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Trends of abundance indices of albacore tuna (*Thunnus alalunga*) obtained by GLM fitting of the French troll and baitboat catch per unit of effort data for the period 1967 to 1986.

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ABSTRACT

French troll and baitboat catch data collected in the period 1967 to 1986 were used to obtain abundance indices of Albacore tuna in the north-east Atlantic ocean. Linear models fitted to the catch per unit of effort data produced indices that increase slightly from 1967 to 1978 and then decrease from 1979 to 1986. The rate of decline in the period 1979 to 1986 is discussed because there are doubts that this decline does not accurately reflect the evolution in actual abundance.

INTRODUCTION

Management of the tuna fisheries is one of the fundamental issues of the International Commission for Conservation of the Atlantic Tuna (ICCAT). To achieve this goal, good abundances indices are required in order to correctly tune the models (global or structural). Therefore, the PSG (Programme Special Germon) of the ICCAT rapidly emphasized the need for producing such indices (Anon., 1992). As a consequence, IFREMER recovered from historical troll and baitboat catch data collected from 1967 to 1986. This data were mainly analyzed by Bard (1981).

EVOLUTION OF THE FRENCH ALBACORE TUNA FISHERY

To catch young albacore that migrate through the Gulf of Biscay during the summer period, Spanish, French and Portuguese fishermen have developed a surface fishery. They started fishing with sailing trollers since the 19th century (Bard, 1981). The pool and line techniques (used by baitboats) appeared in 1949 (Bard, 1981), and developed with the troll so that in 1967 their catch pooled together reached 48,000 metric tons. However, the French fleet started to decrease for economical reasons. The first step was the decrease in the baitboat fleet in the 60s, as illustrated by figure 1. In the 70s, landings stabilized around 7,500 metric tons a year. However, the trollers started to stop their activity in the beginning of the 80's. In the mid 80s, new surface gear types appeared: the pelagic trawl and the drifting gillnet.

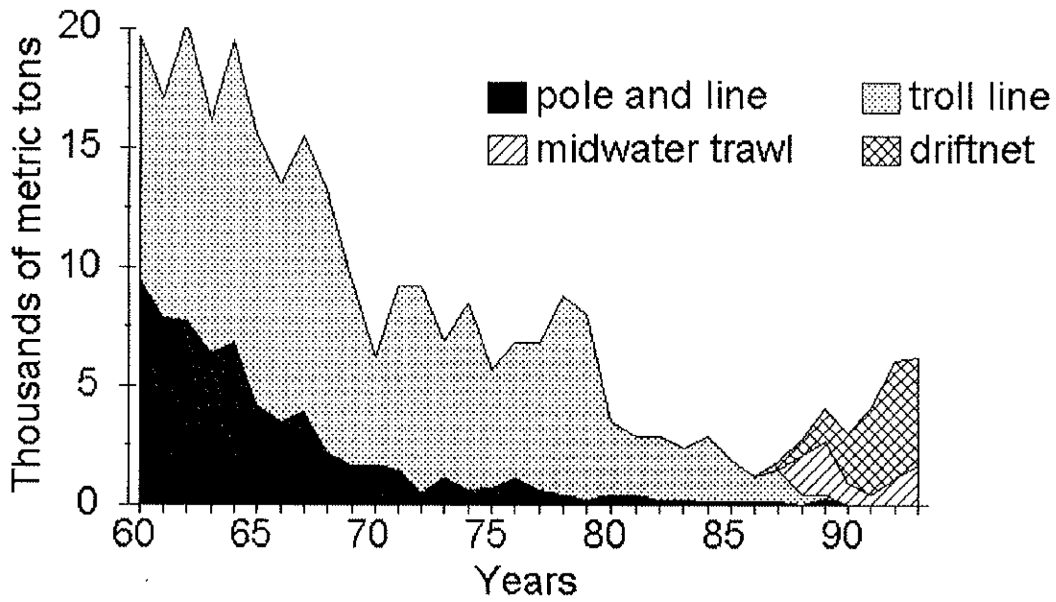

Figure 1. Evolution of the landings of the French Albacore tuna fishery since 1960.

DATA

Original data

From 1967 to 1986, French historical baitboat and troll catch data have been reported by fishermen in logbooks collected by the CNEXO and since 1974 by IFREMER (when the CNEXO merged with the ISTPM to form the IFREMER). The records contain among other data, the following information:

- vessel identification
- gear used
- vessel activity (fishing, changing area, facing bad sea conditions)
- position (latitude and longitude in tenth of degree)
- date
- catches in number of albacore (total and for most of the time in traditional commercial size classes)

French Fishermen define three commercial classes that correspond roughly to age 1, age 2 and age 3 (Bard, 1981). Fish heavier than 10 kg (age 4 or more) were reported separately in the logbooks. Commercial classes will be referred hereafter as classes 1, 2 and 3, and class 2+3 will be obtained by pooling class 2 and class 3 together.

Fishing effort was derived from the vessel activity. Therefore, it was possible to calculate CPUE defined as the number of fish caught per fishing day.

Data were compiled for mapping representation of effort, catch and CPUE data for both gears.

In 1975, there were no more baitboats in the French fleet, and in 1986 due to the drastic reduction of effort of French trollers (figure 1), data collection stopped. Nevertheless, these data represent a large time series and are certainly useful to estimate trends of Albacore abundance in the Gulf of Biscay over this period.

Subset of data used for the study

The corrected original data set contained 71 543 observations. Each observation correspond to the parameters and catch (in number of fish by class) of a fishing day and a boat. However, vessels could have different activities: fishing all day long, fishing while changing area or fishing in a rough sea with the vessel facing the waves. For these last two activities, data where considered to be without precise effort (data). The dataset could be described as shown in table 1.

Table 1. Composition of catch data in number of observations by day and boat.

Gear	Troll	Baitboat	Both
Catch data usable in the analysis	32 045	545	32 590
Catch data without precise effort	16 912	602	17 514
Catch data not distributed by class	23 677	1 511	25 188
Total	69 236	2 307	71 543

Since fishing effort could not be precisely estimated when a vessel was searching for fish or facing a rough sea, observations with these activities were not used in the final runs. Nevertheless, runs including these data with an estimated effort showed similar trends of abundance.

Extrapolation of non-distributed catch was realized but the results from the linear model fit were very similar in trends.

There was no data available concerning the vessel characteristics, thus it was not possible to ascertain the class of vessels except for gear types. Standardized CPUEs by vessel were calculated by means of a GLM on the corrected original dataset and showed that most of the 494 vessels were very similar in terms of mean CPUE.

It was decided that vessels that did not produce a minimum of 20 annual observations during at least 3 years would be omitted from the analyses. In fact these data are less useful to describe trends in abundance, since they can not be compared over years. Therefore, 22 617 catch observations of 127 vessels (5 baitboats and 122 trollers with similar mean CPUE) remained for the main analyses. This subset of data was called the selected dataset. Nevertheless, runs were made to check that no information was lost when using this dataset.

METHODS

Abundance indices estimates

The trends in Albacore abundance are estimated by looking at the catch per unit of effort (CPUE) data with a multivariate linear model. The following general model was applied for each commercial class c (2, 3 and 2+3):

$$\ln(CPUE_{c,v,d}) = \mu + E_y + E_g + E_p + E_a + E_{c'\neq c} + I_{c'\neq c,y,g,p,a} + e_{c'\neq c,v,d} \qquad (1)$$

where $CPUE_{c,v,d}$ are the CPUE of commercial class c for the vessel v during the day d (of year y, at period p in area a);
μ is a constant;
E_y is the year effect that measures the variability between years and can be interpreted as an estimator of the index of abundance for year y;
E_g is the vessel category (gear for instance) effect which is assumed constant over time for a given vessel category;
E_p is the period effect; E_a is the area effect;
$E_{c'\neq c}$ is the effect of the other commercial classes CPUEs;
$I_{c'\neq c,y,g,p,a}$ is the sum of the interactions between effects; and
$\varepsilon_{c'\neq c,v,d}$ is a residual term.

In the case of this study, monthly 5°×5°-degrees areas strata (s) were used rather than the daily positions of the catch data.

Choice of models

A general model was used to select the predominant effects. The criteria for selection was based on the F value. In a first step, vessels were aggregated by gear category since SAS was not able to handle the many empty matrix cells when using a vessel effect.

Table 2. Sum of squares (SSQ) of the major terms of the general model. The P-levels for all the terms listed in the table were less than 0.0001. Other terms had a F value less than 4, and increasing P-levels.

Term	Degrees of freedom	SSQ	F value
Year	19	242	10.6
Month × area	23	229	8.3
Year × month	74	693	7.8
Month × gear	4	36	7.4
Year × area	123	1 078	7.3
Year × area × month	136	1 090	6.7
Total model	442	14 287	26.9
Error	22 174	26 600	-

From this table, it appears that the year effect is effectively significant. Also the area-time (or strata) effect month × area (E_s) is significant and can be interpreted as the catchability of fish in the spatio-temporal strata.

Because models with no crossed effects showed that the vessel effect had a larger SSQ than the year effect but with a lower F value and 126 degrees of freedom, vessel effect was kept for the other models.

Moreover, final analyses were conducted only with troll catch data because baitboat catch data did not extend over the whole period and because they represented only 1.67 % of the usable subset of catch data. The consequence of this was that the month × vessel effect became insignificant. The trends for the beginning of the studied period were not modified.

Finally, CPUE data of the first class (age 1) were not used in this study because these fishes were not targeted and even avoided

Also previous analyses and comments made at the ICCAT Albacore workshop of June 1994, suggested to fit models for class 2+3 CPUE. The fitted a model with a year × vessel effect instead of a spatio-temporal effect to look at the last years indices since we suspected some change in the vessel efficiency when the fleet decreases.

Therefore, the models described in table 3 (bottom of the page), among others, were fitted using the GLM procedure of the software SAS on a Unix workstation.

Abundance indices calculation

The residuals of the effects E_y generated by the GLM for year y are assumed to have a Normal distribution with mean μ_y and standard deviation σ_y. Hence, the standardized CPUE (and in a similar way, the confidence intervals) were then estimated using the following transformation (Patterson, 1966):

$$IA_y = \exp(\mu_y + \sigma_y^2/2) \qquad (2)$$

These terms were divided by their mean over all the period in order to obtain abundances indices.

RESULTS

The following table give the results of the fitting procedure of the different models:

Table 3. Summary of the GLM fits over the period 1967 to 1986, except for M4 fitted over 1978 to 1986.

Run n°	Class targeted	Model $\ln(CPUE_{c,y,v,s}) = \mu + \ldots + e_{c'\neq c,y,v,s}$	R^2	CV	DF	F value
M1	2	$E_y + E_v + E_s + E_1 + E_3$	0.28	36.8	195	44.5
M2	3	$E_y + E_v + E_s + E_1 + E_2$	0.29	98.2	195	47.9
M3	2+3	$E_y + E_v + E_s + E_1$	0.24	29.7	189	36.6
M4	2+3	$E_y + E_{y,v} + E_1$	0.19	30.8	126	10.74

CV and DF are the coefficient of variation and the degrees of freedom of the models. All models had P-level less than 0.0001.

Abundance indices of class 2 and class 3

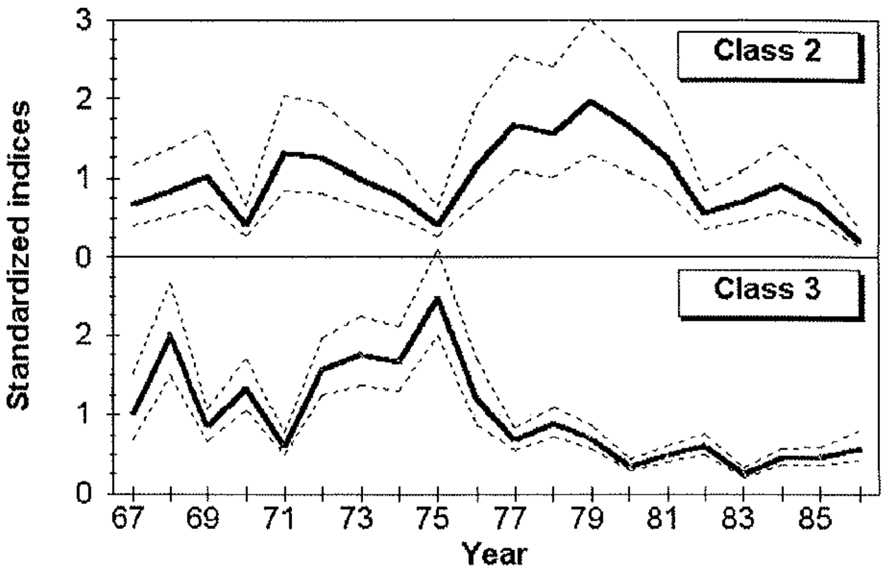

Figure 2. Evolution of Albacore abundance indices for classes 2 and 3.

For class 2, abundance indices are slowly increasing from 1967 to 1979 (figure 2), with two periods of low standardized CPUE: 1970 and 1975 corresponding to two well known low recruitments of fish born in 1968 and 1973 (Bard, 1981). After 1979, class 2 abundance indices clearly decrease by a factor of 10. Class 3 abundances also increase at the beginning of the period, but start to decrease as soon as 1976 and seem to stabilize at about 40% of the average over the period 1967 to 1986. This difference in trends is reflected by a change in the catch structure: from 1967 to 1975, class 3 represent more than 20 % of the total catch of the trollers

Due to the predominance of class 2 Albacore (65 to 75 % of the total catch), trends of class 2+3 reflects those of class 2, with a slow increase in abundance until 1979, followed by a steep decrease (figure 3).

The first period is punctuated by two low values in 1970 and 1975. These two events follow the years 1968 and 1973 that were already known for their low recruitment (Bard, 1981).

The model without spatio-temporal effect as proposed by Laurec (1977) but taking into account a crossed effect year × vessel shows that the decrease in abundance starts two years later. The fluctuation of these indices are more important than for the M3 indices due to the fact that less vessels were used to fit the CPUEs.

DISCUSSION

Several observations lead us to prefer indices from model M4 for the period 1979 to 1986:

[redacted]

reduced first their fishing area in 1980 and 1981. The logbooks also show that they did not fish anymore during October after 1979. Afterwards, it appears clearly on the dataset used for the

CONCLUSION

Indices given in table 4 were selected from this analysis for the purpose of VPA tuning. Until 1981, they show a slight increase in abundance preceding a period of decline due, in unknown proportions to a decrease of albacore abundance and a decrease of vessel efficiency.

	Model (Class)			
year	M1 (2)	M2 (3)	M3 (2+3)	M4 (2+3)
67	0.68	1.01	0.69	
68	.85	1.99	1.11	
69	1.02	0.85	1.12	
70	0.43	1.34	0.63	
71	1.31	0.62	1.25	
72	1.25	1.56	1.33	
73	0.99	1.75	1.31	
74	0.78	1.66	1.36	
75	0.42	2.48	0.95	
76	1.15	1.22	1.23	
77	1.66	0.68	1.46	
78	1.56	0.89	1.27	1.04
79	1.96	0.71	1.46	1.46
80	1.65	0.36	1.13	1.57
81	1.25	0.50	0.99	1.55
82	0.55	0.61	0.60	0.86
83	0.70	0.26	0.47	0.47
84	0.91	0.46	0.71	1.70
85	0.66	0.47	0.67	0.37
86	0.22	0.58	0.24	0.62

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