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IS THERE A RELATIONSHIP BETWEEN ENVIRONMENTAL VARIABLES AND THE SURFACE CATCH OF ALBACORE (*THUNNUS ALALUNGA*, BONNATERRE 1788) IN THE NORTH ATLANTIC ?

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SUMMARY

The latest International Commission for the Conservation of Atlantic Tunas (ICCAT) Symposium highlighted the importance of considering environmental parameters, their time-area variability and trends, and encouraged further research into how they affect tuna fisheries. The present paper features the results of a correlation analysis of north Atlantic climatic time-series, time-series of atmospheric variables on the Cantabrian coast (northern Spain), and time-series of albacore (*Thunnus alalunga*, Bonnaterre, 1788) recruitment and catches in the north Atlantic surface fishery from 1975-1995.

The results show a correlation between the Gulf Stream index and surface fishery catches in the north Atlantic. Further, smaller-scale analyses of these time-series are necessary to achieve a better understanding of the relationships found between the surface catches and the variations in environmental factors, such as the association with Gulf Stream changes.

RÉSUMÉ

Au Symposium Thon ICCAT, on a souligné l'importance qu'ont les paramètres environnementaux, leur variabilité spatio-temporelle et leurs tendances, et on a encouragé la recherche sur leur incidence sur les pêcheries de thonidés. On a effectué une analyse de corrélation entre les séries temporelles climatologiques de l'Atlantique Nord, les séries temporelles de variables atmosphériques sur la Côte Cantabrique et les séries temporelles de recrutement et de capture du germon *Thunnus alalunga* (Bonnaterre, 1788) dans la pêcherie de superficie du stock nord pour la période 1975-1995.

Les résultats démontrent qu'il y a une corrélation entre l'indice du Gulf Stream et les prises de germon de la pêcherie de superficie dans l'Atlantique Nord. Suite à la découverte de ces relations, il est nécessaire de procéder à l'analyse de ces séries temporelles à une échelle spatio-temporelle plus fine, afin de comprendre les mécanismes environnementaux qui ont une incidence sur le rendement de la pêcherie de superficie, comme l'association aux changements du Gulf Stream.

RESUMEN

En el Simposio de ICCAT sobre túnidos se señaló la importancia que tienen los parámetros medio ambientales, su variabilidad espacio-temporal y sus tendencias y se instó a investigar cómo inciden en las pesquerías de túnidos. Se ha efectuado un análisis de correlación entre series temporales climatológicas del Atlántico norte, series temporales de variables atmosféricas en la costa del Cantábrico y las series temporales de reclutamiento y capturas del atún blanco *Thunnus alalunga* (Bonnaterre 1788) en la pesquería de superficie del stock norte para el período 1975-1995.

Los resultados demuestran una correlación entre el índice de la Corriente del Golfo y las capturas de atún blanco de la pesquería de superficie en el Atlántico norte. A partir de estas relaciones encontradas es necesario efectuar análisis de estas series temporales a escala espacio-temporal más fina, para comprender los mecanismos del medio físico que afectan a los rendimientos de la pesquería de superficie, como es la asociación con los cambios de la Corriente del Golfo.

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INTRODUCTION

Climatic variations are one of the main causes of natural change in marine ecosystems. Fluctuations in North-east Atlantic fisheries are an example of such changes. Most of the time, these biological processes are difficult to relate to environmental factors, such as temperature or wind-speed, since these relationships are complex.

The International Convention for the Conservation of Atlantic Tunas (ICCAT) Symposium (Anon., 1996a) highlighted the importance of taking into consideration the oceanographic environment's space-time variability and trends in order to correctly assess tuna resources.

The North Atlantic albacore *Thunnus alalunga* (Bonnaterre, 1788) is a highly migratory species. Recruitment into the surface fishery is linked to the annual migration of young individuals to their feeding areas in the east Atlantic during the summer. These movements are affected, to a degree that largely depends on the ages of the fish, by climatic conditions (Dao and Bard, 1971).

Santiago (pers. com. in Anon, 1996b) introduced Drinkwater's North Atlantic Oscillation (NAO) index (1995) as a factor to consider in the dynamic of the North Atlantic albacore stock.

In the present study, we tried to confirm whether the interannual variability of certain physical variables is related to the capture of albacore in the North Atlantic surface fishery. The period analysed was restricted to 1975-1995, due to the short series of captures per age of the northern stock, which is the object of assessment (Anon., 1996b), in contrast with the long climatic time-series.

MATERIAL

The environmental data included in this paper are of two kinds: oceanic time-series, and local time-series.

Among the former, we studied the NAO index and the Gulf Stream latitude index (GULF). The NAO index used was taken from Hurrell (1995), and is based on the difference in normalised pressures at sea level in Punta Delgada (Azores) and Stykkisholmur (Iceland). Hurrell calculates the seasonal indices as a three-month running average. In the present study, we have included the annual averages of these indices for the period between 1975 and 1995. This index is defined as a large-scale, north-south oscillating movement of atmospheric masses between the subtropical and subpolar regions of the Atlantic; this phenomenon repeats itself with a periodicity that varies from 6-10 years. The NAO is related to the strengthening and weakening of the west winds, and this is the dominant factor in interannual climatic variability throughout the North-east Atlantic coast. It has also been suggested that changes in the NAO index values induce co-ordinated changes in the convective activity of the North Atlantic (Dickson et al., 1996), with the Greenland and Sargasso Seas being in phase (convection occurs with low NAO index values), and the Labrador Sea in counterphase (convection occurs with high NAO values). In addition, changes in the NAO have been related to retraction and intensification of storms in different areas. The changes in surface and deep currents in the Atlantic suggest that the NAO could reflect joint changes in the ocean-atmosphere interaction processes.

The Gulf Stream latitude index (GULF) has been described by Taylor (1996), and was extrapolated from monthly charts of the latitude of the north wall of the Gulf Stream at six longitudes measured between 65 ° W and 79° W for the period of 1966 to 1996. Applying a principal component analysis to the resulting correlation matrix, Taylor (1996) found a common variation pattern to the six longitudes. The estimated correlation coefficients explain that the north-south oscillation described by the principal component is evident in all of the longitudes. In the present paper, we have averaged out the monthly values to obtain an annual value for the Gulf Stream during the period of study, 1975-1995. The position of the north wall of the Gulf when it separates from the American continental shelf is a factor of great importance in climatic studies, since this current is responsible for the greatest heat transport in the northern hemisphere. High NAO values correspond to a strengthening of the west winds in the middle latitudes of the Atlantic, as well as the displacement of these winds further north (Alheit and Hagen, 1997). This atmospheric displacement seems to be able to induce, with an adjustment time, another displacement the position of the Gulf Stream path. The adjustment time for oceanic circulation has been fixed at two years by and Taylor Stephens (1997) for the three decades studied.

As to local environmental variables, meteorological time series were included: air temperature (TEMPERATURE), atmospheric pressure (PRESSURE), precipitation (PRECIPITATION) and east and west component winds. The meteorological series were provided by the Spanish National Meteorological Institute in Santander. Monthly data have been averaged out to obtain an annual value for the period between 1975 and 1995. Annual averages of air, atmospheric pressure and total annual precipitation have been used. For the wind analysis, we selected winds from the first (C1) and fourth (C4) quadrants, which were then classified according to the intensity of wind velocity in two categories: winds higher than 4 m/s (V4) and winds higher than 7 m/s (V7), so that four variables were included in the analysis (C1V4, C1V7, C4V4, C4V7).

The biological reference data were: recruitment (RECRUITS) obtained in a virtual population analysis (Anon., 1996b) and aggregate captures of age groups 2 and 3 (CAP2+3), obtained from the matrix of northern stock captures (Santiago, 1996); both series corresponded to the 1975-1995 period. These age groups were chosen because they are the most representative of the North Atlantic surface fishery.

METHOD

A first correlation analysis was carried out between the pairs of annual time-series described, using Pearson's significance correlation (95%).

A second correlation analysis was made between the NAO index with a two-year lag regarding the latitude of the Gulf Stream index series and the aggregate catches of age groups 2 and 3 of the northern albacore stock. The two-year lag between the NAO and the Gulf index was based on the results reported in Taylor and Stephens (1997).

RESULTS AND DISCUSSION

Table I shows the results of the analysis conducted with all of the pairs of annual variables considered. The co-efficient values in boldface correspond to the correlations that turned out to be significant, with a probability of $p < 0.05$.

A negative significant correlation can be observed between the NAO index and the recruitment of he North Atlantic albacore stock. The importance that this index may have in the dynamics of this species was already suggested by Santiago (pers. com.) in the Albacore Assessment Group (Anon., 1996).

A negative correlation was also obtained between the latitude of the Gulf Stream and the aggregate catch of age groups 2 and 3 in the northern stock. This correlation could be considered the result of a displacement of the habitat of immature individuals to more northerly zones, originated by the displacement to more northerly latitudes of the currents due to their association with the oscillation effect of the Gulf Stream, which could influence the capturability of the surface fleet. Dao and Bard (1971) describe how the currents induced by the action of winds with south-west (SW) or north-east (NE) components affect the movements of this species during its summer migration to feeding grounds.

The correlations between local meteorological variables, both positive and negative, can be explained by their high degree of interdependence. However, no significant correlation was obtained between local meteorological series and the catch of albacore age groups 2 and 3. The situation of the Iberian Peninsula in high NAO conditions is one of isolation with regard to the influence of the westerly winds (Alheit and Hagen, 1997). In such a situation, this region is subjected to winds with an eastern component, a factor which could explain the lack of correlation between these local meteorological variables and the surface catch of albacore in the North-east Atlantic, which includes the Bay of Biscay. The variability of the Spanish surface fleet's catch rates among the different methods and space-time strata (Garcia and Mejuto, 1993), which has not been taken into account in this analysis, could explain this lack of correlation between the local climatic time-series and the annual catch throughout the Atlantic.

Table II shows the correlations obtained with a two-year lag between the NAO index and the latitude of Gulf Stream and the catches of inmature albacore. The positive correlation found between the NAO index and the Gulf Stream index has already been described by Taylor and Stephens (1997). The negative correlation (- 0.41) between the catches of age 2 and 3 fish and the NAO index two years before, in the 1975-1995 period, is not significant ($P<0.05$), but it is very close. The fact that this correlation is not significant does not imply the nonexistence of a relationship between the NAO index and the juvenile catch, since in this study the variables are treaded on an annual basis, and the series of years is short. The NAO index and the Gulf Stream index are positively correlated, and there may be a NAO index effect in the catches of juveniles with a two-year lag that was not detected in this analysis. The space-time variability of the catches in the different age groups (Garcia and Mejuto, 1993) is a factor to consider in future analyses.

CONCLUSIONS

In the present paper, we have tried to confirm the relationships between annual climatic time-series and the surface catch of albacore tuna for the North Atlantic stock. A negative annual relationship was found between the latitude of the Gulf Stream and the capture of juveniles in the North-east Atlantic surface fishery. An analysis of these time series on a smaller time-space scale could provide results to better explain the correlations found, and other possible interactions between climate fluctuations and albacore fishery yield.

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REFERENCES

Anon., 1996, a. Report on the ICCAT Tuna Symposium (Ponta Delgada, Azores, 10-18 June 1996). SCRS/1996/ 6.

Anon., 1996, b. Detailed Report on Albacore (Report of 1996 SCRS Albacore Stock Assessment Session, Taipei, Taiwan, August 5-10, 1996) . SCRS/1996/ 29.

Alheit, J. and E. Hagen. 1997. Long-term climate forcing of European herring and sardine populations. Fish. Oceanogr., 6:2, pp 130-139.

Dao, J.C and F.X.Bard., 1971. Les migrations estivales des germons inmatures. CNEXO, Rapports scientifiques et techniques, N°4.

Dickson, R., J. Lazier , J. Meincke, P. Rhines and J. Swift. 1996. Long-term coordinated changes in the convective activity of the North Atlantic. Prog. Oceano. Vol. 38, pp 241-295.

Drinkwater, K.F., E. Coulbourne, K.D. Gilbert, 1995. Overview of environmental conditions in the northwest Atlantic in 1994. NAFO SCR Doc. 95/43.

Garcia, B. y J.Mejuto,. 1993. A simple descriptive and comparative analysis of the activity of the peninsular Spanish fleets targeting albacore (*Thunnus alalunga*), in the Atlantic Ocean from 1990-1991. ICCAT Col. Vol. Sci. Pap. XL (2): 306-315.

Hurrel, J.W. 1995. Decadal trends in the North Atlantic Oscillation: Regional temperatures and precipitation. Science, vol. 269, pp 676-679.

Santiago, J. 1996. Estimation of North Atlantic albacore catch-at-age for the period 1975-1995. ICCAT, SCRS/96/73.

Taylor, A.H. 1996. North-south shifts of the Gulf Stream : ocean-atmosphere interactions in the North Atlantic. International Journal of Climatology, 16, 559-583.

Taylor, A. H. and J.A.Stephens. 1997. The north Atlantic Oscillation and the latitude of the Gulf Stream. Tellus, 48 A. Tellusa TA 70655d.

Table 1. Correlation matrix for climatic time series, recruitment and albacore catches analysed.

significant correlation cofficients P< 0.05 in boldface

	TEMPERATURE	PRECIPITACION	NAO	C4V7	C4V4	C1V7	C1V4	PRESSURE	GULF	RECRUITMENT
PRECIPITATION	**-0,74**									
NAO	0,24	0,07								
C4V7	-0,37	**0,44**	0,33							
C4V4	**-0,53**	**0,55**	0,07	**0,84**						
C1V7	0,28	-0,15	-0,12	0,24	0,08					
C1V4	0,08	-0,18	-0,25	0,24	0,06	**0,82**				
PRESSURE	-0,17	**0,47**	0,33	0,20	0,15	-0,18	-0,22			
GULF	**0,44**	-0,42	0,10	-0,40	**-0,50**	-0,17	-0,27	-0,22		
RECRUITMENT	-0,21	0,09	**-0,45**	-0,32	-0,22	-0,20	-0,06	0,22	0,04	
CAP2+3	0,03	0,10	-0,17	0,03	0,15	-0,03	0,09	-0,03	**-0,44**	0,22

Tabla 2. Correlation matrix for NAO index with 2- year lag with variables: the latitude of the north wall of the Gulf stream and albacore catches ages 2+3.

significant correlation cofficients P< 0.05 in boldface

	CAP23	NAO
NAO	-0,412	
GULF	**-0,439**	**0,547**