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THERMAL ANOMALIES IN TROPICAL AREAS OF THE ATLANTIC: POSSIBLE CONSEQUENCES FOR ALBACORE (Thunnus alalunga) RECRUITMENT

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Abstract

We have tried to test the hypothesis that sea surface temperature anomalies in the supposed spawning area have an influence on the recruitment of albacore, three years later.

Considering a temperature of 24^{0}C as a spawning limiting factor, we have computed the anomalies since 1964 in the 14^{0}N to 30^0 N and 30^{0}W to 60^{0}W geographical area, from May to Setember, and in the part of the area where the monthly mean temperature since 1964 was between 24^{0}and 25^{0}C.

Recruitment estimated from cohort analysis and recruitment estimated from catches by unit of effort (CPUE 3), taken back to the year of birth, seem respectively correlated with the thermal anomalies with a 3 years lag until 1976 and 1977, according to the year of birth.

From 1978 onwards, the CPUE 3 are lower than expected from the chronology of thermal anomalies. We suppose that a discontinuity in the CPUE 3 series may explain this difference.

Resumen

El reclutamiento de la albacora (Thunnus alalunga) y las anomalías térmicas en el Atlántico tropical.

Tratamos de probar la hipótesis de que la temperatura superficial del mar es uno de los factores limitantes de la sobrevivencia de lás albacoras juveniles. Con esta intención se correlacionan las anomalías térmicas de las posibles áreas de freza (in Aloncle et Delaporte, 1974 y Bard, 1981) y el reclutamiento algunos años más tarde.

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De las capturas con cebo vivo y al curricán se pueden separar fácilmente tres clases: "bonites", "demis" y "gros". Pero la edad absoluta no es conocida con seguridad. En adelante supondremos que los "bonites" tienen dos años, y los "demis" y "gros" tres y cuatro años respectivamente.

El reclutamiento ha sido estimado de dos maneras: la captura por unidad de esfuerzo de los "demis" (González-Garcés y Mejuto, 1984) y los resultados del análisis de multicohortes (Bard, 1981), entre 1964 y 1976. De acuerdo con varios autores, suponemos que el área de freza se extiende entre 14^0 y 30^0 N y desde 30^0 a 60^0 W. Dentro de esta área, fue calculada la anomalía térmica media desde Mayo a Agosto con los datos del Atlas Focal (Picaut et al. 1985). Se calculó la anomalía térmica como la diferencia entre la temperatura mensual media interanual y la temperatura mensual, entre 1964 y 1984. Se trata de áreas donde la temperatura media mensual está comprendida entre 24^0 y 25^0 C que es considerada como el umbral mínimo de freza (in Bard, 1981).

Los reclutamientos estimados por ambos métodos correlacionan bien con las anomalías térmicas: r= 0,81 con el análisis de multicohortes y r = 0,86 con la CPUE 3 hasta 1977. Así, una anomalía térmica positiva parece aumentar el reclutamiento de "demis" tres años más tarde, y las anomalías térmicas negativas reducir este reclutamiento. Sin embargo, con los datos de 1977, la CPUE 3 observada es menor que la pronosticada. Esta diferencia se puede interpretar como una falta de continuidad en los datos usados para la estimación de la CPUE 3.

The data used

Spawning area of albacore and recruitment estimates

The spawning area and the spawning period are not well-known. The data collected in the atlas by Nishikawa et al. (1985) are very scattered. However, using historical data, Aloncle and Delaporte (1974) indicated an area situated to the north of the West Indies between 20^0 N and 30^0 N. Furthermore, they indicated catches of larvae at 10^0 N. Bard (1981), provides a rough map of this spawning area (fig. 1) and says that spawning occurs over 6 months from April, in waters whose temperature is above 24 C. Otherwise, by convention, we admit that a separation between the Northern and Southern stocks is situated around 5^0 N.

We have used recruitment data published by I.C.C.A.T. (Gonzales Garces and Mejuto, 1984) and cohort analyses published by Bard (1981). Fishes are graded into four categories according to weight: "bonite", "demi", "gros" and "très gros". A doubt persist in the absolute age of albacore. According to González Garces and Mejuto (1984), we have assumed that the "demis" are three years old.

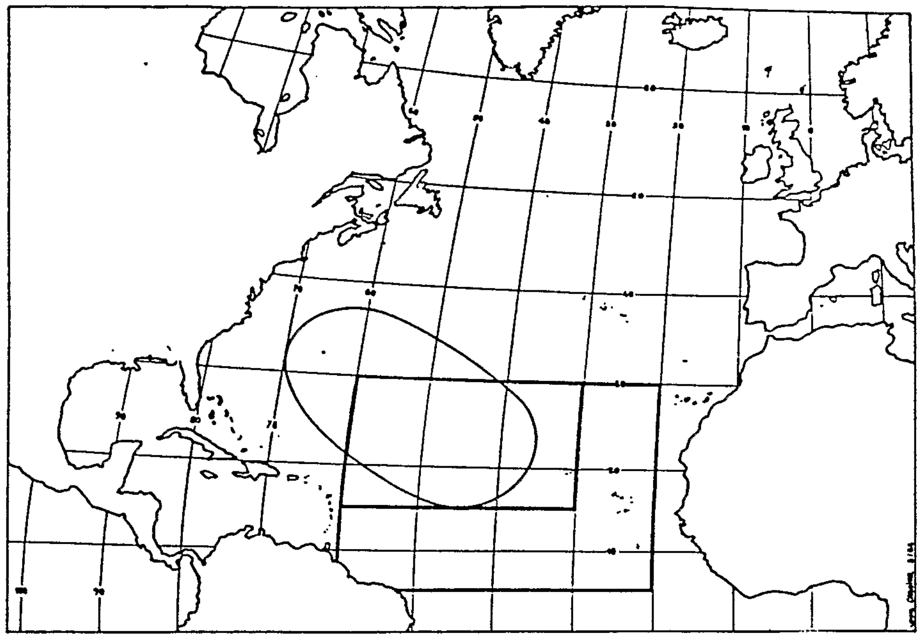

Fig. 1.- Approximative spawning area of albacore according to Bard, 1981. The other limits show two areas in which thermal anomalies have been cal culated.

The data published by Gonzãlez Garcẽs and Mejuto (1984) concern catches per unit of effort of three years old fish (CPUE 3); they are taken back to the birth year. We have used the demographic table published by Bard, and considering that the "demis" are three years old, shifted his table back by one year which causes a logical connection with the CPUE 3 (fig. 2, 3 and 4).

Sea surface temperatures in Tropical Atlantic

We have used temperature data from which the FOCAL atlas was compiled (Picaut et al., 1985). This atlas is limited to the north by 30⁰ and to the west by 60⁰ ; it is composed of maps established from monthly averages 2⁰ by 2⁰ squares covering the period 1964-1979. We have used the available data until 1984. For each 2⁰ by 2⁰ square, the thermal anomaly of a month is equal to the difference between the temperature of the month of the year n and the average temperature of the same month for the whole period.

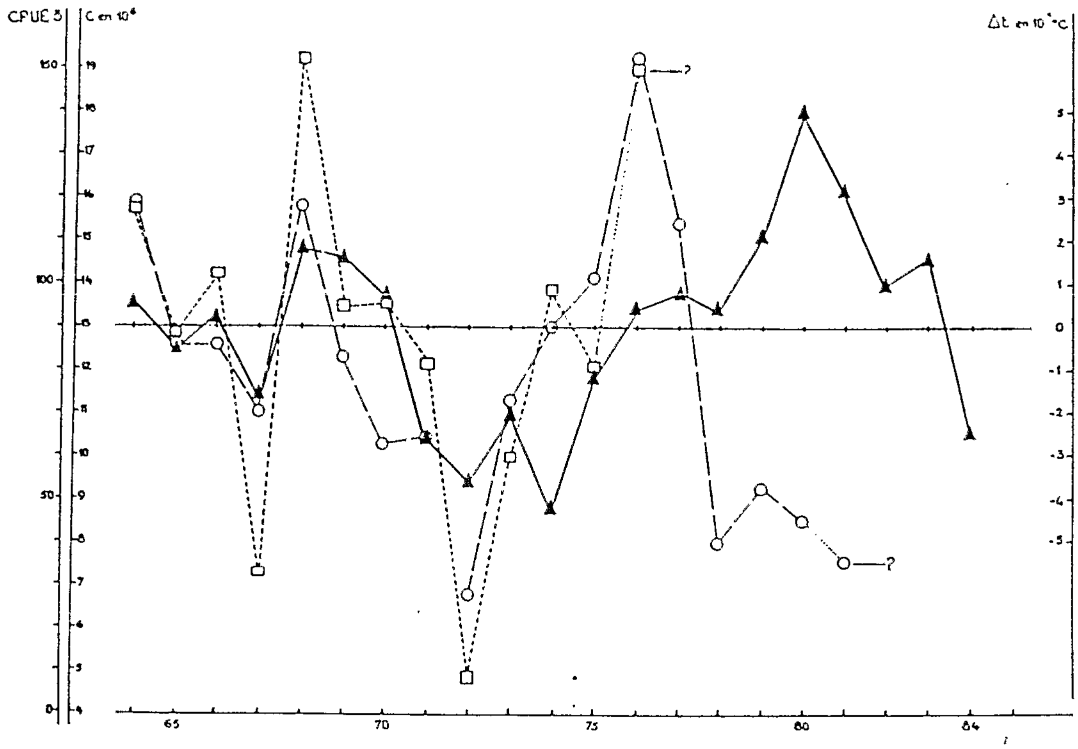

Fig. 2.- Chronology of CPUE 3 O , of cohort analysis □ and of thermal anomalies ▲ (extraction of area whose mean temperature for each month is between 24 and 25°C, inside 14 to 30°N and 30 to 60° W); mean of anomalies from May to September.

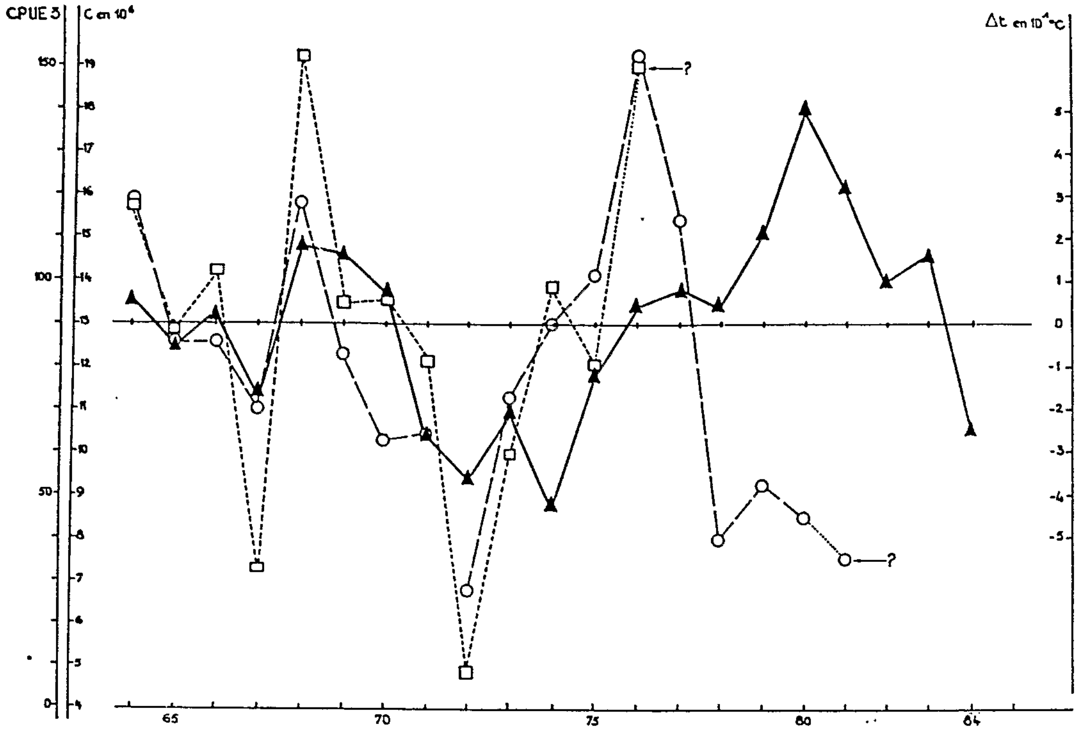

Fig. 3.- Chronology of CPUE 3 **O** , of cohort analysis **□** and of thermal anomalies **▲** (extraction of area whose mean temperature for each month is between 24 and 27^{0}C, inside 14 to 30^{0}N and 30 to 60^{0}W); mean of anomàlies from May to September.

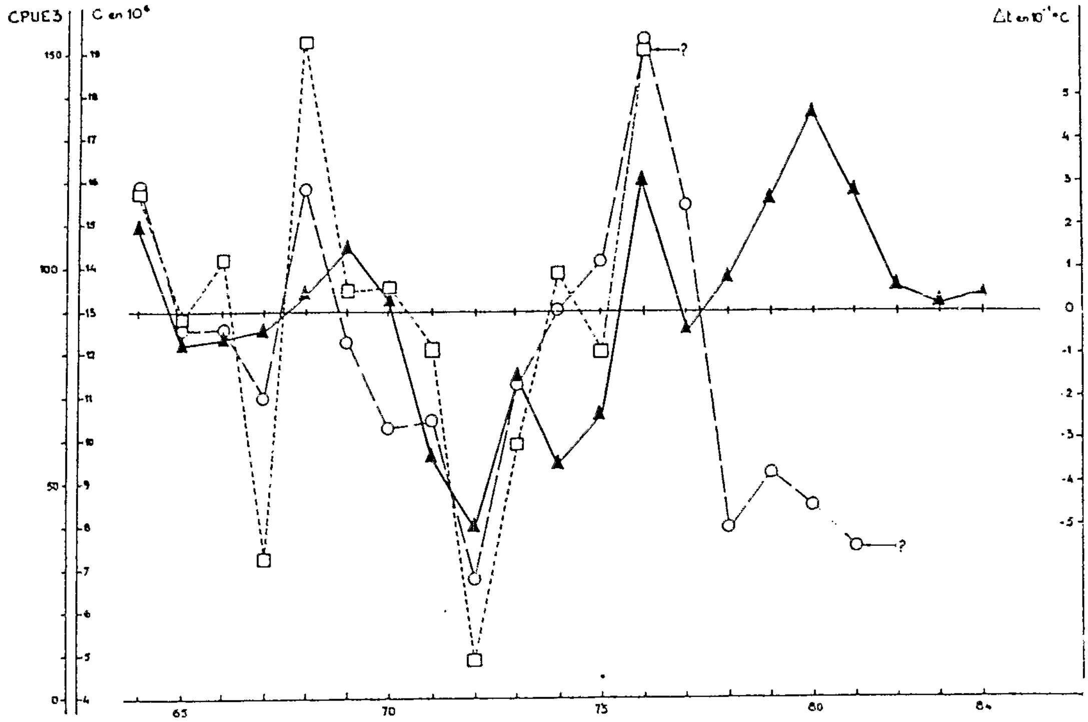

Fig. 4.- Chronology of CPUE 3 O , of cohort analysis □ and of thermic anomalies ▲ (extraction of area whose mean temperature for each month is between 24 and 25° C, inside 4 to 30° N and 20 to 60° W) ; mean of anomalies from May to September.

Data processing: choice of the investigated area, search for significant thermal anomalies.

Considering the geographical limits of the thermal data available and doubt about the spawning area, we have chosen to study two areas, one between 14° to 30° N and 30° to 60° W, the other one between 4° to 30° N and 20° to 30° W.

Our aim is to try to test the hypothesis that temperature anomalies have an effect on recruitment; we assume a temperature of 24° C as a limiting factor for spawning and/or the survival of larvae. In these conditions, it was not useful to look for thermal anomalies in the whole area. Thus we calculated the anomalies for the elementary squares whose average monthly temperature, for the whole period, was between three intervals : 24° to 27° , 24° to 26° , 24° to 25°C. Consequently, for a given interval, the geographical limits vary from month to month.

Considering the doubts about the spawning period, we have calculated different sets of monthly anomalies in the 14° to 30°N and 30° to 60°W area and compared them to the serie of CPUE 3. The anomalies tested are the following:

- average of the anomalies of the twelve months of the year,
- average of the anomalies from May to December of the year n and from January to April of the year n + 1 to test a possible influence on the survival of larvae,
- average of the different sets of anomalies during the likely spawning season.

Finally, we chose the average of the anomalies from May to September as it seemed to us to be the most representative for the spawning season.

The temperature interval which is best correlated with the estimate of recruitment is 24°to 25°C, which tends to show that the 24°C isotherm is a limiting factor.

Indeed, it seems logical to think that a negative anomaly in waters whose temperature is near 27°C cannot be a limiting factor. On the contrary, a negative anomaly of 0.5 in waters whose average temperature is between 24°and 25 (i.e. near 24°5) comes close to the limit of 24°C. Concerning the influence of the geographical area, that limited by 14°N and 30°N and 30°W and 60°W provides the best correlation.

Comments

Thermal anomalies and recruitment estimates from cohort analyses are well-correlated ($r = 0.81$) until 1976, the last year cohort analyses published by Bard. Thermal anomalies and CPUE 3 values are well-correlated until 1977 ($r = 0.88$). The "good" years (1964-1968-1976) which result in good catches of "demis" in

1967-1971 and 1979 accord with positive anomalies. The year 1972 (catches made in 1975) corresponds to a strong negative anomaly. The year 1976 must be treated separately. Indeed, on the whole it was cooler than the others, although it presented an obvious positive geographically limited anomaly during the summer months (fig. 5) corresponding to the interval 24-25°C selected.

From 1978 onwards, the CPUE 3 value is clearly lower than the chronology of thermal anomalies would lead us to suppose, if we assume that a positive anomaly corresponds to a good recruitment of "demis" three years later and that a negative anomaly corresponds to poor recruitment.

Such a correlation should be treated with some caution and should be considered as a likely hypothesis which needs further tests to be confirmed.

Several elements which are not well know can affect the correlation: the doubt about the absolute age of albacore, the period and area of spawning and the range of temperature considered to be a limiting factor. The correlation may be spurious due to the shortness of the time series or to underlying correlation between temperature and other physical parameter such as wind, nutrients, thickness of the mixed layer.

CPUE 3 is probably not the best parameter, but its time series is longer than the cohort analysis which ends in 1976. Recent CPUE 3 values should not be compared to the preceding ones because they are calculated only from Spanish data. Furthermore, a possible deterioration of the relationship abundance and CPUE 3 should not be excluded.

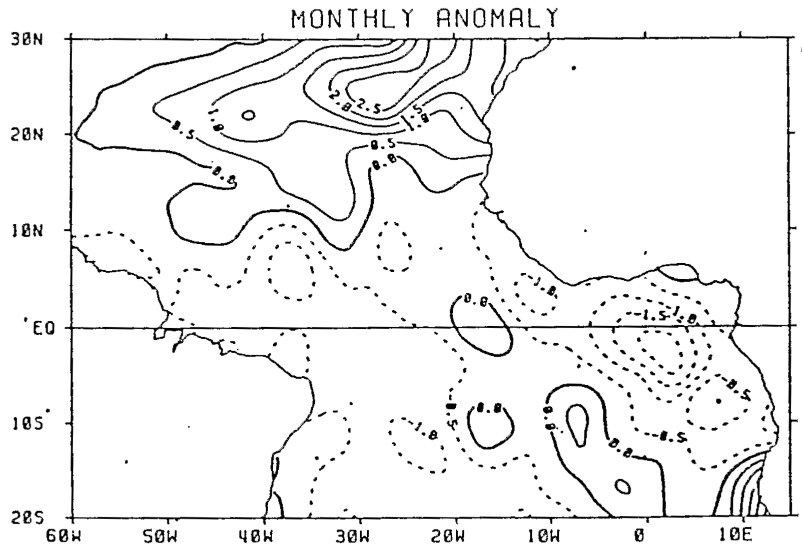

Fig. 5.- Monthly anomaly for August 1976. The year 1976 as a whole cold, presents a positive anomaly during the end of summer in the area studied (Picaut et al., 1985).

Conclusion

Great care must be taken to interpret such correlation. The recruitment of "demis", albacores which we think are three years old, seems to be correlated with anomalies observed three years earlier in the supposed spawning area, until the birth year 1977.

Later than 1977, the recruitment is lower than the chronology of anomalies would lead us to suppose, and we suggest that there is a discontinuity in the series of CPUE 3 values. The year 1984 has presented a cold anomaly in the presumed spawning area; in spite of the difference observed since 1977, the future will tell us if a small recruitment of "demis" corresponds to this year in 1987.

Acknowledgments

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