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# ESTIMATION OF RECRUITMENT OF 1973 COHORT OF BLUEFIN TUNA IN THE WEST ATLANTIC, USING TAGGING RESULTS

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SUMMARY

Recruitment level of the 1973 cohort of bluefin tuna in the west Atlantic was estimated from tag release-recapture (Parrack, SCRS/80/43) and catch (Parrack, SCRS/81/55) data. This estimation was made on the assumption that Z and F were constant during the data available and then these values were corrected using the tag shedding rate reported by Baglin et al. (SCRS/79/84). The number of recruitment at age 1 was estimated to be more than one million fish.

RESUME

Le niveau de recrutement de la cohorte de 1973 du thon rouge de l'Atlantique ouest a été estimé à partir des données de marquage-récupération (Parrack, SCRS/80/43) et de capture (Parrack, SCRS/81/55). Cette estimation a été faite en postulant une valeur constante de Z et F pour la série des données disponibles, et ces valeurs ont ensuite été corrigées en utilisant le taux de rejet de marques signalé par Baglin et al (SCRS/79/84). Il a été estimé que le recrutement à l'âge 1 s'élevait à plus d'un million de poissons.

RESUMEN

El nivel del reclutamiento de la cohorte de atún rojo de 1973 en el Atlántico Oeste se estimó en base a datos de marcado-recaptura (Parrack, SCRS/80/43) y captura (Parrack,SCRS/81/55). Esta estimación se realizó bajo el supuesto que Z y F eran constantes en los datos disponibles, y después se corrigieron por medio de la tasa de pérdida de marcas informada por Baglin et al.(SCRS/79/84). La cifra de reclutamiento a la edad 1 se estimó en mas de un millón de peces.

## INTRODUCTION

Recently stock assessment of Atlantic bluefin tuna has been done mainly based on cohort analysis (Parrack 1981, 1982, Suzuki and Hisada 1982, etc.). The results indicate that there are often considerable differences among the estimates of number of stock and this may be attributed to the intrinsic nature of this method. So, it is desirable to try another independent method to assess the stock and to check the results of cohort analysis.

In this paper, it is aimed to estimates the recruitment level of bluefin tuna in the West Atlantic based on tag release-recapture data and catch data, and to compare with the results of cohort analysis.

## MATERIALS

In order to assess the stock size using tagging results, detailed release-recapture data by age and year are desirable, however, most of the data published for bluefin tuna are not in such a form. In this paper the analysis was done basing upon only the data of detailed release-recapture on 1973 cohort appeared in Parrack (1981). Catch data by age and year corresponding to release-recapture period in Parrack (1982) are also used. These data are shown in Table 1.

## METHOD AND RESULTS

The analysis was made on the assumption of the following behavior pattern for the young bluefin tuna in the western Atlantic: Fish recruit to U.S. surface fishery before they attain to 2 years old. Since then, they make seasonal north-southward migration from off New Jersey to Long Island. While most of fish continue the same pattern of migration year by year, some fish emigrate to outside from fishery. The fish once emigrated will not immigrate into the fishery during their young ages. In addition, the tagged fish are assumed to mix randomly with the other fish in the distributional and fishing areas.

### Estimation of Z and F

Basing on the recapture data of Table 1, relation between the time elapsed and yearly recapture (natural logarithm) of 1973 cohort is shown in Fig. 1. As the straight line could well be fitted to the relation except for the first year recapture, total mortality rate (Z) is estimated as 1.1469 from the regression (r=0.99) for those four ages.

According to the above assumption for the fish behavior, Z must include F and other mortalities such as M, emigration, tagging mortality, etc. If we assume F to be constant for different ages, this value can be estimated basing on Z and yearly recapture data.

Z of the tagged fish in the first (release) year is likely to be smaller than that of succeeding years, because the tagging operation was not done just in the begginning of the fishing season and also the recapture in the first year was less than that of the second year. For the explanation of this possible lower Z in the first year, the following two cases are assumed: 1) F of tagged fish in the first year is apparently smaller than that in the latter years, while other mortalities are same as those in the latter years. 2) Z of tagged fish in the first year is smaller than that (1.1469) of the succeeding years, while the ratio of F to Z is constant.

For these two cases, F and Z in the first year ($F_1$, $Z_1$) and F in latter years ($F_2$) are calculated using the following equations, (1) - (3).

Number of tagged fish remained in the begginning of the second year ($A_2$) is given by

$$A_2 = A_1 \cdot e^{-Z_1} \qquad ---- (1)$$

where $A_1$ = number released

$Z_1$ = instantaneous total mortality rate of the tagged fish in the release year.

Number of recapture in the release year ($R_1$) is calculated by

$$R_1 = A_1 \cdot F_1/Z_1 \cdot ( 1 - e^{-Z_1} ) \qquad ---- (2)$$

where $F_1$ = instantaneous fishing mortality rate in the release year.

Sum of recapture from second year to the last year reported is given by

$$\sum_{i=2}^{5} R_i = A_2 \cdot F_2/Z_2 \cdot ( 1 - e^{-4 \cdot Z_2} ) \qquad ---- (3)$$

where $R_i$ = recapture in the i age

$F_2$ = instantaneous fishing mortality rate after release year

$Z_2$ = instantaneous total mortality rate after release year (1.1469).

The results are as follows:

| | Case 1 | Case 2 |
|---|---|---|
| $F_1$ | 0.0750 | 0.0588 |
| $F_2$ | 0.3881 | 0.2269 |
| $Z_1$ | 0.8338 | 0.2972 |
| $Z_2$ | 1.1469 | 1.1469 |

Estimation of recruitment

Employing these F, Z values and catch data, number of stock at the begginning of the second year ($N_2$) is given by

$$N_2 = \sum_{i=2}^{5} C_i \; / \; ( \; {}^{F_2}/_{Z_2} \; ( \; 1 - e^{-4 \cdot Z_2} \; ) \quad - - - - \; (4)$$

where $C_i$ = catch in number in the i year.

$N_2$ for the Case 1 is calculated as about 800,000 and for the Case 2, about 1,430,000.

As Z of non-tagged fish in the release year is not estimated, number of stock at the begginning of release year ($N_1$) was evaluated from $N_2$, catch data and assumed M value (0.18). Results were about 1,030,000 for Case 1 and 1,780,000 for Case 2. As M was only considered and not other mortalities in this occasion, those must be lowest estimates.

There may be tagging mortality and shedding of tag in young bluefin tagging (Baglin et al., 1980). When such parameters are taken into consideration, estimates of $N_1$ will decrease to some extent.

Comparison with the results by cohort analysis

Estimates of number of stock at age 1 are compared with those based on cohort analysis by Parrack (1982) and Suzuki and Hisada (1982) as in Table 2 and 3. Estimate by Parrack is considerably less than each of Case 1 and 2. Estimate by Suzuki and Hisada is nearly same to that of Case 1.

According to the above assumption on the behavior pattern of fish, estimates of Z and F calculated based on tagging data are not the representatives for whole stock since Z obtained from tag release-recapture data includes emigration of fish. Therefore, to enable the comparison with the results of cohort analysis, number of stock and F by age were estimated by VPA (virtual population aanalysis) and shown in Table 2. These estimates are different from the values by Parrack and similar to those by Suzuki and Hisada in Case 1 (Table 2, 3).

REFERENCES

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Table 1. Tag release-recapture and catch data of 1973 cohort.

| YEAR | RELEASE | RECAPTURE | CATCH |
|---|---|---|---|
| 1973 | - | - | 0 |
| 1974 | 983 | 50 | 61242 |
| 1975 | - | 90 | 173790 |
| 1976 | - | 39 | 73701 |
| 1977 | - | 11 | 22603 |
| 1978 | - | 3 | 9939 |

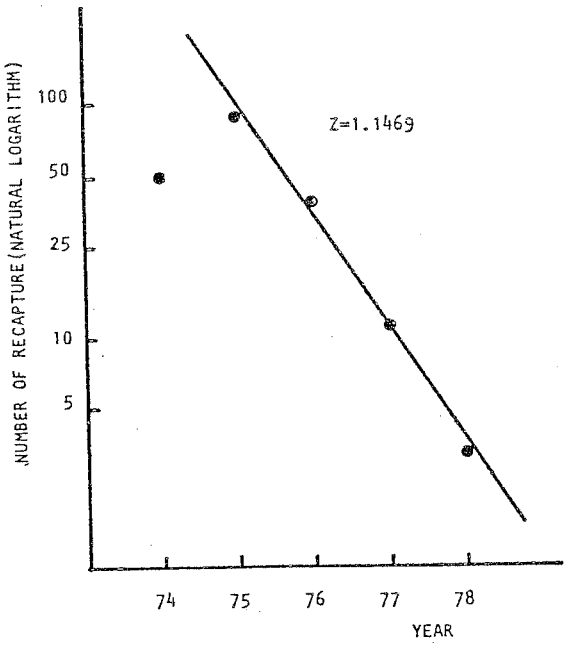


Fig. 1. Relation between the time elapsed and yearly recapture (natural logarithm) of 1973 cohort cited in Table 1.

Table 2. Estimation of number of 1973 cohort in the west Atlantic.

CASE 1

| AGE | M | F | NUMBER | CATCH |
|---|---|---|---|---|
| 1 | 0.18 | 0.0672 | 1029103 | 61242 |
| 2 | 0.18 | 0.2683 | 803740 | 173790 |
| 3 | 0.18 | 0.1702 | 513358 | 73701 |
| 4 | 0.18 | 0.0707 | 361697 | 22603 |
| 5 | 0.18 | 0.0393 | 281507 | 9939 |
| 6 | 0.18 | 0.0101 | 226068 | 2084 |
| 7 | 0.18 | 0.0136 | 186926 | 2310 |

CASE 2

| AGE | M | F | NUMBER | CATCH |
|---|---|---|---|---|
| 1 | 0.18 | 0.0383 | 1779070 | 61242 |
| 2 | 0.18 | 0.1421 | 1430141 | 173790 |
| 3 | 0.18 | 0.0808 | 1036274 | 73701 |
| 4 | 0.18 | 0.0314 | 798384 | 22603 |
| 5 | 0.18 | 0.0169 | 646246 | 9939 |
| 6 | 0.18 | 0.0043 | 530720 | 2084 |
| 7 | 0.18 | 0.0057 | 441393 | 2310 |

Table 3. Results of cohort analisis estimated by Parrack(1982) and Suzuki and Hisada(1982) on 1973 cohort.

Parrack(1982)

| AGE | M | F | NUMBER | CATCH |
|---|---|---|---|---|
| 1 | 0.18 | 0.1059 | 665108 | 61242 |
| 2 | 0.18 | 0.4737 | 499737 | 173790 |
| 3 | 0.18 | 0.3684 | 259914 | 73701 |
| 4 | 0.18 | 0.1791 | 150200 | 22603 |
| 5 | 0.18 | 0.1091 | 103883 | 9939 |
| 6 | 0.18 | 0.0294 | 78549 | 2084 |
| 7 | 0.18 | 0.0193 | 63709 | 1114 |

Suzuki and Hisada(1982)

| AGE | M | F | NUMBER | CATCH |
|---|---|---|---|---|
| 1 | 0.18 | 0.0642 | 1076978 | 61242 |
| 2 | 0.18 | 0.2541 | 843597 | 173790 |
| 3 | 0.18 | 0.1588 | 546544 | 73701 |
| 4 | 0.18 | 0.0655 | 389464 | 22603 |
| 5 | 0.18 | 0.0362 | 304695 | 9939 |
| 6 | 0.18 | 0.0093 | 245463 | 2084 |
| 7 | 0.18 | 0.0125 | 203129 | 2310 |