On estimating fishing intensity of tuna longline, taking an example from North Atlantic stock of white marlin, *Tetrapturus albidus*

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Abstract

Problems in estimating fishing intensity of the tuna longline described by HONMA (1974) were studied by comparing the results of computations from two sets of different "average years period" and "time stratum" on the basis of the same data. The North Atlantic stock of white marlin which has been exposed under rapidly changing exploitation pattern of the Japanese fleet was discussed as an example. The results show that a care should be taken to decide the average years period and time stratum, since their different choice may affect significantly the calculated annual fishing intensity especially when the operational strategy changes.

Using the average years periods and time stratum that seem to be appropriate for the North Atlantic white marlin, the density index was calculated for the partial areas of distribution. These estimates appeared to show nearly comparable trends to those from the entire stock area.

Introduction

The longline fishery in the Atlantic Ocean has captured billfishes as by-product as in other oceans. The longline vessels are generally mobile and capable of changing their target from one tuna species to another resulting in a significant change in their effort distribution in area and season. When the Japanese longline statistics are analized as primary data, such a change in operations has created serious problems in estimating effective fishing effort directed to billfishes for the purpose of the stock assessment.

HONMA (1974) reported on the procedures to eliminate or reduce biases in obtaining estimates of fishing effort for the longline fishery, and since then his method has been

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applied to the billfishes in the Pacific (SHOMURA 1980) and the Atlantic Ocean.

In recent years, the Japanese longline fishing grounds in the Atlantic has been contracted and localized to temparate waters ascribable to the shift of target species to bigeye and bluefin tunas, resulting in the sharp decrease of billfish catches. Such change in fishing strategy has apparently increased a concern in estimating the effective effort on Atlantic billfish species, even though the HONMA method is valid in principle. Since the data available for the effort estimation is limited to the Japanese only which accounts for less than 10 % of the total Atlantic billfish catches in certain species, the magnitude of possible gap between the principle in HONMA method and reality might be amplified to a great extent. This paper deals with some aspects of the problems concerning HONMA method by taking an example for the case of assumed white marlin stock in the North Atlantic Ocean.

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Materials and methods

A series of effort and catch statistics by area on Japanese longline fishery covering a period 1962 to 1979 were utilized (Fishery Agency of Japan, 1965-1981). A unit of area by latitude 5° × longitude 5° by month is the smallest breakdown of area-time stratum for these statistics.

Assuming the constant average distribution pattern of density indices by season, HONMA method adjusts the nominal longline fishing effort by multiplying the relative efficiency factor, which is calculated for selected average years period as a ratio of average density for each subarea and season to overall average density of the stock. This method is convenient to the longline fishery as the fishery changes erratically area and season of operations due to socio-ecomonic factors.

HONMA (op.cit.) originally chose season, i.e., quarter of the year as a time stratum in estimating fishing intensity on Atlantic yellowfin stock taken by the Japanese longline boats. In the present report, first, the effect of the different average years periods and time strata on the resultant estimates of fishing intensity are compared. Second, how far the current commercial data only from the partial stock areas stand for the density indices for the entire area are examined. This second point could be assessed by comparing the two sets of density indices from the partial and entire stock areas, using historical

Japanese data.

Most of the calculations were made with the ACOS 800-II at the Computing Center for Research in Agriculture, Forestry of the Ministry of Agriculture, Forestry and Fishery.

Results and discussion

Selection of average years period and time stratum

CONSER (1980) already made considerations about the effects of selecting different period for average years in the estimation of fishing intensity by HONMA method and concluded that the choice of several periods was not so sensitive to the results. On this concern, the present analysis, however, leads to different conclusion in the case of the white marlin in the North Atlantic.

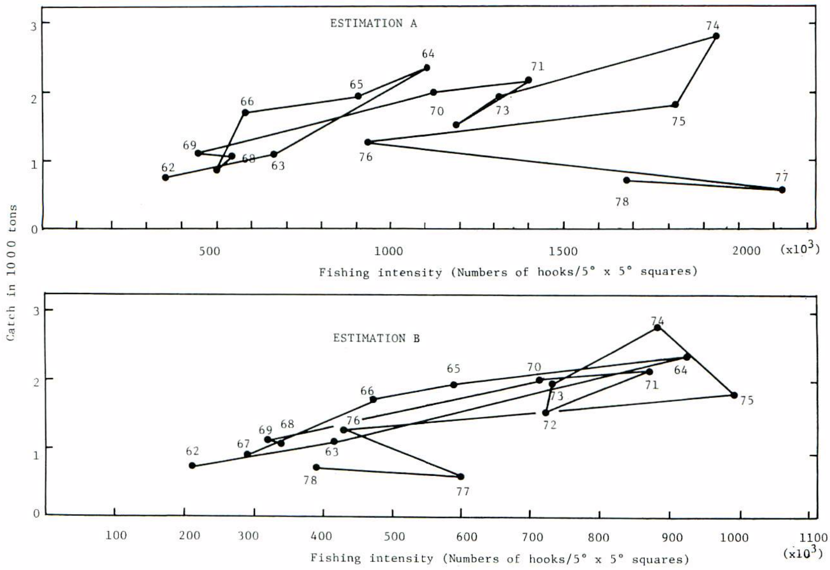

Fig. 1. Comparison of two sets of overall fishing intensity on northern stock of white marlin plotted against the same catches, 1962—1978. Estimations A and B from FARBER and CONSER (1981) and the present study, respectively. See text for explanation.

Figure 1 compares two sets of annual fishing intensity estimated by HONMA method, plotted against corresponding catch, on the northern stock of white marlin. Estimation A is by FARBER and CONSER (1981) based on average years period 1964-1972 and quarterly time stratum for the area north of the equator. Estimation B is by the present estimation based on average years period 1965-1975 and monthly time stratum for the area north of

5°N excluding the Gulf of Guinea. Since the difference in the extent of the stock area is negligible between both estimates, differnces in fishing intensity are attributable to the differences in the average years period and time stratum.

It is pointed out from Figure 1 that a large difference is observed in relative strength of estimated annual fishing intensity for the years 1977 and 1978. This difference is serious, provided the data set fits the model, because it is apparent that the effort level in 1977 and 1978 is on the overfishing side of the yield curve in the estimation A and not on this side in the estimation B.

Table 1. Catches in number of white marlin and proportion by areas (shown in Fig. 2 in this paper) to the North Atlantic catches taken by the Japanese longline fleet (Cited from Table 3 of KIKAWA and HONMA 1980).

Catch in number			Proportion to North Atlantic catch			
Year	Whole Atlantic	North Atlantic	Areas 1, 2 & 3	Area 1	Area 2	Area 3
1968	42,957	12,513	0.625	0.127	0.262	0.237
1969	26,976	16,248	0.721	0.036	0.279	0.406
1970	31,787	19,682	0.792	0.372	0.332	0.089
1971	36,359	34,438	0.862	0.302	0.497	0.063
1972	15,333	12,361	0.718	0.388	0.236	0.094
1973	13,215	12,502	0.972	0.538	0.395	0.040
1974	12,412	12,233	0.939	0.597	0.236	0.107
1975	15,192	14,766	0.917	0.718	0.106	0.093
1976	15,839	15,785	0.945	0.515	0.388	0.041
1977	3,156	2,625	0.814	0.573	0.152	0.089

As mentioned by KIKAWA and HONMA (1980), more than half of the annual catch of white marlin by the Japanese longline fleet were made in the Gulf of Mexico since 1973 (Table 1 and Figure 2). It is also indicated that in the Northern Gulf of Mexico (NGM, north of 25°N) the hook rates of white marlin in the first quarter was exceptionally high only in 1972, whereas in the following years the highest hook rates were recorded in the third quarter and the hook rates in the first quarter were very low (Figure 3). During the period 1964-1972, which was adopted for the calculation of the average density index by estimation A, the examination of the catch-effort data base revealed that longline operations in the first quarter in the NGM were recorded in only two years, 1964 and 1972. Calculated hook rates were as high as 0.34 for 1964 and 0.74 for 1972 each from very small effort of 9 days (19,225 hooks) and 5 days (11,562 hooks) operations, respectively. Therefore, estimation A picked up density index rather unusual that would not represent average years index of density for the area in question. In the

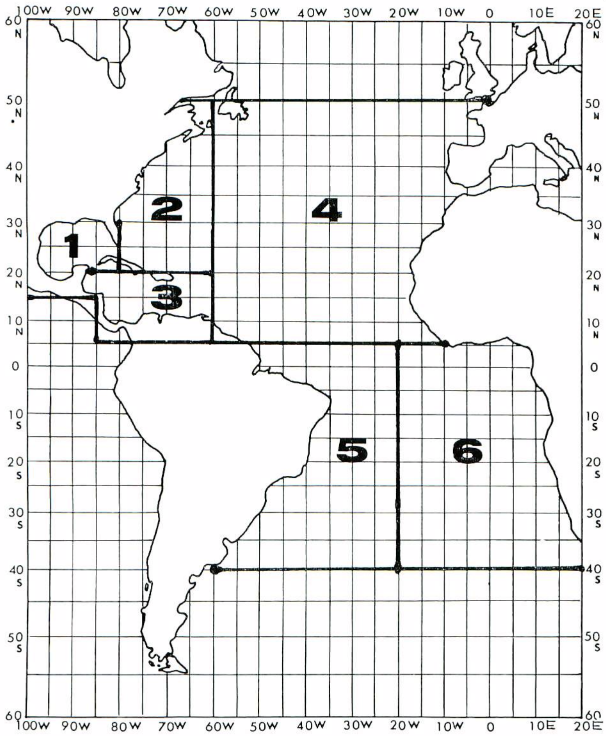

Fig. 2. ICCAT billfish areas. Area number 1, 2 and 3 correspond to those indicated in Table 1.

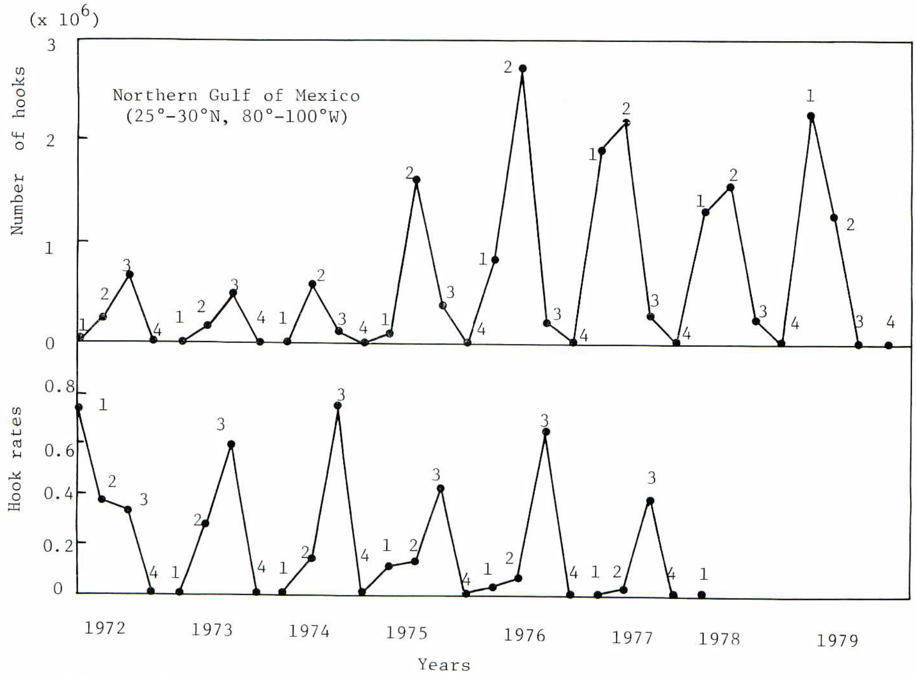

Fig. 3. Quarterly hook rates of white marlin and number of hooks used in the Northern Gulf of Mexico by the Japanese longline fishery (Modified from Figure 3 of KIKAWA and HONMA 1980). Numerals in the Figure denote quarters.

case of estimation B that adopted average years from 1965 to 1975, average hook rates in the NGM were far less than those of estimation A due to averaging of hook rates for the years 1972 to 1975.

This difference in the two sets of calculations is more clearly shown in Figure 4 that compares fishing intensity of the Japanese longline fishery on white marlin in the North Atlantic by estimations A and B and ratio of A to B. From about 1974 on, when the shift of the Japanese fishing effort to the NGM has begun, the ratio increased, especially in 1977 and 1978, indicating that estimation A gives marked amplification of the fishing intensity in recent years.

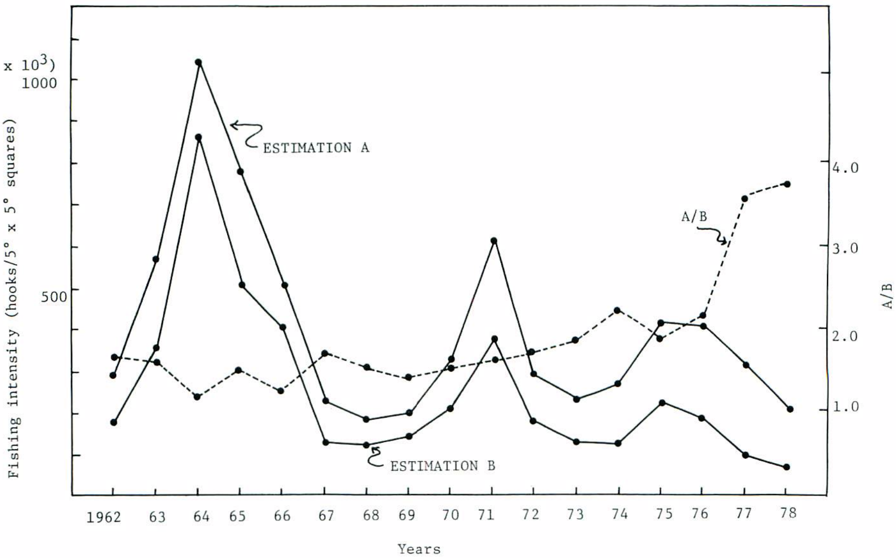

Fig. 4. Comparison of two sets of fishing intensity by the Japanese longline fishery on white marlin in the North Atlantic by the estimations A and B and ratio of B to A (dotted line).

The point above discussed did not mention about the differnce in time stratum, which is also critical factor in the computation, quarterly or monthly basis used in calculating density indices. Detailed examination of the Japanese longline catch statistics indicates that exceptionally high hook rates in the first quarter of 1964 and 1972 were obtained from small number of operations only in January and no operations from the other two months of the first quarter during the years 1964-1972. On the other hand, in the NGM a drastic change in quarterly distribution of fishing effort occurred (Figure 3). Namely, until 1976, highest effort was expended in the second or third quarter, whereas after 1977 comparable or even higher number (in 1979) of hooks were casted in the first quarter due to switch of target species to bluefin tuna.

As a result, in the estimation A, the fishing intensity has become overestimated for the years 1977 and on, because of higher average hook rates and large number of hooks exerted in the first quarter. On the other hand, this is not the case for the estimation B, because of lower hook rates and small number of hooks in January and February and large number of hooks with lower hook rates in March. It is concluded that enough considerations should be given in selecting time stratum, preferably as small a stratum as possible within the scope of available data in addition to average years period in applying this method, especially when drastic changes in the key Japanese fishery occurred.

Density indices estimated from data in different coverage

Major motivation developing HONMA method was to reduce possible biases in estimating effective effort introduced by area-time changes of fishing operations of the longline fleets, which are characteristic of the Japanese boats. Among several assumptions required to validate this method, the constant area-time distribution pattern of hook rates for the applied species is one of the most important ones. In reality, such a pattern fluctuates from year to year. However, this fluctuation would be averaged out if the fishing data cover sufficiently the entire distribution area for more than several years, as far as the longline fishery is concerned.

If the key Japanese data are available for major areas of the stock distribution, the problem of areal data coverage would not produce significant effects on estimation of the overall effective fishing effort, for markedly different pattern from the average one throughout the entire stock area is unlikely to occur. On the other hand, if the fishery covers only partial area of distribution as in the recent Japanese fishing pattern for white marlin (Figure 5), anomalies from the average pattern in distribution would be magnified due to fluctuation of seasonal migration and changes in vulnerability. Consequently, the bias in estimating effective effort from such limited data might be enlarged.

In an attempt to evaluate the magnitude of this variation, index of stock density of the North Atlantic white marlin was compared in terms of hook rates using two different sets of the same Japanese data;

Estimation C: Based on rather limited number of 5° squares for which Japanese catch and effort data are available every year for 1974-1978. These squares are shown in Figure 5 as dark circles and represent the recent Japanese fishing pattern.

Estimation D: Based on all 5° squares for which Japanese catch and effort data are available.

The data from 1963, when full expansion of the Japanese longline fishing ground was achieved, to 1978 were selected for both estimations and effective effort were calculated using average years period 1965-1975 and monthly time stratum. The extent of the northern stock of white marlin is north of equator and south of 45°N.

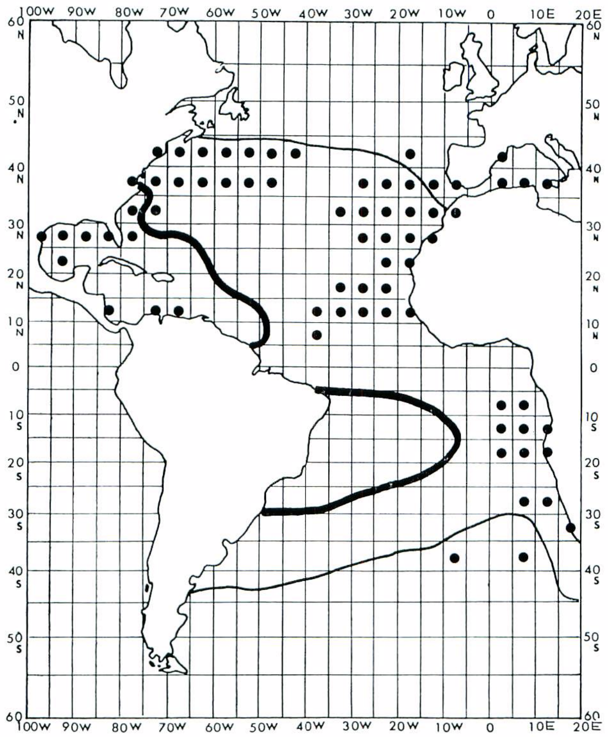

Fig. 5. Schematic representation of the extent of overall distribution deliniated by fine lines and abundant distribution by thick lines for white marlin in the Atlantic.
Fishing efforts excerted in the higher latitudes than 40°S and 45°N are not shown in the Figure. Dark circles represent 5° squares with which the Japanese longline boats operated every year during 1974—1978 period.

As shown in Figure 6, two estimates are in a fairly good accordance in their annual trends. The close coincidence of the two estimates after 1972 obviously reflects the fact that the data base used for two calculations is almost the same. Therefore, the conclusion is that the density indices calculated by the recent Japanese longline data, although obtained from the limited areas and seasons, would trace changes of abundance in the entire stock. However, it should be noted that there might be other unknown factors that give significant biases to the estimation of fishing intensity, since the fishing strategy of the Japanese longline fishery is changing drastically in a complicated manner.

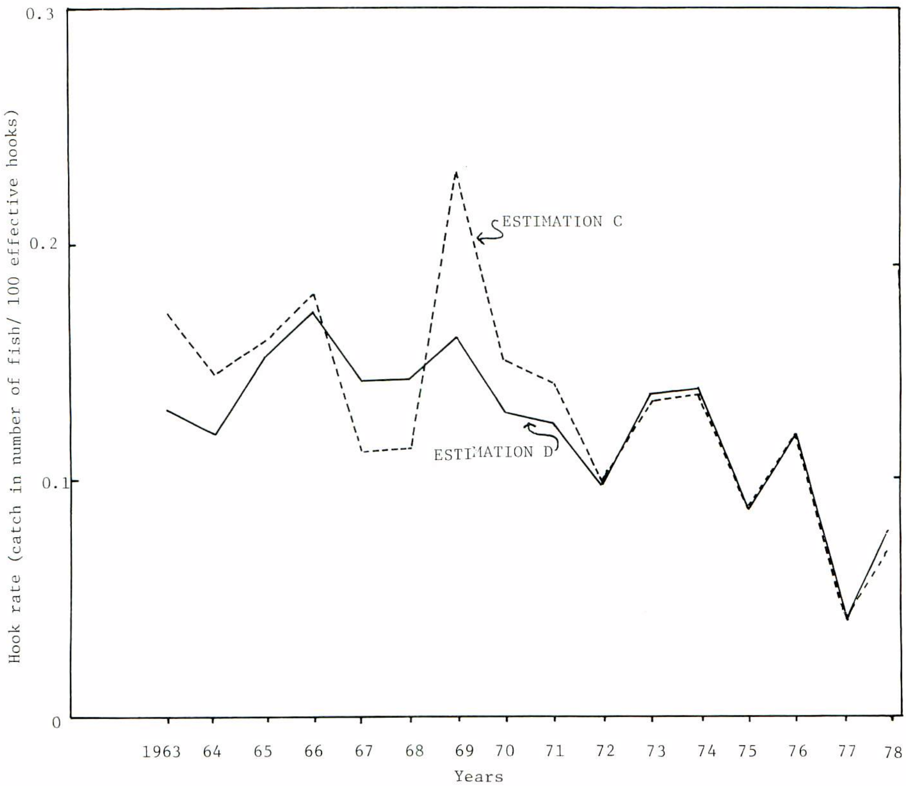

Fig. 6. Annual change in stock abundance estimated by two sets of hook rates on white marlin in the North Atlantic.
Solid and dotted lines denote hook rates computed from entire 5° squares fished and 5° squares of partial areas shown by dots in Figure 5.

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北大西洋のニシマカジキ（*Tetrapturus albidus*）を例としたマグロはえ縄漁業の漁獲強度の推定について

鈴木治郎・木川昭二

摘　要

同一のデータに基づいて，2つの異なった〝平年の期間〟と〝時間層〟を用いて計算した結果を比較することによって，本間（1974）の方法によるマグロはえ縄漁業の漁獲強度を推定するさいの問題点を検討した。例として，漁業の利用形態の急激な変化を示している日本のマグロはえ縄漁業で獲られる北大西洋のニシマカジキのストックをとりあげた。結果は，漁業の操業形態が大きく変化した場合には異なった平年の期間と時間層を用いることによって，漁獲強度の推定値が大きく異なることがあるので，これらの2要素の決定には慎重な配慮が必要であることを示している。

近年日本のマグロはえ縄漁場は北大西洋のニシマカジキの主分布域の一部しかカバーしていない。このような偏よった漁場から得られたニシマカジキの密度指数と全北大西洋から得られた密度指数とを比較した。その結果，両者間の年変動傾向は，ほぼ一致していることが示唆された。