3. DYNAMICS OF GLOBAL CLIMATIC INDICES AND MAIN COMMERCIAL CATCHES

An important question is whether the main commercial stock production is affected by common factors, which also control the synchronous fluctuations of the principal climatic, geophysical and biological indices.

The total world marine catch averages 73 million tons per year, which consists of about 550 species. However, as few as 12 species (about 2 percent of total number of commercial species) provide up to 40-50% of the world marine catch. These are: Japanese, Californian Peruvian and European sardine, Pacific salmon, Alaska pollock, Chilean jack mackerel, Peruvian anchovy, Atlantic cod, Atlantic and Pacific herring, South African sardine, and Peruvian anchovy. Seventy to ninety percent of the total commercial catches in Russia, Norway, Iceland, Japan, Peru, and Chile depend on these commercial species (hereafter referred to as the "major commercial species"). The remaining 538 species constitute the second half of total marine catch.

In the late 1980s, the annual commercial catch in the Pacific was close to 54 million tons. The total catch of the 5 main Pacific commercial species (Japanese and Peruvian sardine, Alaska pollock, Chilean jack mackerel, and Peruvian anchovy) made up 52% of this total (28 million tons). In the late 1960s, the total marine catch in the Atlantic was estimated to be 22 million tons, of which three of the five main Atlantic commercial species (Atlantic cod, Atlantic herring and South African sardine) made up 44% (9.6 million tons).

It was found that the 12 major commercial species could be divided into two principal groups, based on the peculiarities of their long-term dynamics (Fig. 3.1 and 3.2). The first group consisted of Japanese, Californian and Peruvian sardine, Pacific salmon, Alaskan pollock, Chilean jack mackerel, Peruvian anchovy and European sardine. The maximum catch of these species occurred in the late 1930s and early 1990s, with the minimum catch in the 1960s. The second group comprises Atlantic cod, Atlantic and Pacific herring, South African sardine, and Peruvian anchovy. The maximum catch for this group was in the 1960s, and the minima occurred in the 1930s and 1990s. Therefore, the catch dynamics of the two groups are opposite in phase.

Several characteristics are used to indicate the climate changes. The global temperature anomaly (dT) is a widely known climatic index, but as described above, it is quite variable and its trend can only be traced reliably after considerable (> 10 year) smoothing. Unlike dT, ACI is less variable and so is a more convenient index.

The catches of these groups undergo synchronous, long-term fluctuations, which are likely to be caused by changes in some common natural factors, such as global climate change. Therefore, an important issue is the degree of correlation between the stock dynamics of highly abundant commercial species and ACI.

The catches of the first group are closely correlated with the zonal ACI curve (Figure 3.3; correlation coefficients vary within the range of 0.7-0.9). The catches of the second group of species are closely correlated with the meridional ACI form (Figure 3.4; correlation coefficients are in the range 0.62-0.74). The correlation coefficient for Peruvian anchovy is about 0.4, but even in this case the run of the two curves is generally the same. The dependence of Peruvian anchovy catch on climate characteristics is very specific and considered below (see Chapter 10).

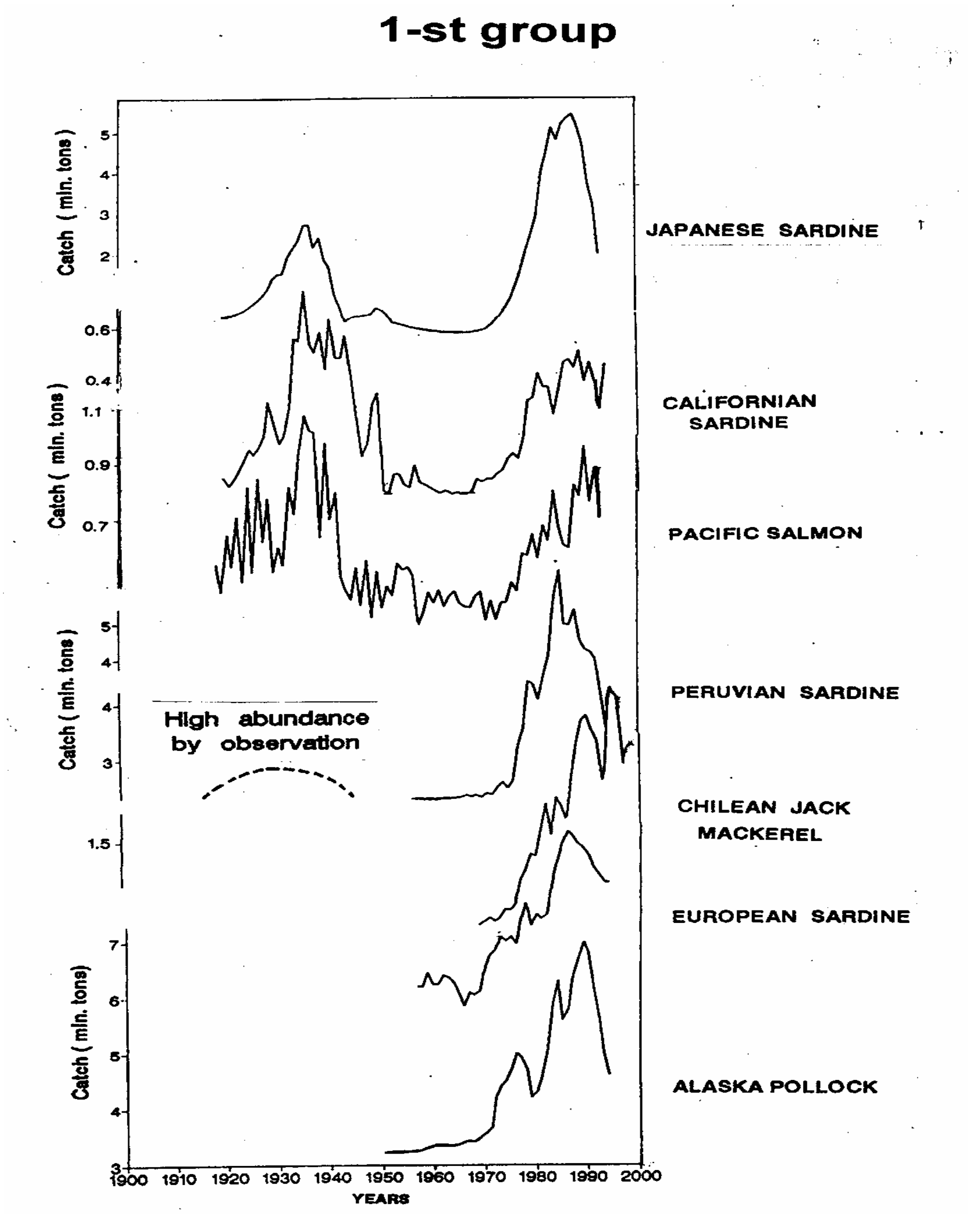


Figure 3.1 Synchronous catch fluctuations of "zonal-dependent" main commercial species (see text for details).

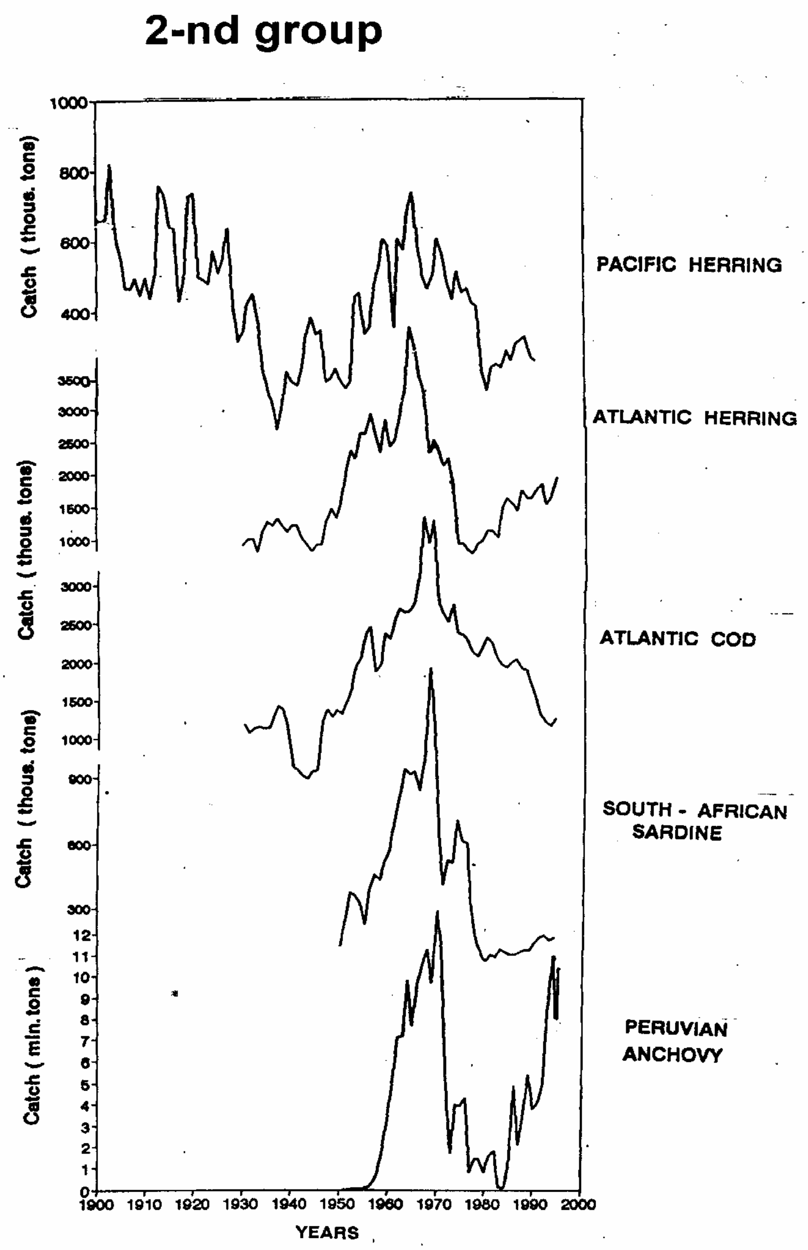
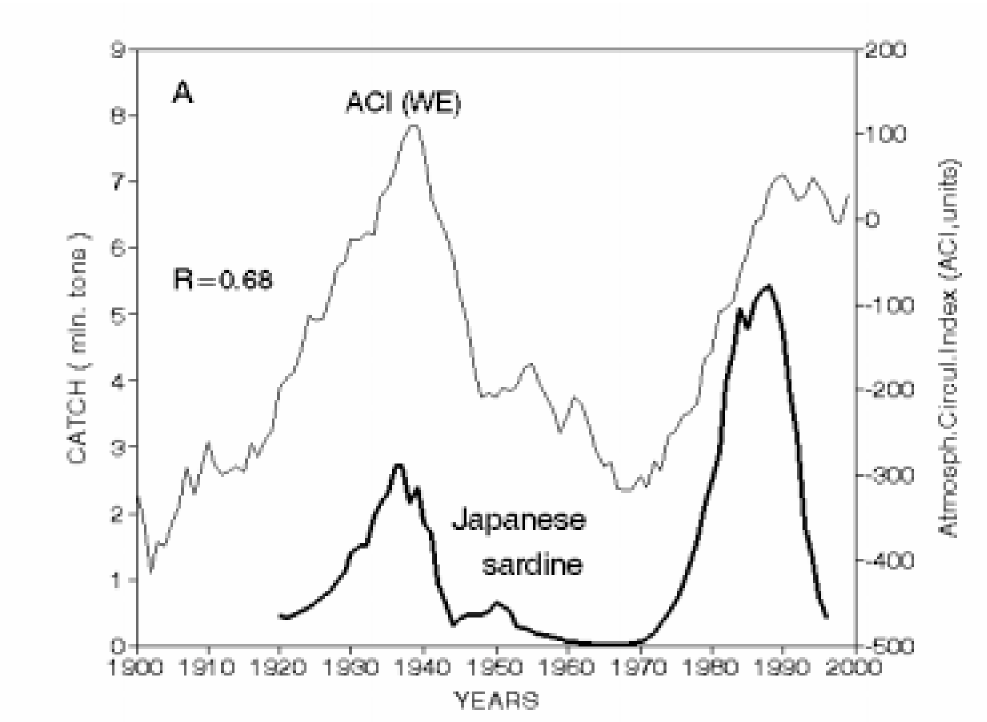


Figure 3.2 Synchronous catch fluctuations of "meridional-dependent" main commercial species (see text for details).



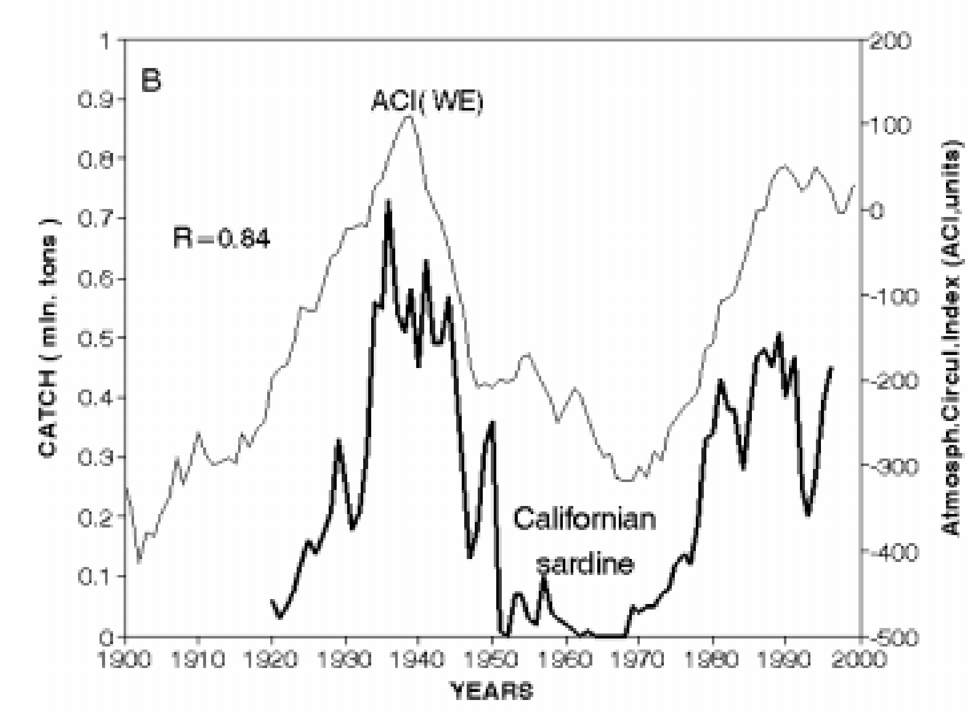
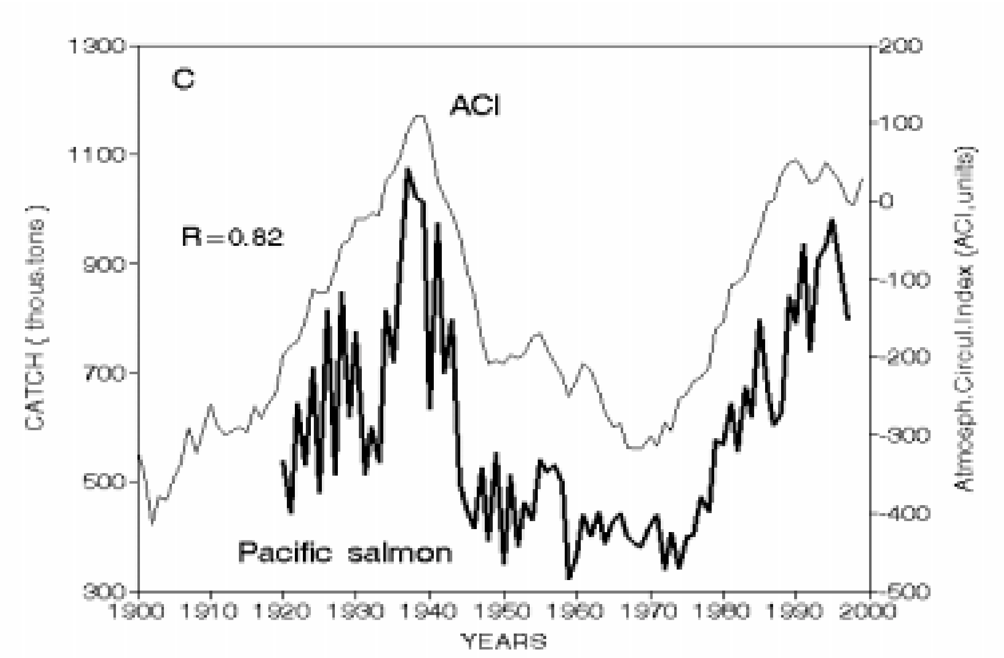


Figure 3.3 Correlation between dynamics of "zonal" ACI and catch of the major commercial "zonal–dependent" species.



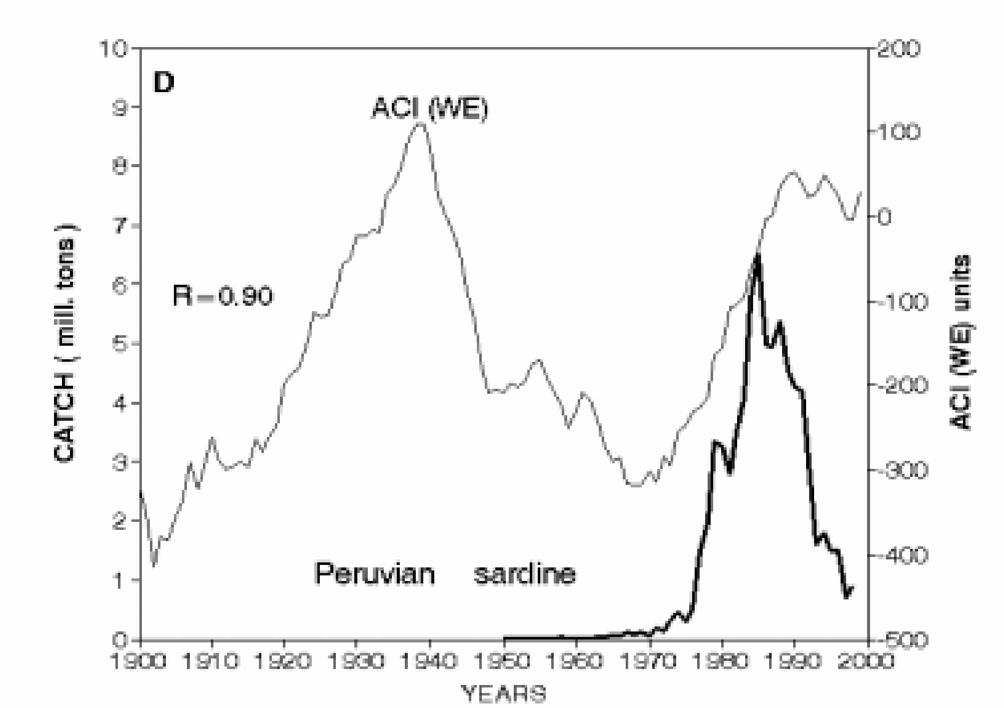


Figure 3.3 (continued). Correlation between the dynamics of "zonal" ACI and catch of the major commercial "zonal–dependent" species.

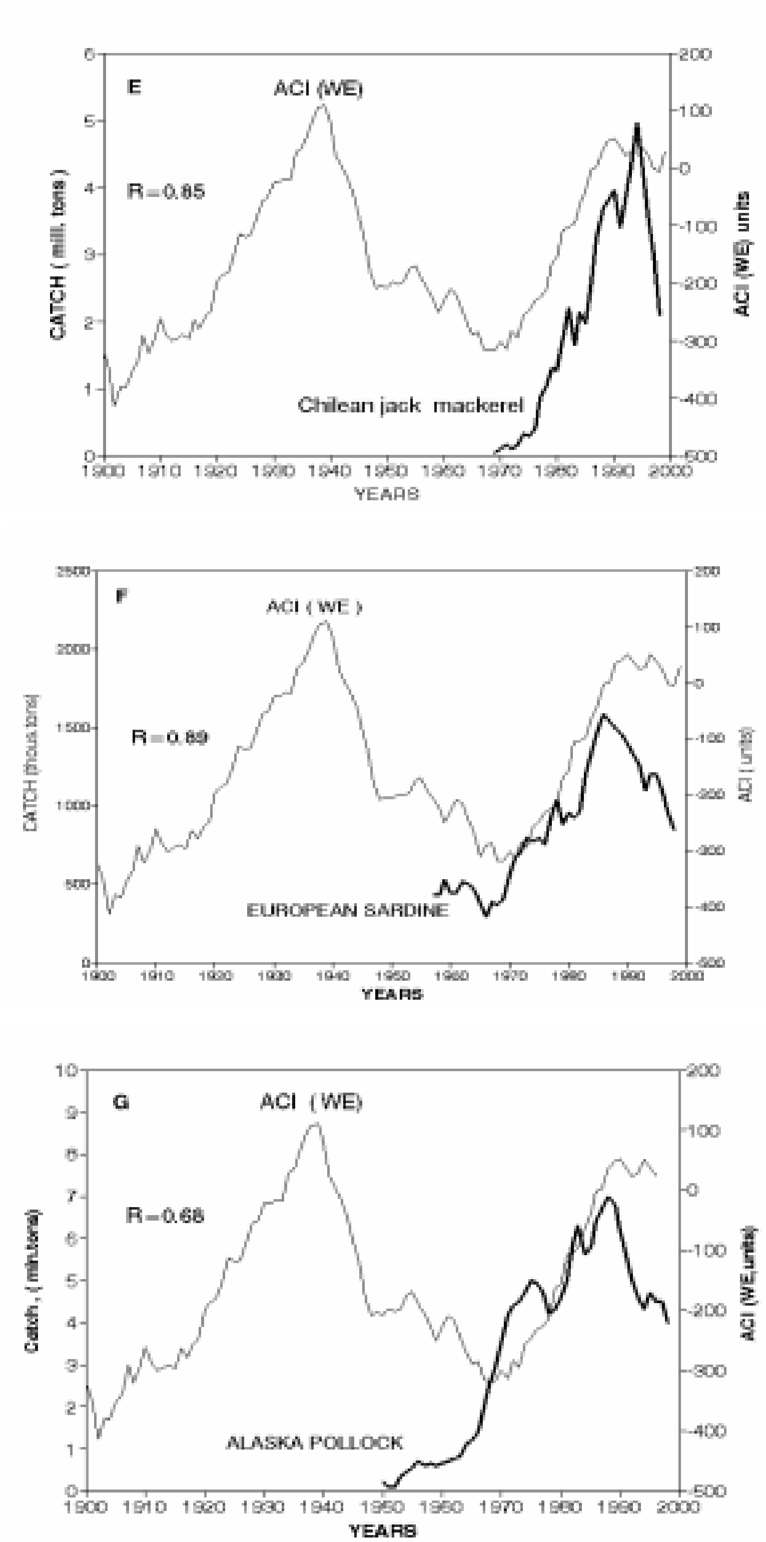


Figure 3.3 (continued). Correlation between dynamics of “zonal” ACI and catch of major commercial “zonal–dependent” species.

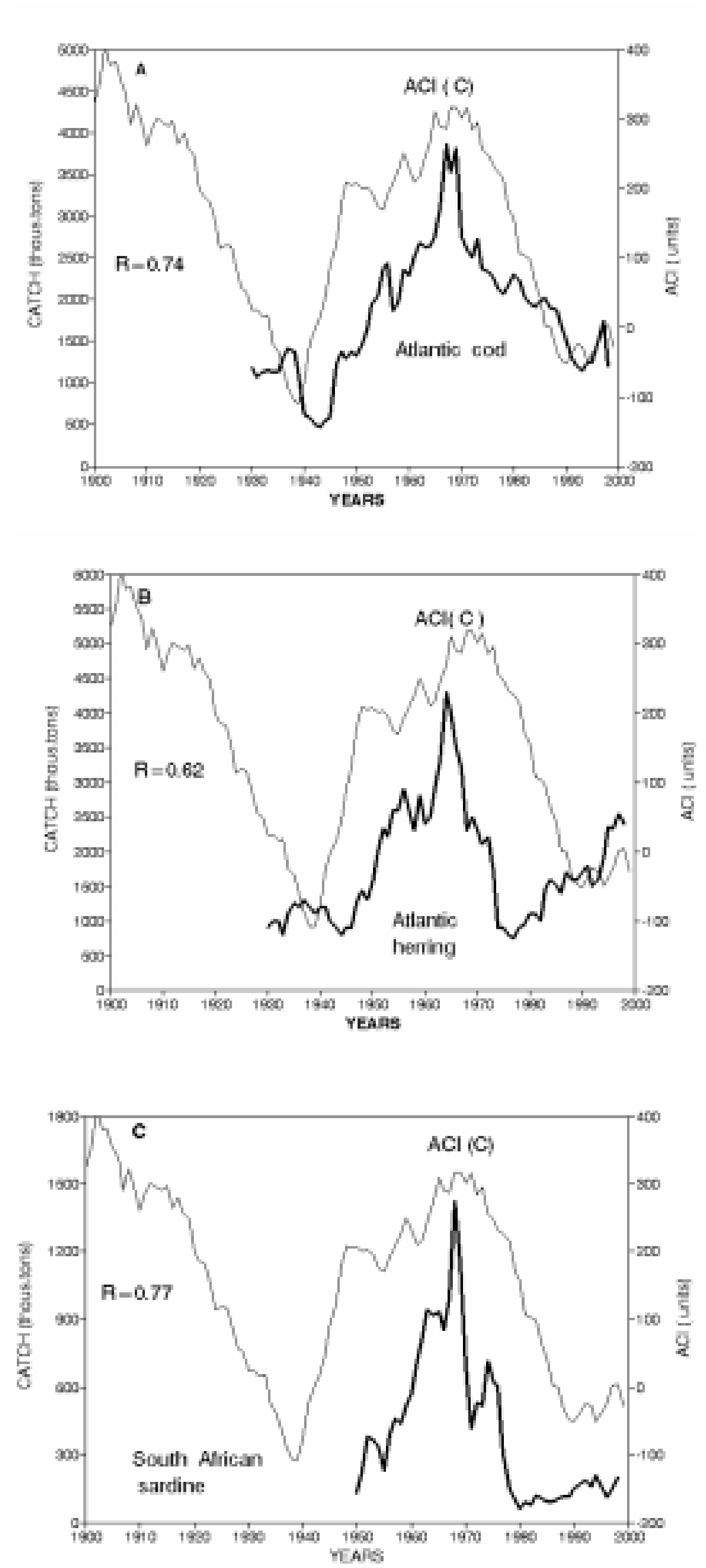
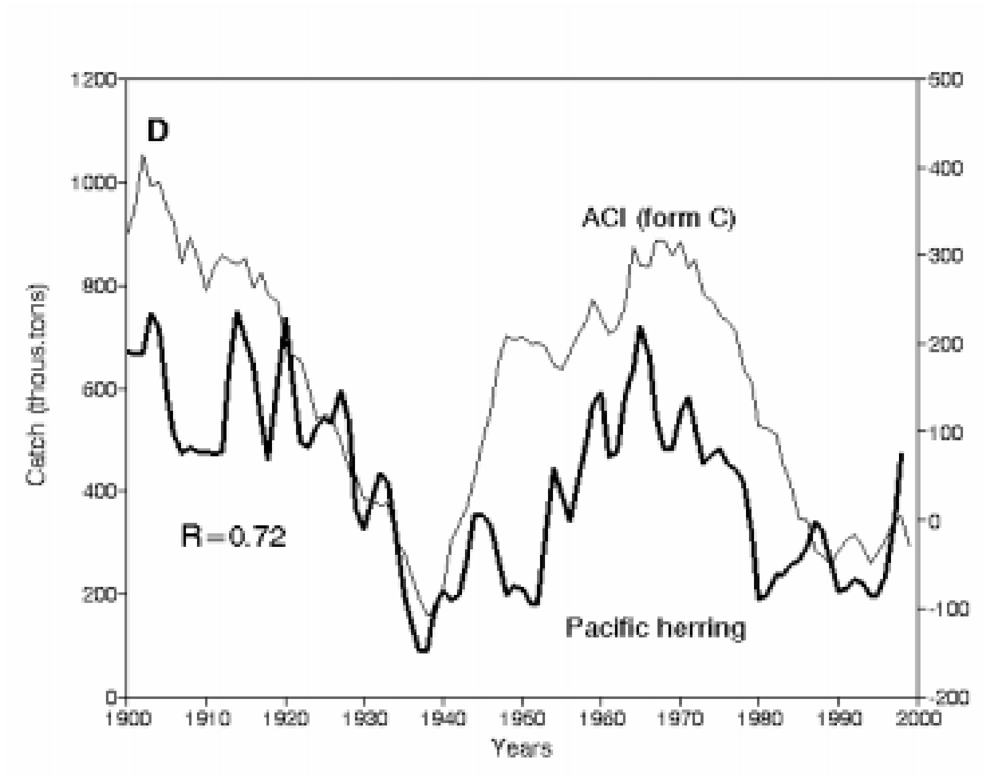


Figure 3.4 Correlation between dynamics of “meridional” ACI and catch of the major commercial “ zonal-dependent” species.



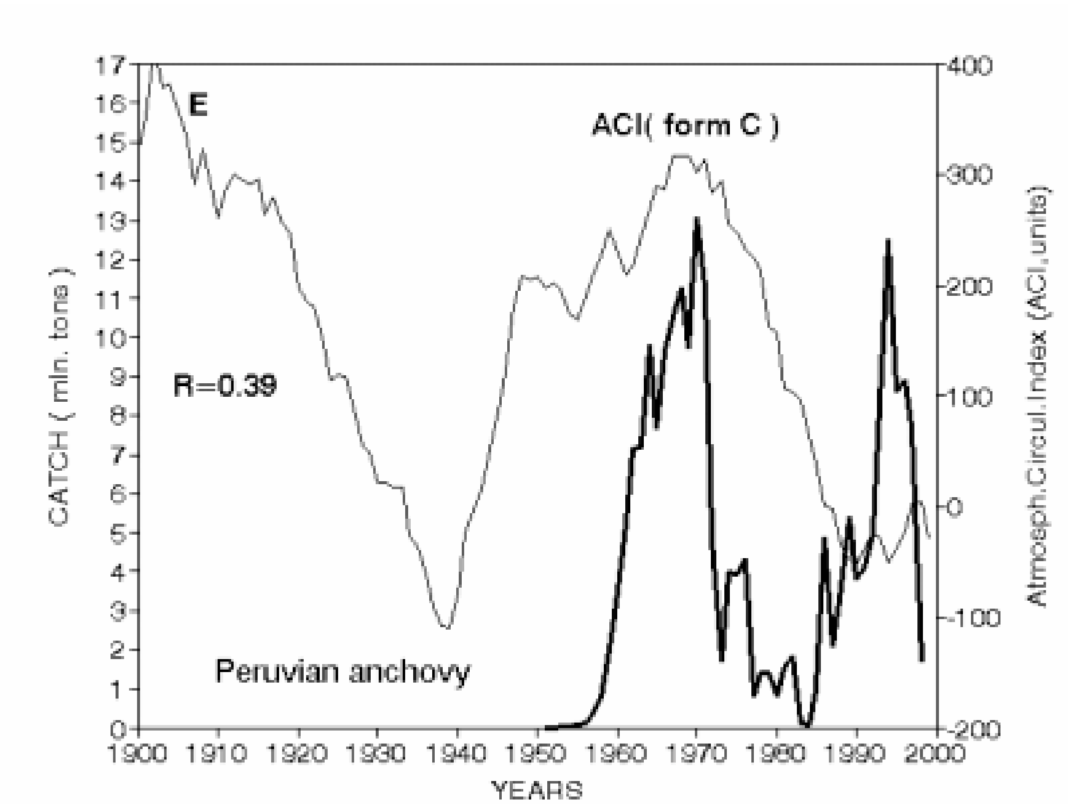


Figure 3.4 (continued) Correlation between the dynamics of "meridional" ACI and the catch of the major commercial "meridional-dependent" species.

The production of main commercial fish species in both the Atlantic and Pacific undergoes long-term climate oscillations (Figure 3.5A). The corresponding curves reflect two principal processes: (i) large-scale regular fluctuations in the fish production, and (ii) gradual increases in fishing grounds and fishing capacity. The capacity of the world fishing fleets has increased almost linearly by 12 million tons over 1973-1993. However, the relative commercial catch per 100 ton capacity has stayed practically stable for the same period (FAO 1994; Moiseev 1995). When the long-term trend is removed, the regular fluctuations of the major commercial fish production in both Atlantic and Pacific oceans become clearer (Figure 3.5B).

The Atmospheric Circulation Index (ACI), though measured in the Atlantic-Eurasian sector of the Western Hemisphere, almost coincides in dynamics with both dT and LOD, and therefore can be considered as a global index. It has no overall trend and can be directly compared with fishery indices, such as catch dynamics.

The ACI dynamics (Figure 3.6A) exhibits regular, roughly 30-year, alternation of the "circulation epochs" characterised by predominance of either «zonal» or «meridional» components. These epochs correspond to the periods of either global warming or global cooling. In fact, only the upper parts (peaks) of C (“meridional”) and WE (“zonal”) curves are of practical significance (Figure 3.6B)

The alternation of “cool” (meridional) and "warm" (zonal) circulation epochs correspond also to the long-term changes in the catch of main commercial species over the Atlantic and Pacific. The maximum production of seven of the twelve major commercial species fall on the "warm" period, whereas the production of the remaining 5 species is in good agreement with the "cool" periods (Klyashtorin 1998).

The relationship between the circulation epochs and maximums of the major commercial fish production in both the Atlantic and Pacific oceans is shown in Figure 3.7. The long-term fish production follows the regular alternation between the "meridional" and "zonal" circulation epochs. Regular alternation of the epochs for the last 110 years suggests that the present epoch of "zonal" circulation is coming into its final phase and the new "meridional" epoch is due.

What changes are expected to occur in commercial fish production in the oncoming circulation epochs? The most important fishery regions are the North Atlantic and North Pacific. A close agreement between the dynamics of climatic indices and commercial catches in the North Pacific is shown in Figure 3.8. The long-term fluctuations of the major pelagic fish species in the North Pacific can be described as the sequential passing of two climate-governed "waves" with the maxima falling on 1940-50s and 1970-90s.

The last (current) “wave” is coming into its final phase similar to that of 40-50s. This means that the population of main commercial species in North Pacific (Japanese Sardine, Alaska pollock and Pacific salmon) is expected to decline in the near future.

Unlike the North Pacific, the maximum of commercial fish production in the North Atlantic falls on the "meridional" ACI epoch of 1950-70s. The oncoming "meridional" circulation epoch in the North Atlantic is similar to that of 50-70s when production of herring, and cod and other gadoids reached up to 9 million tons. Therefore, with the coming of the meridional circulation epoch, we may expect an increase in these species population (herring, and cod and other gadoids) in the North Atlantic over the next decade.

More recent data confirm this viewpoint. The population of Atlantic (and Pacific) herring has already started to rise. Since the cod population has always followed herring in the past, the same dynamics may be expected in the future decade as well.

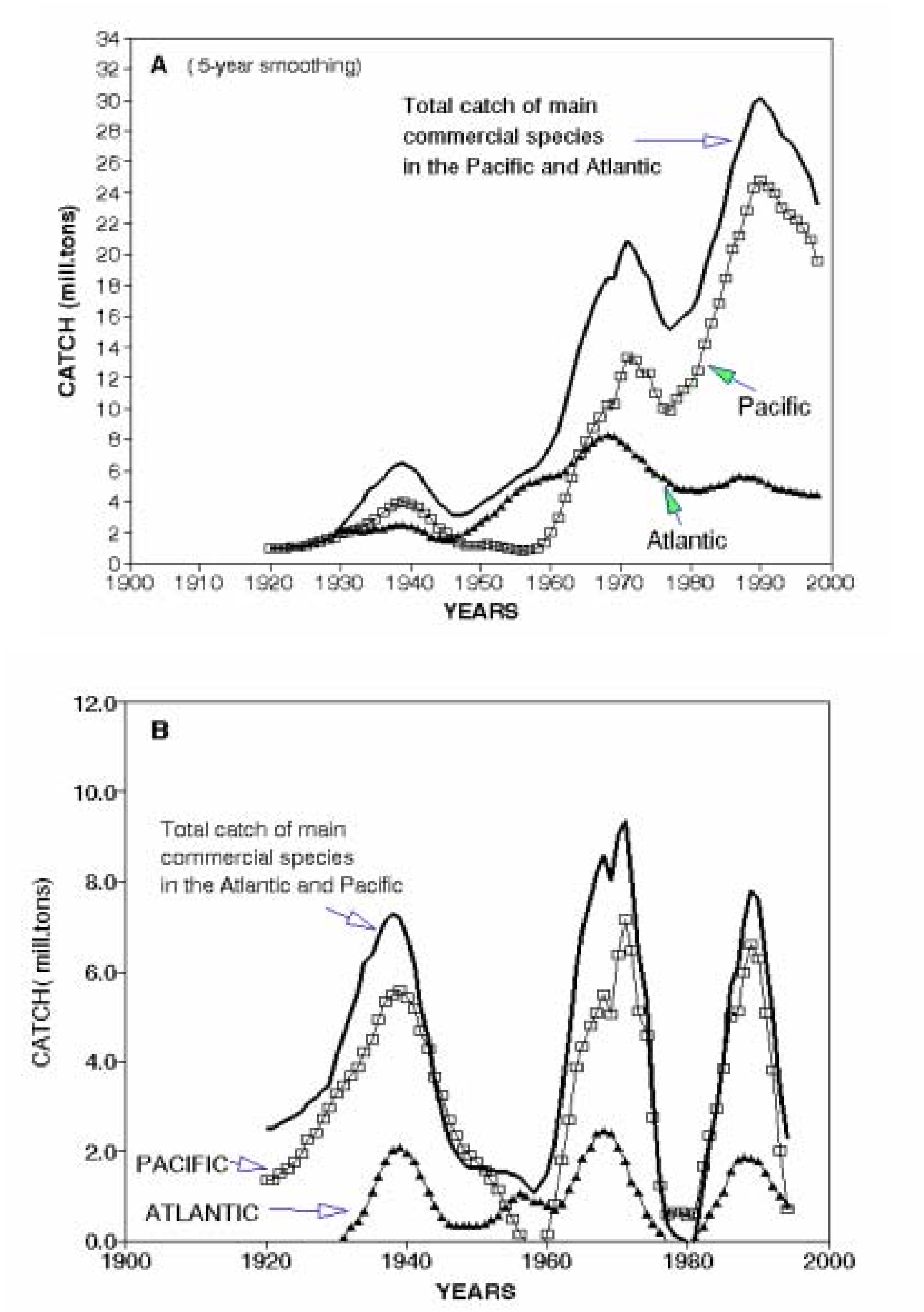


Figure 3.5 Long-term catch dynamics of main commercial species in the Atlantic and Pacific: A – before trend removal; B - detrended (see the text for details).

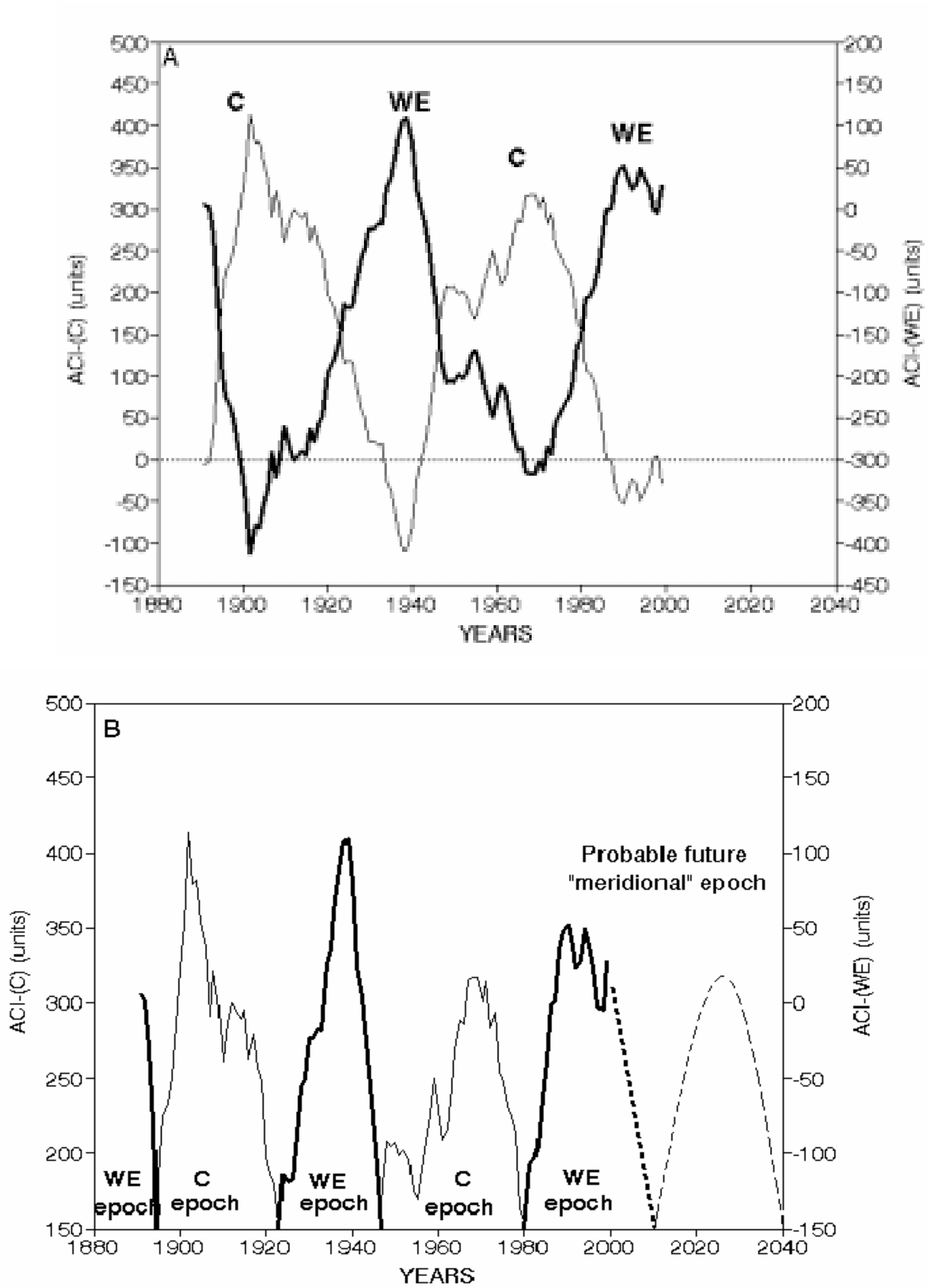


Figure 3.6 Dynamics of "meridional" (C) and "zonal" (WE) forms of the Atmospheric Circulation Index (A), and alternation of "meridional" and " zonal" circulation epochs (B) (see the text for details).

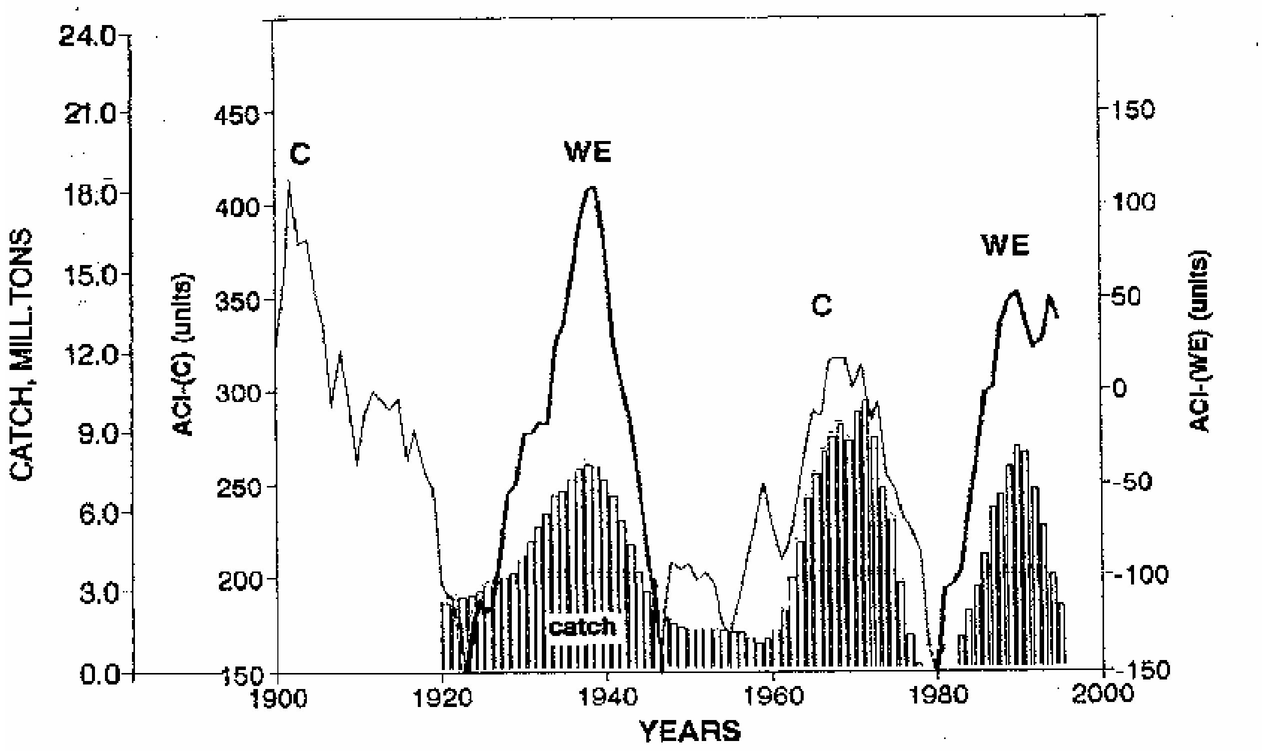


Figure 3.7 Catch oscillation of total major commercial species in the Pacific and Atlantic as compared with alternating meridional and zonal circulation epochs.

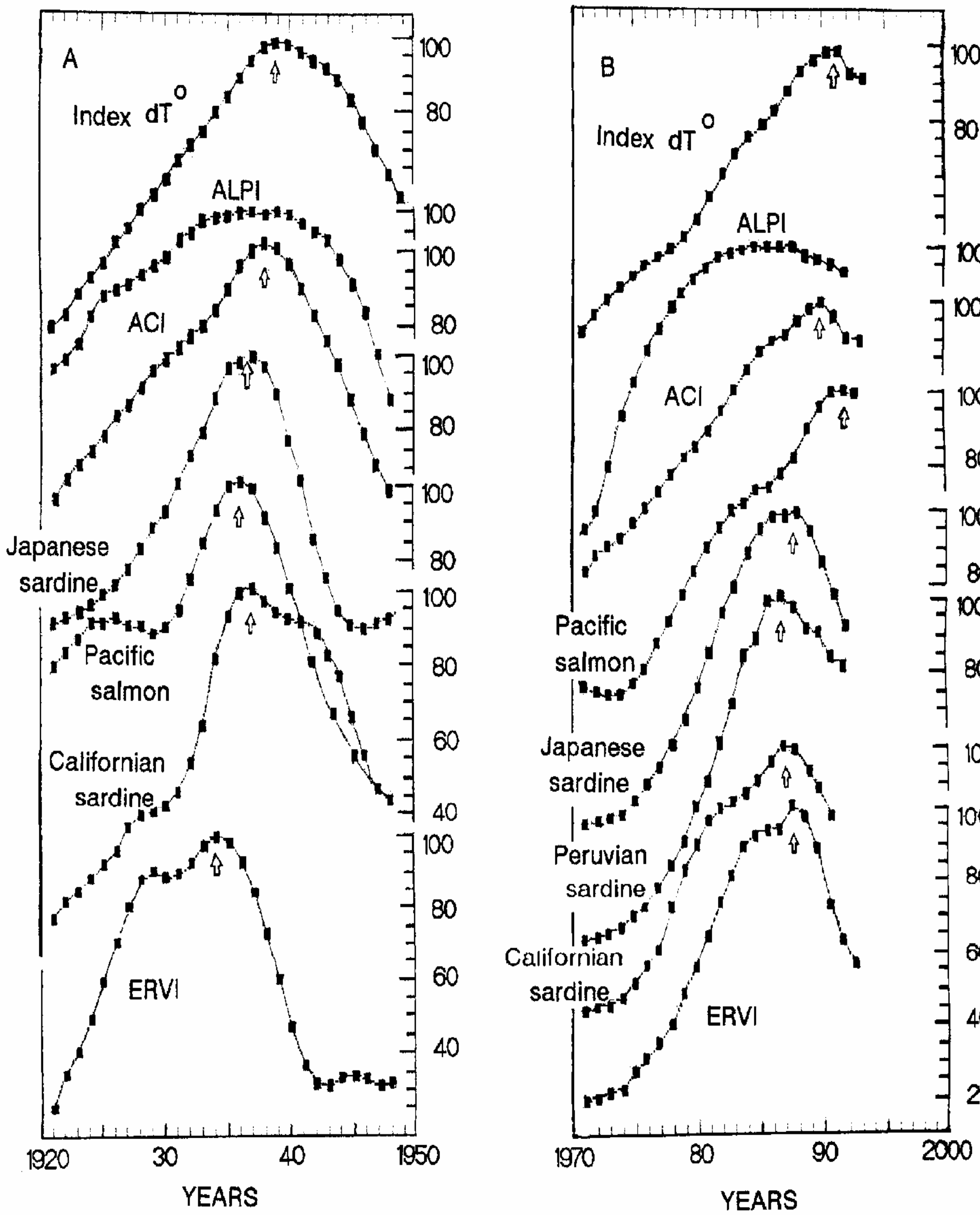


Figure 3.8 The general scheme of patterns in climatic indices and commercial catches in the Pacific for the periods of the 1920-1950 (A) and 1970-1995 (B). All curves are presented relative to a specific maximum taken as 100 percent and marked by arrows (from Klyashtorin 1998). dT:Global air surface temperature anomaly. ACI: Atmospheric Circulation Index. ALPI:Aleutan Low Pressure Index. ERVI: Earth Rotation Velocity Index (- LOD). See text for the details.

3.1 SUMMARY

ACI may be considered as a reliable climatic index related to long-term regular changes in the major commercial fish stocks.

The new "meridional" epoch of the atmospheric circulation is beginning to shift from the present "latitudinal" epoch. In the next decade, the production of the major commercial species is expected to decrease in the North Pacific and increase in the North Atlantic.

The data suggest a good agreement between the catch dynamics of the major commercial species and the patterns in various climatic indices. Climate indices may therefore be a useful tool with which to develop preliminary forecasts. To develop more reliable predictions, it is necessary to have longer time series, which go beyond available fishery statistics. This requires data on climate and fish populations covering hundreds and even thousands of years, which will be described in Chapter 4.