPI (North Pacific Index) show cyclic fluctuations simultaneous with an about 55-60 year period. Two maxima were recorded in the 20-th century: the first was in the 1940s, the second in 1990s,

which changed over into downward phase. The PDO dynamics agree the course of changes in ALPI and NPI indices which determine the pattern of atmospheric circulation in the region.

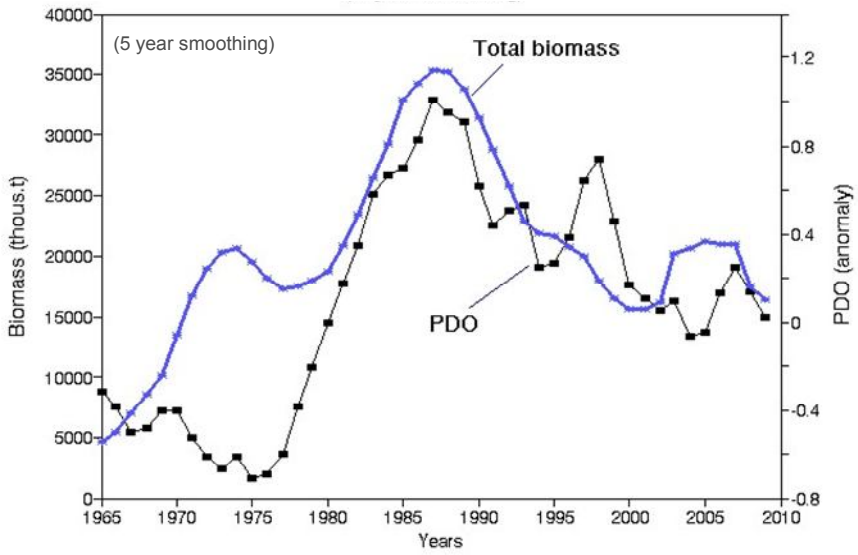
Comparative dynamics of Pacific Decadal Oscillation (PDO),
Aleutians Low Pressure Index (ALPI) and North Pacific Index (NPI)



Slide 10.

Dynamics of fishable biomass of walleye pollock generally agree with PDO. Retrospectively, the peak of the Bering Sea walleye pollock biomass coincided with the maximum values of PDO in the 1990s. Between 1978 and 1995 the upward and downward trends in PDO and biomass were simultaneous. Later, walleye pollock stocks dropped and that trend agreed with PDO decline. The differences in those trends in 1965-1977 can be attributed to the fact that systematic walleye pollock biomass assessment had not been done yet.

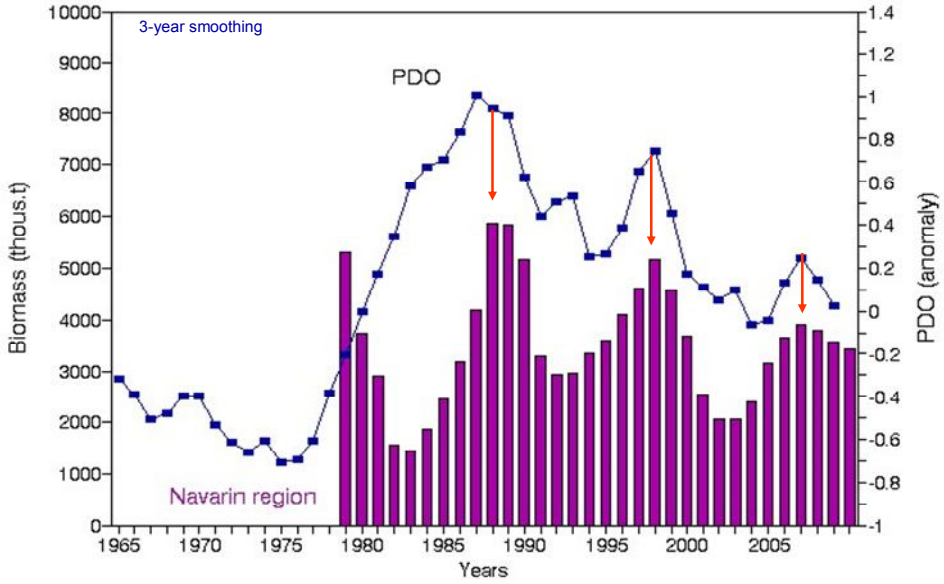
Comparative dynamics of Pacific Decadal Oscillation (PDO)
and total Bering Sea walleye pollock biomass



Slide 11.

The closest results were shown by PDO index anomalies and variations in walleye pollock biomass in Navarin region if the data are smoothed for 3 years. There was a notable accord between the three biomass maxima and positive PDO anomalies observed in the late 1980s, in the late 1990s and in 2007. Besides, variability trends agreed as well.

Comparative dynamics of Pacific Decadal Oscillation (PDO) and pollock biomass in the Navarin region, 1979-2009



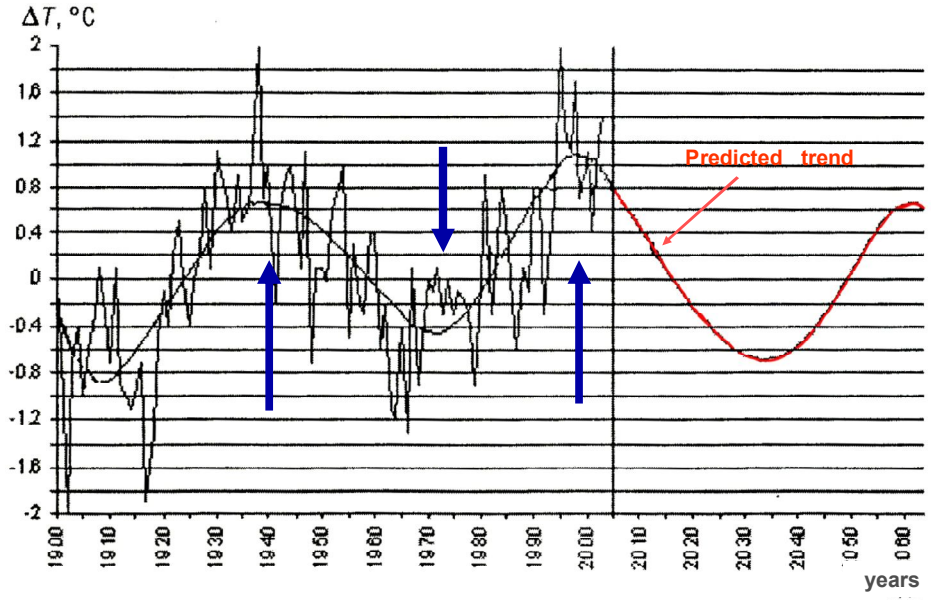
The upward and downward trends in Bering Sea pollock stocks found, and PDO anomalies constitute a trend only; they do not make it possible to project future changes in biomass in a statistically confident way. However, the relationships detected make it possible to forecast variations in Bering Sea pollock stocks qualitatively, depending on climate changes: ‘high”, “medium”, “low”.

Slide 12.

The Russian Arctic and Antarctic Research Institute data indicate that the air surface temperatures in Arctic in the past 100 years follow a roughly 60 year cycle. The second in the 20-th century warming climatic cycle is being completed in the North Pacific. A downward trend in temperature is expected in 2010-2030s, which in our view may give rise to a significant decline in pollock stocks of the Bering Sea.

Arctic air surface temperature 1900-2005 and its probable long term trend according to prediction of Russian Arctic and Antarctic Research Institute (AARI)

From the book: Frolov et al., (2009). "Climate Change in Eurasian Arctic Shelf Seas. Centennial Ice Cover Observations. Praxis Publishing Ltd, Chichester, UK, 164p. "



Conclusions

Variations in PDO, ALPI, NPI, TSI and Arctic dT observed in recent 100 years prove the existence of a roughly 60 year regularity in climatic changes of the North Pacific and Arctic. At present the period warming is ending, and temperature is passing into a cooling trend phase.

As forecasted this cooling will affect the stock condition of pollock in the Bering Sea. A decrease in biomass of this species valued by the global fisheries might be expected in 2010s-2030s.

The climate–based forecast does not suggest any annual fluctuations in the fisheries stock but points to interannual trend, i.e. direction of long-term changes.