SCRS/1985/027

Col.Vol.Sci.Pap. ICCAT, 24 : 154-160 (1986)

COMMENTS ON THE RECENT ASSESSMENT WORK ON THE ATLANTIC BLUEFIN TUNA

T. Nagai
Far Seas Fisheries Research Laboratory
5-7-1 Orido, Shimizu, Shizuoka pref., Japan

SUMMARY

Some problems in the recent assessment work on the western Atlantic bluefin tuna, particularly those made at the Dartmouth meeting were pointed out.

RESUME

Certains problèmes ont été signalés en ce qui concerne les travaux récents d'évaluation sur le thon rouge de l'Atlantique ouest, et en particulier ceux de la réunion de Dartmouth.

RESUMEN

Se señalan algunos problemas surgidos en las recientes tareas de evaluación del atún rojo del Atlántico, en especial las realizadas en la reunión de Dartmouth.

The purpose of this paper is 1) to point out some problems in the recent assessment works of the western Atlantic bluefin tuna, particularly those made at the Dartmouth meeting (Anon. 1985), 2) to study the biological aspects of this stock and 3) to suggest the direction which future assessment works should be taken.

1. Stock Structure

Recently, it was rather powerful opinion that there are two separate stocks of the bluefin tuna in each side of the Atlantic Ocean because two distinctive spawning areas are observed in the Gulf of Mexico and around the Sicily island in the Mediterranean (Richards, 1976), while it being confirmed from mark-recapture experiments the fact that the species concerned undergo trans-Atlantic migration. Though the extent of the mixing of the two stocks is not fully clear, the preliminary analysis by Calaprice (1985 MS) suggests a small mixing rate of only 5 to 10 percent. Further, the mixing referred here only means that a part of each stocks are caught in other habitat in the way of migration. It is not yet known whether one stock joins the other in reproduction. If the extent of mixing is as limited as it now appears to be, it would be reasonable to conduct analyses and fisheries management of the bluefin tuna, not as a single stock, but as two distinct stocks - eastern and western.

2. Population Parameter

Growth Equation: The von Bertalanffy growth equation given by Parrack and Pharse (1979) is based on mark-recapture data. However, since almost all the tagged fishes were recaptured for a short period and those smaller than 140 cm in fork length, the author feels uncertain if the equation correctly shows the growth of older fish. The equation is currently in use because it fits the growth of the fewer recaptured fish over longer periods (e.g. Hurley and Iles, 1982) and the L_∞ of 313 cm is close to the maximum length of the fish caught.

Sex Ratio: According to the growth equation by Butler et al. (1977) where age determination is based on the otoliths, when the male reaches the age three and its fork length exceeds 100 cm, it grows faster into a larger fish than the female. Even though it is not absolutely clear if the otoliths growth line is formed annually, it seems certain that there exists sexual dimorphism among the bluefin tuna. The study of sex ratio by length made by Nagai (1985a) suggests that sex ratio for the fish smaller than 260 cm is approximately 0.5. Males exceeding females in number over the length classes larger than 260 cm, it seems that the difference in growth rates between sexes should not be neglected.

Length-Age Conversion: ICCAT's Standing Committee on Research and Statistics has pointed out that the year class strength could be smoothed out, when using a single von Bertalanffy growth equation in length-age conversion (Anon. 1984). This is due to the fact that difference in growth rates among cohorts as well as individuals in the same year class and sexual dimorphism have not been taken into consideration.

The scientists at the Dartmouth Meeting, shelved the problems they pointed out in the previous year and used the conventional length-age conversion using one growth equation. This was because it is difficult to prepare an appropriate length-age conversion model that will solve the problems, and it is even more difficult to provide necessary data to support the new model.

The bluefin catch-by-size can be classified into some types (Nagai and Suzuki, 1985). Figure 1 shows the typical third quarter type. As seen in the Figure, polymodal distribution is clear for the fish smaller than 160 cm; there are very few medium-sized fish of 160 cm - 200 cm; and over 200 cm a single length group with a gentle curve descending towards both sides is observed. This length group larger than 200 cm contains fish of many age groups. The different growth rates among individuals of the same age must be small to convert the length group larger than 200 cm into age groups within the range where the difference in growth rate between sexes is negligible without taking into account the growth rate differences among year classes.

Age determination study shows that among the fish larger than 200 cm, the standard deviation of the age specific mean length is 3 cm at the minimum and more than 12 cm at the maximum (Nagai, 1985b; Hurley and Iles, 1983). The author believes that length-age conversion is possible for the fish smaller than 260 cm if the standard deviation is at the minimum. But this is an exceptionally lucky case. Length-age conversion is not possible for the length classes larger than 260 cm because of the significant difference in sex ratio by length. Length-age conversion would also be impossible for the fish larger than 200 cm when the standard deviation of the age specific mean length exceeds 5 cm, because the difference in annual growth among individuals of the same age group will be greater than the annual growth expected from the growth equation. At any rate the current length-age conversion using only one growth equation will result in large errors for the catch-at-age data, particularly for that of older fish.

Natural Mortality Coefficient: No accurate information is available concerning the natural mortality coefficient of the western Atlantic bluefin tuna. The natural mortality coefficient obtained by studying the trap catch at Barbate, Spain is 0.18 (Rodoriguez-Roda, 1977), which value is also used for the western stock. The natural mortality coefficient obtained through correlation between the growth parameters and the mean annual temperature of the place where the fish were caught (Pauly, 1980; IATTC, 1982) is in the range of 0.12 to 0.18 or 0.19. The lower the mean annual temperature (10 - 25°C), the smaller the coefficient. Since the bluefin tuna changes its habitat throughout its different growth stages and migrates extensively, it is difficult to represent the mean annual temperature of its habitat by a single value.

3. Yields, and Mean Age of the Bluefin Catches

Figure 2 shows the change in the bluefin tuna yields. Except for the 1960s when Japan made big catches of medium-sized bluefin tuna off the coast of Brazil, the annual yields have been relatively stable in the 1970s at 3,500 to 7,300 tonnes.

According to the catch-at-age data obtained at Dartmouth in the years from 1970 to 1981, the number of catch of 1-to-7-year old fish has reduced to one sixth, while that of 8-year old fish has increased four times (See Fig. 3).

The calculation of the mean age of the catch after 1970 shows the lowest to be 2.5 years old in 1970; the annual mean ages have fluctuated between 2.5 to 3.7-year old in the six years between 1970 and 1976. In 1976 the mean age became 4.6 years old, and with various improvemnts made year after year, exceeded 6 years in most years until 1981. The mean age of the bluefin tuna catch has thus become higher since 1976. Since bluefin tuna is a large-sized fish with a long life span, the yield per recruit increases if the mean age of the catch becomes higher.

4. CPUE Series

It was agreed at the Dartmouth Meeting that there are no CPUE series available to show the stock abundance of small-sized fish. Five CPUE series of Japan and Canada were studied with regard to large-sized fish.

Study of the correlation between the parental stock and the CPUE through preliminary VPA runs has shown either a low correlation or that of negative. It was therefore recognized that neither Japan's nor Canada's CPUE can be used in VPA tuning.

Nevertheless, two CPUEs were finally chosen based on the scientists' feeling that the decrease in the CPUEs in the 1970s must have occurred due to too much fishing of small- and medium-sized fish in the 1960s.

These are 1°-squares CPUE data by Japanese longliners operating in the Gulf of Mexico and the CPUE of the Canadian rod-and-reel fishing off Prince Edward Island. The author feels that instead of making this arbitrary choice of CPUEs, the scientists should have decided that there are no CPUEs available for the tuning of VPA.

Another important point worth noting is that these CPUEs are things of the past and quite absolute. The operation of Japanese longliners in the Gulf of Mexico ended for good in 1981. As for Canadian rod-and-reel, the introduction of tended lines has significantly increased its CPUEs so that it is no longer consistent with the CPUEs before 1980.

CPUEs will continue to be an important data in determining the relative abundance of a particular stock. Accurate gathering of CPUE data will be a future challenge to the SCRS.

5. Assessment Methods

Standardization of CPUEs: At the Dartmouth Meeting a generalized linear model based on the multiplicative model was applied to the data obtained from Japanese longliners (Robson, 1966; Gavaris, 1980), and the standardization procedures were used for three cases of 5 CPUE series. Of these the 1°-squares CPUE data from the Gulf of Mexico was chosen.

But the contribution factor (r^2) of this CPUE data is only 0.47. If the contribution factor, which is an indication of a model's reliability, is as low as this, the model could not adequately explain all the past phenomena contained in the data.

Since only spawning adults are caught in the Gulf of Mexico, the CPUEs could possibly be used to indicate the abundance of this stock. But in other northwestern Atlantic it would be extremely difficult to obtain the two stock abundance of small- and large-sized fish, separately, from the longliners' data which contains fish of all size.

Objective Function: At the Dartmouth Meeting the objective function was used for VPA tuning. Terminal F, which will minimize the sum of residuals calculated with the specified objective function, was sought by changing F into various values.

The use of the CPUE series with high contribution factor in the objective function might be barely permissible. But the use of the abovementioned CPUE series is clearly inappropriate as an attempt to tune the VPA with a model which could not explain the phenomena adequately.

Further, only a small number of medium-sized fish occurring in the longliners' catches as previously pointed out, it seems that the availability for this size fish is low. It is well known from the longliners data that medium-sized bluefin tuna are found scattered in the open seas far from the coast not only in the Atlantic (Suzuki and Hisada, 1983) but also in the Pacific.

To assume a constant catchability in the objective function contradicts with the fact of the fewer medium-sized fish in the abovementioned catch. The catch-by-size of the spawning adults in the Gulf of Mexico also shows few fish smaller than 240 - 250 cm. This also casts doubt on the validity of assuming a constant catchability.

Sensitivity Analysis: At present sensitivity is checked by analyzing with changing natural mortality coefficients, since no specific value can be obtained even within a specified scope of natural mortality coefficient. At the Dartmouth Meeting the estimated TAC value under the 1982 fishing pattern was 6,300 tons when the natural mortality coefficient was 0.18, but was more than 12,700 tons when the coefficient was 0.10. For the latter case a high TAC value is due to a high yield per recruit though the estimate of recruits is low compared with that of the former case.

It was only natural that the figure of 12,700 tons was rejected by the Working Group, which prefers conservative estimates. Even then the extent the value of natural mortality coefficient influences the outcome of the assessment is amazing. When we scientists are unable to make accurate estimate of natural mortality coefficients, I wonder if it is possible to make assessments in which fishermen and administrators put confidence in actuality.

6. Comparison of Productivity between Eastern and Western Atlantic Stocks

The VPA analysis using the catch-at-age of one to four-year old bluefin tuna caught by the juvenile BFT fisheries in the Bay of Biscay, Morocco waters and the Spanish Mediterranean shows the recruits of age zero fish to fluctuate between 700,000 to 6 million in the years between 1972 and 1983, with the peaks occurring in 1974, 1982 and 1983 (Rey and Cort, 1985).

The aforementioned study is interesting because it suggests several things. Firstly, there is no doubt that the dominant year class was produced in 1974 (6 million) and 1982 (4 million). Also their catch-at-age data shows the catch of one year old fish to be 580,000 in the 1965 year class and 660,000 in the 1966 year class. These are also considered to be dominant year classes. This gives us the interval of seven to eight years between two successive dominant year classes. This roughly matches with the finding that there is a six- to seven-year cycle in the fluctuation of trap catches (Rodoriguez-Roda, 1971).

Secondly, for the fish older than two-year old the number of catch of the dominant year classes became fewer than the younger and older cohorts.

Thirdly, the number of recruits in the dominant year class are 4.4 to 6.7 times compared to the ordinary recruits (900,000 for 1976 - 1981 year classes).

Assuming all the fish used in this analysis were migrating from the Mediterranean, having come through the Strait of Gibraltar, and further assuming that the decrease in the number from age zero to age one fish can be explained only by the natural mortality coefficient (0.14), then the number of fish at age 1 in the dominant year class and ordinary year class is 3.5 million to 5.2 million and 780,000, respectively.

At the Dartmouth Meeting the number of one year old fish in western Atlantic was estimated to be 940,000 in the dominant 1973 cohort and 210,000 in weak cohorts (1975 - 1976 year class), which would mean that productivity of bluefin tuna in western Atlantic is roughly one-fourth of that in eastern Atlantic in theory. But actually the analysis made by Cort and Rey (1985) does not include the catch made in the Mediterranean along the coasts of France, Italy and Yugoslavia. Therefore the figure one-fourth is obviously an underestimate.

According to the comparative study made by Dicenta et al. (1980) on the productivity of the bluefin tuna in the Gulf of Mexico and western Mediterranean based on egg and larval survey, productivity in the Gulf of Mexico is more or less the same as that in western Mediterranean. If this is the truth, it clearly contradicts with the productivity figure obtained by comparing the recruits at age 1 in western and eastern Atlantic.

Granted that egg and larval survey is a difficult data to handle, it can still be used with sufficient accuracy to determine if the productivity of the bluefin tuna in western Atlantic is only one-fourth compared to that in eastern Atlantic or is roughly the same as that in eastern Atlantic. It could be that the bluefin tuna abundance in western Atlantic is grossly underestimated.

7. Some Suggestions on Fisheries Management

For western Atlantic there are sufficient catch statistics of the bluefin tuna, while size statistics, though improving in recent years, was far from being adequate before 1970 (Nagai, 1984). Since it is impossible to trace back size data into the past, there is no way we can upgrade the catch-by-size data now in our possession.

Although excellent mathematical techniques are available in estimating stock abundance, we cannot adequately explain our actual data, as in the case of 1° squares CPUE analysis in the Gulf of Mexico. At present some of the CPUE series needed by scientists are no longer available because fishing has been suspended or is not consistent in their quality.

Under such circumstances two alternatives seem possible for the bluefin tuna scientists. One is to identify the kind of data needed for their research, study possible ways of obtaining them from the individual fisheries, and improve the present monitoring system to work more effectively.

Another alternative is to go for a more macro approach instead of coming up with plausible stock assessment, which in actual practice is difficult to carry out.

As previously pointed out, the mean age of the bluefin tuna catch has become higher since 1976. This means that fisheries management has improved, resulting in less catch of small-sized fish.

Further, the annual bluefin tuna catch has been relatively stable between 3,500 to 7,300 tonnes since 1970. It would be possible to maintain the minimum catch figure of this period in the mid-term and/or long-term with fixing the fishing in the future and continue the present monitoring system. In this case it would be much easier to obtain cooperation of the fishermen to our research activities.

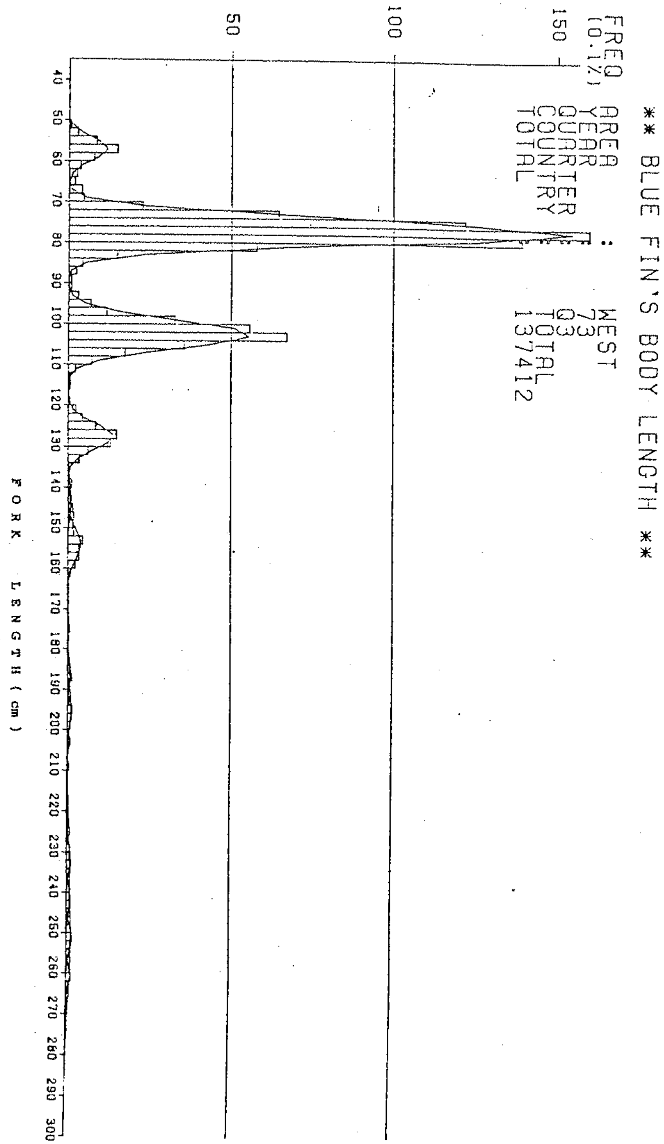

Fig. 1. The quaterly catch-by-size histogram of bluefin tuna in the western Atlantic Ocean (A typical third quater type).

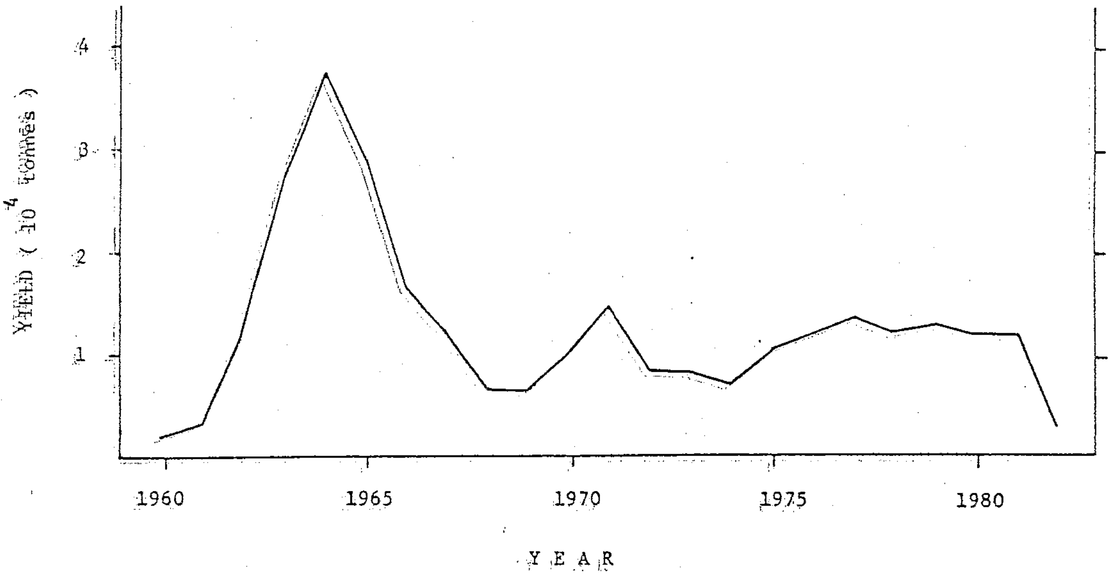

Fig. 2. Graph showing the annual yields of bluefin tuna in the western Atlantic Ocean, 1960-1982.

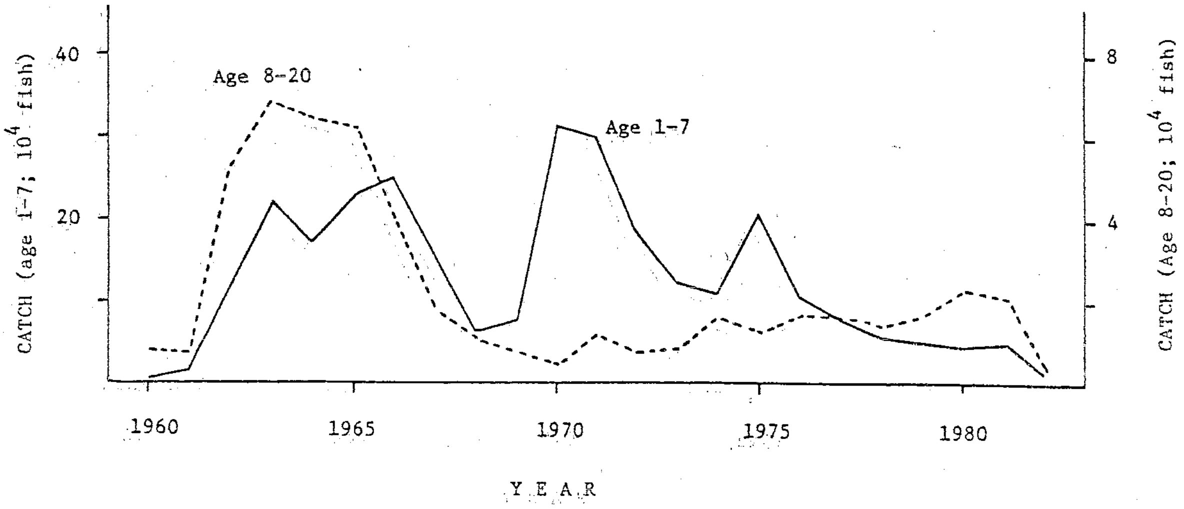

Fig. 3. Trends on the catches of the bluefin tuna classified into two age groups in the western Atlantic Ocean, 1980-1982.