SCRS/1984/039 Rev. Col.Vol.Sci.Pap. ICCAT, 22: 157-184 (1985)

STOCK STATUS ON THE WESTERN ATLANTIC BLUEFIN TUNA ASSESSED WITH THE USE OF VIRTUAL POPULATION ANALYSIS

T. Nagai, Z. Suzuki
Far Seas Fisheries Research Laboratory

SUMMARY

The catch-by-size data on a quarterly basis are available for western Atlantic bluefin tuna during 1960-1981. In the present paper, the length-age conversion was made by taking into consideration individual variations of body length within an age group, while paying attention to sexual dimorphism. The change in abundance of the western stock was examined with the use of virtual population analysis based on the newly estimated catch-at-age data. It was made clear that, after the 1970's, recruits have not necessarily continued to decrease; the spawning stock that once decreased in the early 1970's has stabilized and the size of the recruit is not related to that of the spawning stock. Further, it was indicated that in the latter half of the 1970's the recruit level was relatively low but stable.

RESUME

Les données trimestrielles de capture par taille du thon rouge de l'Atlantique ouest sont disponibles pour les années 1960-81. Le présent document fournit une conversion taille-âge effectuée en considérant les variations de taille entre individus dans un même groupe d'âge, tout en tenant compte du dimorphisme sexuel. Les modifications de l'abondance du stock ouest sont examinées par l'analyse des populations virtuelles à partir des nouvelles estimations des données de capture à un âge donné. Il est évident qu'après les années soixante-dix les recrues n'ont pas forcément continué à diminuer, que le stock reproducteur réduit au début des années soixante-dix s'est de nouveau stabilisé, et que le volume de recrues n'est pas lié à celui du stock reproducteur. Il est en outre indiqué que pendant la deuxième moitié des années soixante-dix le niveau des recrues était relativement faible, mais stable.

RESUMEN

Se dipone de los datos de captura por talla, por trimestre, referentes al atún rojo del Atlántico Oeste y al periodo 1960-1981. En este documento se ha hecho la conversión talla-edad teniendo en cuenta las variaciones individuales de la talla dentro del mismo grupo de edad, y tambien el dimorfismo sexual. Se estudió el cambio en la abundancia de la población del Oeste por medio del análisis de población (VPA), en base a los nuevos datos estimados de captura a la edad. Quedó patente que despues del año 1970, los reclutas no han continuado en descenso, que la población reproductora - que disminuyó a principios de los años 1970 - se ha estabilizado y que el volumen del reclutamiento no está en relación con el de la población reproductora. Por otra parte, se señaló que a finales de la década de los 70, el nivel del reclutamiento era bajo pero estable.

Virtual population analysis (VPA) has so far been used for stock assessment of the western Atlantic bluefin tuna. The catch-at-age data used in the VPA analysis are obtained by converting fork length composition by using von Bertalanffy's growth equation. As a matter of fact, however, different growth rates among individuals and between sexes are not taken into account in the conversion. In this connection, in order to improve stock asessment of bluefin tuna, the standing committee on research and statistics of ICCAT recommended that the difference of growth rates should be taken in the conversion model from length to age (Anon., 1984 a). The auther thought that a growth equation commonly used to both sexes could be applied until the fish reached the fork length at which sexual dimorphism became apparant (Nagai, 1984 a). Accordingly, he estimated growth equation parameters by using mean fork length by age obtained by modal analysis and then applied a quadratic curve to express the relationship between mean fork length by age and its standard deviation. While recently, through cooperation of the countries concerned and efforts of the ICCAT Secretariat, catch-by-size data on a quately basis during 1960 ~ 1981 has been made available as ICCAT's data base. Fish from ages 1 to 3 have an apparently well separated mode in their length composition according to this data. In certain cases, clearly separated modes are observed in fish of ages up to 5 or 6. Generally speaking, however, as fork length and age increase, the separation among modes became unclear. Therefore, if no information is available with regard to length-age relationship in this sense, it is impossible to convert each of the catch-by-size data on a quaterly basis to age composition. If a certain relationship between mean fork length by age and its standard deviation is estimated, then it is possible to make length-age conversion in which different growth rates among individuals are taken into account to those catch-by-size data.

The purpose of this paper is to try length-age conversion based on the quadratic equation given by Nagai (1984 a) for the relationship between mean fork length by age and its standard deviation. In addition, another purpose is to make a stock assessment of the western Atlantic bluefin tuna by applying VPA using the catch-at-age data.

Materials and Methods

1. The catch-by-size data on a quaterly basis during 1960 ~ 1981

ICCAT prepared annual catch by size data on a quarterly basis by country by type of fishery for a period of 22 years from 1960 to 1981 as the result of the preparatory meeting held in Trapani, Italy, May 23 ~ 27, 1983 and the bluefin workshop held in Tsukuba and Shimizu from August to September of the same year (Anon., 1984 b). It was only in the case of Japan's longline fishery, as a matter of fact, that length composition of the catches was made on a quarterly basis. Except for Japan's longline fishery, bluefin tuna fishing in the western Atlantic Ocean is a seasonal fishery. For this reason, it was recognized that the length composition by year could be considered as that on a quarterly basis. In the following analysis, catch-by-size data of various countries and types of fisheries combined in the western Atlantic area were used (see Hist. Bull. Vol. 1, xii). Here, it should be noted that all bluefin tuna caught by Japanese longliners from 1960 to 1966 in the Atlantic Ocean were assumed to belong to the western stock (Anon., 1984 a). In the present analysis, 2cm intervals were used. Explanations on each of the quarterly catch-by-size data will be made later.

2. Length-age conversion model

a. Von Bertalanffy's growth equation used and the subject for age separation

A number of scientists have estimated von Bertalanffy's growth equation parameters concerning the Atlantic bluefin tuna (Rodorigues-Roda, 1964; Sakagawa and Coan, 1974; Parrack and Phrase, 1979; Arena et al., 1980; Nagai, 1984 a). In the present paper, the following growth equation, which is thought to fit well not only small fish but also large fish of the western stock, was used (Nagai, 1984 a).

$$Lt = 394\ (1 - \exp^{(-0.065(t+1.21))}) \quad \ldots\ldots\ldots\ldots (1)$$

where t is a subscript indicating age, and Lt indicates fork length in cm at age t.

It is known that bluefin tuna show what we know as sexual dimorphism: the male grows larger than the female in size. According to Maguire and Hurlbut (1984) who examined the fish caught by trap net in Canada, no significant difference was observed in sex ratio if the fish were smaller than 234cm in size. In the Gulf of Mexico, males were less in number than females in the catches of longline fishery even for the fish smaller than 234cm in fork length (Nagai, 1984 b). That the sexual dimorphism is not clear up to the size of 234cm in fork length can also be gathered from non-official data of the United States submitted at the Tsukuba/Shimizu workshop. The longline fishery targeting the bluefin tuna was conducted in the Gulf of Mexico prior to spawning. Whereas, the trap net fishery of Canada and fishing by the U.S.A. are operated during the feeding season of the fish. Females apparently exceed males in number before spawning season. In the present analysis, however, it is assumed that there is no difference in growth between sexes at least up to a size of 234cm. According to the aforementioned United States' data, the number of females slightly exceeds that of males in 235 ~ 251cm fish. As the fork length increases up to 252 ~ 260cm, the sex ratio reaches close to 50%. And the fish larger than 261cm in fork length, the number of males apparently become larger than that of females. Therefore, it seems to be acceptable to assume that difference in growth rate between sexes is negligible for the fish smaller than 261cm. According to the equation (1), the mean age of 260cm fish in fork length is about 15. Accordingly, in the present analysis, the number of fish caught is estimated by age for the fish from age 1 to age 14 whereas for fish over age 15, it is dealt with collectively. Doubleday (1984) points out that, for purposes of analysis, we had better truncate catch at age distribution at some appropriate age between ages 15 to 20.

b. Relationship between mean fork length by age and its standard deviation

It was thought that the following quadratic equation can be applied for the relationship between mean fork length by age and its standard deviation (Nagai, 1984 a).

$$S = -0.779 + 0.0502\ell - 0.000158\ell^2 \quad \ldots\ldots\ldots\ldots (2)$$

Where ℓ and S represent mean fork length by age and standard deviation, respectively.

c. A program to decompose length composition into normal curves

For each of the quarterly length composition, the number of age groups included is given, while such parameters of normal curves as component ratio, mean fork length and its standard deviation being set. By improving those parameters iteratively, it is judged that solution has been obtained when the defined objective function has satisfied certain given conditions. When calculating by computer to solve the problems, such methods as the steepest descent method and Marquardt method are used. In the steepest descent method, even if an initial value is off the true value, it rapidly converges in the right direction. However, one characteristic is that it converges slowly in the vicinity of the solution. In contrast, it is said that in Marquardt method, such shortcomings have been overcome (Shimadzu, 1980). In the present analysis, the calculation was made by using the modified program based on NORM[illegible] (Hasselblad, 1966; Abramson, 1971) in which the steepest descent method is used due to the restrictions of time and the easier modification technically.

d. Setting of initial value and judgement of convergence

In the program used a maximum number of 20 sets of parameters of normal curves can be obtained. Setting of the initial values was done for each size frequency in the following manner.

Since clearly separated-modes were recognized in small fish, mean fork length by age was set at the same position of the modes in small fish. In the case of separation among modes being unclear or not observed at all, the mean fork length by age calculated from the equation (1) was used (Table 1). Standard deviation corresponding to the mean fork length by age above-mentioned was calculated from equation (2) (Table 1). If a separation among modes was clearly recognized, the ratio of the number of individuals contained between the lowest points of the observed frequency on each side as against the total number was set as the initial value of the component ratio. If no separation of modes was recognized, the conventional method, namely, the inverse procedure using observed age-length curve by von Bertalanffy's growth equation, was used. For example, the fish between the ages of 9.5 and 10.5, in terms of fork length range, were regarded as in the age 10 group.

In the present paper, k sets of initial values were assigned concerning the parameters of normal distribution, using the aforementioned method. Actually, the parameters improved by interation were limited to standard deviation and component ratio only. Further, the range of standard deviation for mean fork length by age was limited to $\pm 20\%$ of the initial value. This is because the variation of standard deviation on using the equation (2) is about $\pm 20\%$ (Fig. 3; Nagai, 1984 a).

The catches of bluefin tuna in terms of number of fish are markedly small for middle age groups from 5 or 6 to 10 in ages. However, catches of over 10 year old fish increase though. It is, therefore, thought that the fishing pattern, that is, distribution of fishing mortality by age would present a peculiar one. In addition, sample size is not necessarily sufficient if we look at the data by fishery type (Nagai, 1984 a). Because of this, quality of designated catch-by-size on a quaterly basis cannot be said to be good one. It is thought, accordingly, that placing bounds on the estimates of component ratio from such points of view was meaningful. There were, however, not so much reasonabilities with placing bounds of $\pm 50\%$ on the initial values of component ratio. Each time calculation was repeated, the absolute value of the difference of likelihood function between $k + 1$ times and k times was checked and when that value became less than 10^{-7}, it was judged that it converged. In this case, the maximum number of iteration was limited at 500 times.

3. Tuning to determine terminal F

The following two tuning methods were adopted, assuming that catchability coefficient q is constant in large fish over a given age. The first was the backward method in which the terminal F that maximize the correlation between abundance of bluefin tuna taken by Japanese longliners in the Gulf of Mexico and its population numbers. The second method given by Powers et al. (1983) in which the terminal F that maximizes the correlation between Japanese longliners' efforts and their partial F. In the present paper, regardless of age and year, natural mortality coefficient M was assumed to be constant 0.18.

In the first method, mean abundance during the period of January to June based on monthly abundance of bluefin tuna in each year for the entire Gulf of Mexico, given by Honma et al.(1984), was used, while mean abundance in a limited time and space, namely in the offshore waters of New Orleans between 25° - 30° N and between 85° - 95° W during the period from April to May, was used (Table 7). Since age-length relationship in equation (1) is almost equal to that used by Powers et al. (1983) for the fish younger than 8 years old, calculation of directed effort was made by dividing numbers of catch by age to be used in the present estimation by the sample CPUE of large fish over the age of 8 estimated by them (Table 7).

Japanese bluefin fishery in the Gulf of Mexico became substantial in 1975. Since then, catches of large sized bluefin tuna by Japanese vessels were taken mostly from the Gulf of Mexico. Bluefin tuna fishing by Japanese vessels in the Gulf of Mexico was suspended in 1982. During those 7 years, it was recognized that the start of the fishing season tended to shift to earlier months every year and it is noted that in 1980 and 1981, the fishing was concentrated in the offshore area of Key West (Honma et al., 1984). Taking this fact into consideration, the correlation was calculated for the three years from 1977 to 1979 out of 7 years in which the time and space distribution of fishing operations was thought to have been stable.

As for large fish assumed having a constant catchability coefficient q, two cases were selected; one was fish between the ages of 12 and 14 and the other, fish 13 to 15 years and older. This is because for the fish of age 12, it was possible that q was still lower compared to fish older than that age. Further, as the numbers of catch for age 15+ fish are high, it was also necessary to understand to what degree terminal F would change if the fish of age 15+ were included. The F value which maximizes the correlation, was determined by the binary search method in the range of the value between 0.0001 and 1.0000 for fish of ages 12 - 14 or 13 - 15+ in 1979. It was concluded that the estimates converged when the absolute value of the difference of succeeding two estimates was less than a minus fifth power of ten.

Results

1. Length-age conversion and catch-at-age data estimated

a. Age separation of quarterly catch-by-size data

The total number of quarterly catch-by-size for the period of 22 years from 1960 to 1981 was 88. However, the 26 catch-by-size data shown in Table 2 were completely or almost identical with other compositions. Therefore, for these 26 compositions, no calculation was required. The second quarter composition of 1970, the fourth quarter composition of 1971, the first and the fourth quarter compositions of 1972 and 1975 each, namely 6 compositions altogether were composed of the teeth of a comb type of distribution. Accordingly, the aforementioned program was not applied to these. As a result, a total of 32 sets of catch-by-size were excluded from the calculation and the analysis was obtained from 56 sets of fork length compositions using a modified NORMSEP program and age separation was done.

The 56 compositions can be divided into four types from the pattern of histogram. The first type comprised only of the aged group, relatively large fish over 120 ~ 130cm (Fig. 1-2). This type of composition was commonly found except for third quarter periods, before the first quarter of 1971. The second type is typical of the third quarters for all 22 years (Fig. 1-3). In this type of composition, small fish from ages 1 to 5 or 6 are dominant. As the ages increase to more than 5 or 6, the number of fish caught declines. In fish of ages over 10, the catch increases slightly. The three and the four types have one common feature in which young fish are few. The former (the third type) has a high percentage of older fish and therefore, displays a negative skewness (Fig. 1-4) while the latter (the fourth type) showing a relatively flat distribution (Fig. 1-5). These two composition types are seen commonly after the second quarter of 1971, except for third quarter periods.

Table 3 shows the result of normal curves fitted to the aforementioned 56 length compositions. In this table, the parameters of normal curves for the 6 tooth comb type compositions are also shown. These consist of the component ratio obtained by age separation by the inverse procedure used so far and of a quarterly mean fork length by age and corresponding standard deviations given in Table 2. In the present analysis, the six compositions having distribution like the teeth of a comb were dealt with for expediency's sake. The reason all 26 compositions whch show no substantial difference from the others are seen in the years before 1970 is because, in making catch-by-size data on a quarterly basis, substitutions were much used during the period.

b. Estimation of catch-at-age

Annual catch-at-age was estimated using the following procedure. Namely, in any given quarter, expected frequencies of each normal distribution shown in Table 3 are calculated and such frequencies are counted by 2cm length intervals. Then, within those intervals, expected frequencies by age are divided by the total and the rate of allocation of age groups of each of the length intervals is calculated. This rate of allocation can be regarded as a kind of age-length key, that usually obtained by age determination based on hard tissues taken from fish samples. Next, catch number, that is, original composition on a quarterly basis can be calculated by multiplying rate of allocation into age groups within a unit interval by histogram of catch. Incidentally, it is apparent that the rate of allocation into age groups by length intervals of fish age 15 may be biased since normal distribution is not applied for the fish older than 16. It should be noted here that there is a difference of 17 ~ 18cm in mean fork length by age between age 14 fish and age 16 fish, whereas, the difference of standard deviation between the two is 2 ~ 3cm (Table 1). Consequently, in the calculation of estimate of catch number by age in age 14 fish, there is almost no effect from neglecting age 16 fish. Thus, the number of fish over the age of 15 caught was obtained by deducting the total number of age 1 ~ 14 fish caught from the total catch number. In the equation (1), it is assumed that the birth date of bluefin tuna is May the first. Because of this, the fish at certain age in the second to fourth quarters of a year belong to the same year class, while those younger than that of the first quarter's. In this context, the birth date was set at January the first, for the sake of expediency, in the present paper in order to prepare catch-at-age data (Table 4). Incidentally, in the latter analyses, tuning to determine terminal F for VPA runs shall be made. It is necessary to prepare catch data corresponding to fishing efforts or abundance indices of Japanese longliners, since these data are used for this purpose. In this paragraph, conversion to obtain the age composition used for tuning is described. The quarterly catch-by-size data of bluefin tuna caught by Japanese longliners can be used as described earlier (Anon., 1984 b). Further, those of the same fishery in the Gulf of Mexico has been estimated separately (Anon., 1983). Therefore, by applying the rate of age allocation within a unit interval to fork length referred to abvoe, length-age conversion can be done. The catch number by age data of Japanese longliners, which is necessary for the tuning, in the period from 1975 to 1981 of the whole western Atlantic Ocean and the Gulf of Mexico is given respectively in Tables 4 and 5. Incidentally, in this length-age conversion, a prior condition that if the fork lengths of the fish are the same, ages of the fish do not differ by type of fishing gear (fishery) or by sea area is attached.

2. Results of tuning

Higher values of F were obtained as a result of tuning by using the fish of ages 13 - 15+, compared to that of ages 12 - 14 (Table 8). Except for the exceptionally small value of 0.0442, the terminal F's obtained were within the range of 0.10 and 0.15. Terminal F needs to be estimated with a certain range because there are not much difference among the correlation coefficients calculated. In the present paper, therefore, calculation was made for cases of terminal F being both 0.10 and 0.15. It it noted here that in the present VPA ages 1 to 14 fish during the period from 1960 to 1981 were dealt with since catches of the fish of ages 15+ have increased from about the middle 1970s and the age composition in the oldest age category might have greatly changed.

It was assumed that the value of F for large fish in 1981 would not be much different from that used for tuning during the period of 1977 to 1979. The terminal F obtained for that period was applied evenly to age 14 fish from 1977 to 1981 and fish of ages 12 and 13 in 1981. As for the value of age 14 fish during the period from 1974 to 1976, the mean F value of ages 12 and 13 fish in respective years was used. The F value in 1974 was rounded to three decimal places and this value was evenly used as the terminal F of age 14 fish for 1960 to 1973. This is an expedient method employed because it was difficult to select terminal F for age 14 fish for and after 1974 in a objective manner. As for the terminal F's of ages 1 to 11 in 1981, the mean F of the same ages for the period from 1975 to 1980 was tentatively put in successively from ages 11 to age 1. The years from 1975 to 1980 signify the period of full scale operations by the Japanese longline fishery for bluefin tuna in the western Atlantic
The values of terminal F thus calculated show that although the value of F of age 5 fish was lower than that of neighbouring age 4 or age 6 fish, or close to the bottom value, the catch number of age 5 fish in 1981 was very high compared to that of the same age fish in other years. The age 5 fish in 1981 were born in 1976. Judging from number of catch of the cohort, it is not realistic to believe that the 1976 year class was a strong one. Accordingly, in the present analysis, it was assumed that the availability of age 5 fish in 1981 was high and for this reason, terminal F of age 4 fish was used. Bsaed upon this value, using the mean F of the same ages in previous 6 years from 1975 to 1980, terminal F of ages 4 to 1 fish was calculated.

3. Yearly changes in population

Fig. 2 shows yearly changes in population of age 1 fish and ages 8-14 fish to represent recruit number and population number of spawnig stock, respectively. Tables 9 and 10 show population by age and age specific fishing mortality coefficients in the case of terminal F = 0.15 input for fish ages 12 to 14 in 1981.

The difference in terminal F's for large fish appears as difference stock level but yearly changes in both cases show similar trends (Fig. 2). In the analysis below, an example of yearly changesof population numbers calculated from terminal F = 0.15 for large sized fish is described. The population of age 1 fish decreased from about 900,000 in 1961 to 300,000 in 1969, and then increased to 900,000 by 1973 and then decreased after 1973. In 1981, the number increased a little and stood at a level of about 400,000. As for population of spawning stock, it was within the range of 400,000 to 600,000 in the 1960s although it had decreased a little by 1967. It began to decrease in the 1970s until it reached about 200,000 in 1978 but thereafter tended to increase. In 1981, it reached close to 300,000 level.

Using spawning indices given by Suzuki and Hisada (1983), spawning potential in the case of terminal F = 0.15 was calculated. And the relationship between the potential and population number of age 1 fish was plotted (Fig. 3). It is pointedout that the range of fluctuation of recruit is larger compared with the range of spawning potential and there is not any clear relation between spawningpotential and recruit.

Fig. 4 shows population number of bluefin tuna at age 1 and at ages 8 to 14 obtained in the present study as against recent VPA results. There is not much difference in the estimates from 1960 to 1970 among the analysis but after 1970, a big difference appears. Because of the nature of VPA, reliability of estimate of population number at age one is low. Therefore, there may not be much meaning in comparing the results of these studies quantitatively. The result of the present analysis is in agreement with the results of studies made by Suzuki and Hisada (1983a) and by Nagai (1984d) at a point whereby the population number of age one fish was on the increase or at high level during the years from 1970 to 1974. It has been on the decrease after 1974 but its level has not in any way reached extreme lows as that of obsearved in the 1960s. The results is also rather in close agreement with Nagai's as well as Suzuki Hisada's studies (Nagai, 1984d; Suzuki and Hisada, 1983a). Meanwhile, Doi et al. (1984) reports from the results of mark-recapture data analysis that the population number of age one fish decreased from 1.3 million in 1974 to 300,000 in 1976 but has, since then, been at the level of approximately 300,000 to 500,000.

The terminal F's put in for the population analysis of the fish of ages 6 to 10 inclusive of 1973 year class are very small. Therefore, it is necessary to pay attention to the fact that estimate of year class strength is not accurate. Not withstanding this, it is indicated that the 1973 year class has been a dominant year class from the fact that its cumulative catch in number has been fairly large compared to other year classes and from the result of population analysis of Japanese longline fishery (Suzuki 1983; Suzuki and Hisada, 1983a). Consequently, it is concluded that the 1973 year class was one of the most strong year classes during the period from 1960 to 1981.

Trends in abundance of spawning stock are almost similar except for latter half of 1970s estimated by Suzuki and Hisada (1983a). However, in Nagai's (1984d) and present studies in which 1973 year class was estimated to be the largest year class, it was shown that after 1979, abundance of spawning stock turned to increase. Whereas according to Poweres et al. (1983) in which the 1973 year class was not predominantly strong, it has continued to decrease. In consideration of various indications of the strong 1973 year class, spawning stock is considered to have been recovering in recent years.

Discussions

In the length-age conversion model used in the present study, different growth rate among individuals is taken into account by using a quadratic curve which can be applied to show the ralationship between mean length by age and its standard deviation. It is assumed in this model that the fish smaller than 260 cm in fork length, namely the fish younger than 15 years old, do not show any distinct sexual dimorphism. It can be said that VPA is an effective method of population analysis with to assess stock status such as of bluefin tuna that have long life span and are exposed to various types of fisheries in accordance with growth stages, provided that prior conditions or premises for that analysis are satisfied. When converting length composition into that of age to obtain annual catch-at-age data used as a basis for VPA, the biggest effect to the result of analysis arises not from standard deviations of mean fork length by age used in the conversion model but from parameters selected for von Bertalanffy's growth equation. It seems that, in this contex, probably there won't be much difference between the result of analysis using the parameter given by Sakagawa and Coan (1974) and that of present one. On the other hand, if small L_∞ is used like in the case of Parrack and Pharse (1979) and Butler et al. (1977), it is estimated that the aged fish will occupy higher proportions in the age composition (Nagai, 1984a).

The quaterly length composition data of western Atlantic bluefin tuna during 1960-1981 worked out by the scientists of ICCAT are relatively good in 45 compositions when visually inspected while it is not so in 33 compositions of which distribution is more or less indented. This is because of small sample size used, particularly those of the years before 1970 and a number of substitution used (Nagai, 1984b). If aforementioned quaterly stratification of length compositions is further divided into monthly length composition (Anon., 1984a), sample size of each stratum becomes small. This will result in increased number of indented distribution of length composition. Poor quality data or reducing quality of fork length composition is not desirable for length-age conversion.

Since the fish older than 15 years were dealt with collectively, not more than only three age groups of large size fish assumed to have constant catchability coefficient q were adopted. This made it technically difficult to tune F for the large size fish, the tuning being a basis for determining F's of other age groups of fish. There is no substantial difference between the terminal F obtained and the values used in the past, namely 0.13 for over age 16 fish (Powers et al., 1983) and 0.15 for age 20 fish (Nagai, 1984d). Actually, the value of terminal F itself is small and therefore, it is necessary to put in accurate terminal F to do reliable VPA calculation. It is suggested that CPUE data of Japanese longliners be used for tunig of young age fish (Doubleday, 1984). However, for the fish younger than age 5 or age 6, the percentage share of Japanese longliner's catch as against the total is low and accordingly his suggestion will be difficult to be realized. Consequently, it is difficult to accurately estimate the absolute abundance of bluefin tuna for the 1975 and following year classes by using VPA. VPA is nothing more than a method by which trend of such year classes' strength is shown. It is also noted that amount of the present catch is so small as to provide sufficient data for continuing the assessment studies with the use of VPA. It is thought that analyzing of mark-recapture data (Doi et al., 1984) would be potentially more effective rather than to do VPA in order to solve the problem (Doubleday, 1984).

As a result of VPA in the present study, it was made clear that after the 1970s, recruits have not necessarily continued to decrease, the spawning stock once decreased in the early 1970s has turned to stabilize and size of recruit is not related to that of spawning stock. The dominant 1973 year class have been appearing in the catches by various fisheries up to 1981 and was still substantiated in 1983. Further, it was indicated that in the latter half of the 1970s the recruit level was relatively low but stable, though the estimates have low reliability. According to Doi et al. (1984), the population number of one year old in that period is comparatively stable and is in the range of 300,000 to 500,000.

Judging from these findings, it can be concluded that the west Atlantic bluefin stock may be capable of supporting the catch level in the late 1970s without any deterioration of the stock status.

References

Abramson, N. J.(ed.) 1971: Computer programs for fish stock assessment., FAO Fish. Tech. Pap. No. 101, 149P.

Anon. 1983: Explanation for estimated length composition on Atlantic bluefin catch by Japanese longline fishery, 1956-1981., (Document submitted to the ICCAT preparatory bluefin tuna meeting held in Trapani, 1983), Far Seas Fish. Res. Lab. 13p.

Anon. 1984a: Proceedings of the eighth regular meeting of the commission Part II (Annex 10-SCRS Reports)., Int. Comm. for the Conserv. of Atlantic Tunas, i+65-207p.

Anon. 1984b: Report of the bluefin workshop., Int. Comm. for the Conserv. of Atlantic Tunas, CVSP, XIX, 282p.

Arena, P., A. Cefali and F. Munao 1980: Analysis of the age, weight, length and growth of Thunnus thynnus (L.) captured in Sicilian Seas., Mem. Biol. Mar. Ocean., X(5): 119-134.

Doi, T., Y. Kishimoto and Z. Suzuki 1984: A preliminary estimation of fishing mortality rates of bluefin tuna in the western Atlantic Ocean, based on tagging experiments in 1975 to 1981., Int. Comm. for the Conserv. of Atlantic Tunas, SCRS Doc. 84/37, 30p.

Doubleday, W. G. 1983: The application of sequential population analysis to the assessment of bluefin tuna (Thunnus thynnus thynnus) in the north Atlantic (SCRS/83/26)., Int. Comm. for the Conserv. of Atlantic Tunas, CVSP, XX: 406-418.

Hasselblad, V. 1966: Estimation of parameters for a mixture of normal distribution., Technometrics, 8(3): 431-444.

Honma, M., T. Matsumoto and H. Kono 1984: Comparison of two abundance indices based on Japanese catch and effort data by one-degree and five-degree squares for the Atlantic bluefin tuna in the Gulf of Mexico., Int. Comm. for the Conserv. of Atlantic Tunas, SCRS Doc. 84/ , 6p.

Maguire, J. J. and T. R. Hurlbut 1984: Bluefin tuna sex proportion at length in the Canadian samples 1974-1983 (SCRS/83/84)., Int. Comm. for the Conserv. of Atlantic Tunas, CVSP, XX: 341-346.

Miyabe, N. 1983: Estimation of recruitment of 1973 cohort of bluefin tuna in the west Atlantic, using tagging results (SCRS/82/39)., Int. Comm. for the Conserv. of Atlantic Tunas, CVSP, XVIII: 464-467.

Nagai, T. 1984a: Age and growth study based on modal analysis for the western Atlantic bluefin tuna., Int. Comm. for the Conserv. of Atlantic Tunas, SCRS Doc. 84/38, 28p.

Nagai, T. 1984b: Atlantic bluefin tuna sex ratio in the catches obtained by Japanese longliners., Int. Comm. for the Conserv. of Atlantic Tunas, SCRS Doc. 84/30, 6p.

Nagai, T. 1984c: Reliability of the size composition data of the catches for the Atlantic bluefin tuna (SCRS/84/41)., Int. Comm. for the Conserv. of Atlantic Tunas, CVSP, XX: 347-353.

Nagai, T. 1984d: Stock assessment of the Atlantic bluefin tuna assessed with the use of separable VPA (SCRS/83/42)., Int. Comm. for the Conserv. of Atlantic Tunas, CVSP XX: 384-398.

Parrack, M. L. and P. L. Pharse 1979: Aspects of the growth of Atlantic bluefin tuna determined from mark-recapture data (SCRS/78/37)., Int. Comm. for the Conserv. of Atlantic Tunas, CVSP, VIII: 356-366.

Table 1. Input parameters of age specific mean fork length and its standard deviation for the western Atlantic bluefin tuna.

	Quater 1		Quater 2		Quater 3		Quater 4	
Age	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
1	70.2	2.7	53.9	2.2	59.5	2.3	64.9	2.5
2	90.7	3.2	75.5	2.8	80.7	2.9	85.7	3.1
3	110.0	3.5	95.7	3.3	100.5	3.4	105.3	3.5
4	128.0	3.8	114.6	3.6	119.1	3.7	123.6	3.7
5	144.8	3.9	132.3	3.8	136.5	3.8	140.7	3.9
6	160.6	3.9	148.9	3.9	152.8	3.9	156.7	3.9
7	175.4	3.9	164.4	3.9	168.1	3.9	171.8	3.9
8	189.2	3.8	178.9	3.9	182.4	3.8	185.9	3.8
9	202.2	3.6	192.6	3.7	195.8	3.7	199.1	3.7
10	214.4	3.4	205.3	3.6	208.4	3.5	211.4	3.5
11	225.8	3.2	217.3	3.4	220.2	3.3	223.0	3.3
12	236.4	3.0	228.5	3.2	231.2	3.1	233.8	3.0
13	246.4	2.7	239.0	2.9	241.5	2.8	244.0	2.8
14	255.8	2.4	248.8	2.6	251.2	2.6	253.5	2.5
15	264.5	2.2	258.0	2.4	260.2	2.3	262.4	2.2
(16)	(272.8)	(2.2)	(266.6)	(2.4)	(268.7)	(2.3)	(270.8)	(2.2)

Remarks: The numerals in the parentheses were shown for reference.

Table 2. List of 26 catch-by-size data on the quaterly basis in which cases the parameters of normal curves were substituted because of no substantial difference being observed.

Decomposed	Substituted	Decomposed	Substituted
'60 Q4	'60 Q1	'64 Q1	'64 Q2
	'60 Q2		'61 Q4
	'61 Q1	'66 Q2	'66 Q1
	'61 Q2		'66 Q4
	'61 Q4	'67 Q2	'67 Q1
	'62 Q1		'67 Q4
	'62 Q2	'68 Q2	'68 Q1
	'62 Q4		'68 Q4
	'63 Q1	'69 Q2	'69 Q1
	'63 Q2		'69 Q1
	'63 Q4	'70 Q2	'70 Q1
	'65 Q1		'70 Q2
	'65 Q2		
	'65 Q4		

Powers, J. E., R. J. Conser and M. L. Parrack 1983: An assessment of Atlantic bluefin tuna resources (SCRS/82/66)., Int. Comm. for the Conserv. of Atlantic Tunas, CVSP, XVIII: 563-612.

Rodriguez-Roda, J. 1964: Biologia del Atun, Thunnus thynnus (L.), de la costa sudatlantica de Espana., Inv. Pesq. 25: 34-146.

Sakagawa, G. T. and A. L. Coan 1974: A review of some aspects of the bluefin tuna (Thunnus thynnus thynnus) fisheries of the Atlantic Ocean (SCRS/73/60)., Int. Comm. for the Conserv. of Atlantic Tunas, CVSP, II: 259-313.

Shimadzu, Y. 1980: [An alternative method for estimating age composition from length frequenty data]., [Report of the 1979 sectional meeting for demersal fish around the western Japan.], 36-48p., Fisheries Agency, Japan.

Suzuki, Z. 1983: CPUE trends of Atlantic bluefin tuna based on age specific effective fishing effort estimated from Japanese longline fishery, 1971-1980 (SCRS/82/43)., Int. Comm. for the Conserv. of Atlantic Tunas, CVSP, XVIII: 474-483.

Suzuki, Z. and K. Hisada 1983a: Critical review and improvement of cohort analyses on bluefin tuna in the western Atlantic (SCRS/82/42)., Int. Comm. for the Conserv. of Atlantic Tunas, CVSP, XVIII: 538-549.

Suzuki, Z. and K. Hisada 1983b: A note on appearance of medium sized bluefin in the catches of Japanese longline boats operated in the northwest Atlantic (SCRS/82/44)., Int. Comm. for the Conserv. of Atlantic Tunas, CVSP, XVIII: 468-473.

Table 3. The estimated parameters of normal curves fitted to the catch-by-size data on a quaterly basis during 1960-1981.

(Upper; Component ratio: Middle; Mean length: Bottom; Standard deviation)

===== PARAMETER =====

AGE	+P+ |M| +S+	1960 Q1	1960 Q2	1960 Q3	1960 Q4	1961 Q1	1961 Q2	1961 Q3	1961 Q4	1962 Q1	1962 Q2	1962 Q3	1962 Q4
0	P	.0	.0	.0014	.0	.0	.0	.0018	.0	.0	.0	.0013	.0
	M	0.0	0.0	36.8	0.0	0.0	0.0	36.8	0.0	0.0	0.0	36.8	0.0
	S	0.0	0.0	2.30	0.0	0.0	0.0	2.30	0.0	0.0	0.0	2.30	0.0
1	P	.0	.0	.0435	.0	.0	.0	.0575	.0	.0	.0	.0492	.0
	M	0.0	0.0	54.0	0.0	0.0	0.0	54.0	0.0	0.0	0.0	54.0	0.0
	S	0.0	0.0	2.27	0.0	0.0	0.0	2.28	0.0	0.0	0.0	2.72	0.0
2	P	.0	.0	.0534	.0	.0	.0	.0710	.0	.0	.0	.1014	.0
	M	0.0	0.0	73.0	0.0	0.0	0.0	73.0	0.0	0.0	0.0	76.0	0.0
	S	0.0	0.0	2.52	0.0	0.0	0.0	2.54	0.0	0.0	0.0	3.48	0.0
3	P	.0	.0	.0053	.0	.0	.0	.0071	.0	.0	.0	.0663	.0
	M	0.0	0.0	91.0	0.0	0.0	0.0	91.0	0.0	0.0	0.0	103.0	0.0
	S	0.0	0.0	2.73	0.0	0.0	0.0	2.74	0.0	0.0	0.0	4.08	0.0
4	P	.0	.0	.0836	.0	.0	.0	.1375	.0	.0	.0	.4590	.0
	M	0.0	0.0	112.0	0.0	0.0	0.0	112.0	0.0	0.0	0.0	120.0	0.0
	S	0.0	0.0	4.44	0.0	0.0	0.0	4.44	0.0	0.0	0.0	4.15	0.0
5	P	.0606	.0606	.2312	.0606	.0606	.0606	.3616	.0606	.0606	.0606	.1790	.0606
	M	140.7	140.7	131.0	140.7	140.7	140.7	131.0	140.7	140.7	140.7	134.0	140.7
	S	5.62	5.62	4.56	5.62	5.62	5.62	4.56	5.62	5.62	5.62	4.56	5.62
6	P	.0467	.0467	.0690	.0467	.0467	.0467	.0388	.0467	.0467	.0467	.0170	.0467
	M	156.7	156.7	148.0	156.7	156.7	156.7	148.0	156.7	156.7	156.7	155.0	156.7
	S	3.15	3.15	4.68	3.15	3.15	3.15	4.68	3.15	3.15	3.15	4.68	3.15
7	P	.0329	.0329	.1815	.0329	.0329	.0329	.1254	.0329	.0329	.0329	.0097	.0329
	M	171.0	171.0	163.0	171.0	171.0	171.0	163.0	171.0	171.0	171.0	168.1	171.0
	S	4.90	4.90	4.68	4.90	4.90	4.90	4.68	4.90	4.90	4.90	4.68	4.90
8	P	.2621	.2621	.0912	.2621	.2621	.2621	.1062	.2621	.2621	.2621	.0300	.2621
	M	187.0	187.0	180.0	187.0	187.0	187.0	180.0	187.0	187.0	187.0	182.4	187.0
	S	3.79	3.79	4.56	3.79	3.79	3.79	4.56	3.79	3.79	3.79	4.56	3.79
9	P	.4307	.4307	.0735	.4307	.4307	.4307	.0213	.4307	.4307	.4307	.0507	.4307
	M	199.1	199.1	193.0	199.1	199.1	199.1	193.0	199.1	199.1	199.1	195.8	199.1
	S	4.79	4.79	4.44	4.79	4.79	4.79	3.99	4.79	4.79	4.79	4.44	4.79
10	P	.0703	.0703	.0517	.0703	.0703	.0703	.0174	.0703	.0703	.0703	.0165	.0703
	M	211.4	211.4	203.0	211.4	211.4	211.4	203.0	211.4	211.4	211.4	208.4	211.4
	S	3.45	3.45	3.54	3.45	3.45	3.45	4.20	3.45	3.45	3.45	3.90	3.45
11	P	.0385	.0385	.0393	.0385	.0385	.0385	.0175	.0385	.0385	.0385	.0066	.0385
	M	223.0	223.0	217.0	223.0	223.0	223.0	217.0	223.0	223.0	223.0	220.2	223.0
	S	2.63	2.63	3.96	2.63	2.63	2.63	3.96	2.63	2.63	2.63	3.43	2.63
12	P	.0582	.0582	.0344	.0582	.0582	.0582	.0220	.0582	.0582	.0582	.0085	.0582
	M	229.0	229.0	229.0	229.0	229.0	229.0	229.0	229.0	229.0	229.0	229.0	229.0
	S	2.88	2.88	2.48	2.88	2.88	2.88	3.72	2.88	2.88	2.88	2.48	2.88
13	P	.0	.0	.0212	.0	.0	.0	.0101	.0	.0	.0	.0036	.0
	M	0.0	0.0	239.0	0.0	0.0	0.0	239.0	0.0	0.0	0.0	241.5	0.0
	S	0.0	0.0	3.36	0.0	0.0	0.0	3.36	0.0	0.0	0.0	3.36	0.0
14	P	.0	.0	.0201	.0	.0	.0	.0040	.0	.0	.0	.0023	.0
	M	0.0	0.0	248.0	0.0	0.0	0.0	248.0	0.0	0.0	0.0	251.2	0.0
	S	0.0	0.0	2.08	0.0	0.0	0.0	3.12	0.0	0.0	0.0	3.11	0.0
15	P	.0	.0	.0012	.0	.0	.0	.0026	.0	.0	.0	.0002	.0
	M	0.0	0.0	257.0	0.0	0.0	0.0	257.0	0.0	0.0	0.0	260.2	0.0
	S	0.0	0.0	1.90	0.0	0.0	0.0	1.84	0.0	0.0	0.0	2.47	0.0
16	P	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3. (Continued)

===== PARAMETER =====

AGE	+P+ |M| +S+	1963 Q1	1963 Q2	1963 Q3	1963 Q4	1964 Q1	1964 Q2	1964 Q3	1964 Q4	1965 Q1	1965 Q2	1965 Q3	1965 Q4
0		.0	.0	.0020	.0	.0	.0	.0007	.0	.0	.0	.0008	.0
		0.0	0.0	36.8	0.0	0.0	0.0	36.8	0.0	0.0	0.0	36.8	0.0
		0.0	0.0	2.30	0.0	0.0	0.0	2.30	0.0	0.0	0.0	2.30	0.0
1		.0	.0	.1366	.0	.0	.0	.1121	.0	.0	.0	.2756	.0
		0.0	0.0	58.0	0.0	0.0	0.0	55.0	0.0	0.0	0.0	55.0	0.0
		0.0	0.0	2.76	0.0	0.0	0.0	2.76	0.0	0.0	0.0	2.76	0.0
2		.0	.0	.1584	.0	.0	.0	.1771	.0	.0	.0	.4309	.0
		0.0	0.0	78.0	0.0	0.0	0.0	77.0	0.0	0.0	0.0	77.0	0.0
		0.0	0.0	3.48	0.0	0.0	0.0	3.48	0.0	0.0	0.0	3.48	0.0
3		.0	.0	.2331	.0	.0	.0	.2089	.0	.0	.0	.1481	.0
		0.0	0.0	99.0	0.0	0.0	0.0	99.0	0.0	0.0	0.0	100.0	0.0
		0.0	0.0	4.08	0.0	0.0	0.0	4.08	0.0	0.0	0.0	4.08	0.0
4		.0	.0	.1808	.0	.0	.0	.0732	.0	.0	.0	.0340	.0
		0.0	0.0	123.0	0.0	0.0	0.0	116.0	0.0	0.0	0.0	132.0	0.0
		0.0	0.0	4.44	0.0	0.0	0.0	3.12	0.0	0.0	0.0	4.44	0.0
5		.0606	.0606	.1335	.0606	.0	.0	.2514	.0	.0606	.0606	.0430	.0606
		140.7	140.7	139.0	140.7	0.0	0.0	136.5	0.0	140.7	140.7	142.0	140.7
		5.62	5.62	4.56	5.62	0.0	0.0	4.56	0.0	5.62	5.62	3.10	5.62
6		.0467	.0467	.0895	.0467	.0552	.0552	.1470	.0552	.0467	.0467	.0225	.0467
		156.7	156.7	152.0	156.7	159.0	159.0	152.8	159.0	156.7	156.7	149.0	156.7
		3.15	3.15	4.68	3.15	4.68	4.68	4.43	4.68	3.15	3.15	3.31	3.15
7		.0329	.0329	.0162	.0329	.0350	.0350	.0071	.0350	.0329	.0329	.0199	.0329
		171.0	171.0	166.0	171.0	176.0	176.0	168.1	176.0	171.0	171.0	169.0	171.0
		4.90	4.90	4.68	4.90	4.68	4.68	4.68	4.68	4.90	4.90	4.68	4.90
8		.2621	.2621	.0103	.2621	.3794	.3794	.0025	.3794	.2621	.2621	.0076	.2621
		187.0	187.0	182.4	187.0	189.0	189.0	182.4	189.0	187.0	187.0	184.0	187.0
		3.79	3.79	4.56	3.79	4.27	4.27	4.56	4.27	3.79	3.79	4.56	3.79
9		.4307	.4307	.0154	.4307	.3981	.3981	.0042	.3981	.4307	.4307	.0023	.4307
		199.1	199.1	195.8	199.1	199.0	199.0	195.8	199.0	199.1	199.1	199.0	199.1
		4.79	4.79	4.44	4.79	4.32	4.32	4.44	4.32	4.79	4.79	2.96	4.79
10		.0703	.0703	.0072	.0703	.0760	.0760	.0010	.0760	.0703	.0703	.0011	.0703
		211.4	211.4	208.4	211.4	210.0	210.0	208.4	210.0	211.4	211.4	208.4	211.4
		3.45	3.45	3.82	3.45	2.72	2.72	3.43	2.72	3.45	3.45	4.20	3.45
11		.0385	.0385	.0072	.0385	.0563	.0563	.0020	.0563	.0385	.0385	.0021	.0385
		223.0	223.0	220.2	223.0	226.0	226.0	220.2	226.0	223.0	223.0	220.2	223.0
		2.63	2.63	3.96	2.63	3.65	3.65	3.87	3.65	2.63	2.63	3.96	2.63
12		.0582	.0582	.0065	.0582	.0	.0	.0077	.0	.0582	.0582	.0045	.0582
		229.0	229.0	231.2	229.0	0.0	0.0	231.2	0.0	229.0	229.0	231.2	229.0
		2.88	2.88	3.72	2.88	0.0	0.0	3.72	0.0	2.88	2.88	3.72	2.88
13		.0	.0	.0042	.0	.0	.0	.0027	.0	.0	.0	.0039	.0
		0.0	0.0	241.5	0.0	0.0	0.0	241.5	0.0	0.0	0.0	241.5	0.0
		0.0	0.0	3.36	0.0	0.0	0.0	3.36	0.0	0.0	0.0	3.36	0.0
14		.0	.0	.0011	.0	.0	.0	.0035	.0	.0	.0	.0029	.0
		0.0	0.0	251.2	0.0	0.0	0.0	251.2	0.0	0.0	0.0	251.2	0.0
		0.0	0.0	3.12	0.0	0.0	0.0	3.12	0.0	0.0	0.0	2.63	0.0
15		.0	.0	.0001	.0	.0	.0	.0008	.0	.0	.0	.0016	.0
		0.0	0.0	260.2	0.0	0.0	0.0	260.2	0.0	0.0	0.0	260.2	0.0
		0.0	0.0	2.76	0.0	0.0	0.0	2.65	0.0	0.0	0.0	2.76	0.0
16		.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3. (Continued)

===== PARAMETER =====

AGE	+P+ |M| +S+	1966 Q1	1966 Q2	1966 Q3	1966 Q4	1967 Q1	1967 Q2	1967 Q3	1967 Q4	1968 Q1	1968 Q2	1968 Q3	1968 Q4
0	P	.0	.0	.0038	.0	.0	.0	.0100	.0	.0	.0	.0019	.0
	M	0.0	0.0	36.8	0.0	0.0	0.0	36.8	0.0	0.0	0.0	36.8	0.0
	S	0.0	0.0	2.30	0.0	0.0	0.0	2.30	0.0	0.0	0.0	2.30	0.0
1	P	.0	.0	.5981	.0	.0	.0	.1080	.0	.0	.0	.0797	.0
	M	0.0	0.0	56.0	0.0	0.0	0.0	64.0	0.0	0.0	0.0	54.0	0.0
	S	0.0	0.0	2.76	0.0	0.0	0.0	2.76	0.0	0.0	0.0	2.76	0.0
2	P	.0	.0	.2973	.0	.0	.0	.6052	.0	.0	.0	.5853	.0
	M	0.0	0.0	74.0	0.0	0.0	0.0	80.5	0.0	0.0	0.0	81.0	0.0
	S	0.0	0.0	3.37	0.0	0.0	0.0	3.48	0.0	0.0	0.0	3.48	0.0
3	P	.0	.0	.0539	.0	.0	.0	.2118	.0	.0	.0	.2822	.0
	M	0.0	0.0	95.0	0.0	0.0	0.0	102.0	0.0	0.0	0.0	101.0	0.0
	S	0.0	0.0	4.08	0.0	0.0	0.0	4.08	0.0	0.0	0.0	4.08	0.0
4	P	.0	.0	.0005	.0	.0	.0	.0346	.0	.0	.0	.0078	.0
	M	0.0	0.0	119.0	0.0	0.0	0.0	122.0	0.0	0.0	0.0	119.0	0.0
	S	0.0	0.0	4.44	0.0	0.0	0.0	3.32	0.0	0.0	0.0	2.96	0.0
5	P	.0009	.0009	.0001	.0009	.0328	.0328	.0244	.0328	.0952	.0952	.0013	.0952
	M	132.3	132.3	136.5	132.3	132.0	132.0	129.0	132.0	132.0	132.0	129.0	132.0
	S	3.80	3.80	4.56	3.80	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04
6	P	.0009	.0009	.0027	.0009	.0655	.0655	.0	.0655	.1904	.1904	.0009	.1904
	M	148.9	148.9	157.0	148.9	154.0	154.0	152.8	154.0	154.0	154.0	156.0	154.0
	S	3.90	3.90	3.12	3.90	3.12	3.12	4.39	3.12	3.12	3.12	3.33	3.12
7	P	.0009	.0009	.0001	.0009	.0164	.0164	.0	.0164	.0515	.0515	.0002	.0515
	M	164.4	164.4	168.1	164.4	168.0	168.0	168.1	168.0	168.5	168.5	168.1	168.5
	S	3.90	3.90	3.12	3.90	3.12	3.12	4.68	3.12	3.12	3.12	3.12	3.12
8	P	.0482	.0482	.0015	.0482	.0332	.0332	.0003	.0332	.0100	.0100	.0	.0100
	M	181.0	181.0	179.0	181.0	181.0	181.0	182.4	181.0	180.0	180.0	182.4	180.0
	S	3.12	3.12	3.04	3.12	3.12	3.12	4.56	3.12	4.68	4.68	3.04	4.68
9	P	.1770	.1770	.0025	.1770	.1613	.1613	.0003	.1613	.1536	.1536	.0035	.1536
	M	194.0	194.0	193.0	194.0	194.5	194.5	195.8	194.5	198.0	198.0	202.0	198.0
	S	3.00	3.00	4.44	3.00	3.21	3.21	3.97	3.21	3.02	3.02	3.89	3.02
10	P	.3034	.3034	.0029	.3034	.3152	.3152	.0009	.3152	.2669	.2669	.0019	.2669
	M	203.0	203.0	213.0	203.0	203.0	203.0	208.4	203.0	203.0	203.0	211.0	203.0
	S	2.88	2.88	4.20	2.88	2.88	2.88	4.20	2.88	3.60	3.60	3.37	3.60
11	P	.2345	.2345	.0011	.2345	.2561	.2561	.0011	.2561	.2250	.2250	.0073	.2250
	M	215.0	215.0	225.0	215.0	215.0	215.0	220.2	215.0	212.0	212.0	220.2	212.0
	S	4.08	4.08	2.92	4.08	4.08	4.08	3.96	4.08	2.72	2.72	3.96	2.72
12	P	.1100	.1100	.0109	.1100	.1194	.1194	.0043	.1194	.0	.0	.0074	.0
	M	224.0	224.0	232.0	224.0	228.0	228.0	231.2	228.0	0.0	0.0	231.2	0.0
	S	2.56	2.56	3.72	2.56	3.84	3.84	3.72	3.84	0.0	0.0	3.72	0.0
13	P	.1269	.1269	.0105	.1269	.0053	.0053	.0050	.0053	.0	.0	.0104	.0
	M	232.5	232.5	241.5	232.5	239.0	239.0	241.5	239.0	0.0	0.0	241.5	0.0
	S	2.32	2.32	3.36	2.32	2.90	2.90	3.36	2.90	0.0	0.0	3.36	0.0
14	P	.0013	.0013	.0114	.0013	.0053	.0053	.0034	.0053	.0	.0	.0100	.0
	M	248.8	248.8	251.2	248.8	248.8	248.8	251.2	248.8	0.0	0.0	251.2	0.0
	S	2.60	2.60	3.12	2.60	2.60	2.60	3.12	2.60	0.0	0.0	3.12	0.0
15	P	.0231	.0231	.0068	.0231	.0053	.0053	.0007	.0053	.0	.0	.0021	.0
	M	258.0	258.0	260.2	258.0	258.0	258.0	260.2	258.0	0.0	0.0	260.2	0.0
	S	2.40	2.40	2.36	2.40	2.40	2.40	2.07	2.40	0.0	0.0	2.14	0.0
16	P	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3. (Continued)

===== PARAMETER =====

AGE	+P+ IMI +S+	<---- 1969			---->	<---- 1970			---->	<---- 1971			---->
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
0	P	.0	.0	.0027	.0	.0	.0	.0028	.0	.0	.0	.0003	.0
	M	0.0	0.0	36.8	0.0	0.0	0.0	36.8	0.0	0.0	0.0	36.8	0.0
	S	0.0	0.0	2.30	0.0	0.0	0.0	2.30	0.0	0.0	0.0	2.30	0.0
1	P	.0	.0	.0955	.0	.0	.0	.1848	.0	.0	.0063	.1987	.0010
	M	0.0	0.0	54.0	0.0	0.0	0.0	53.5	0.0	0.0	66.5	55.5	64.9
	S	0.0	0.0	2.46	0.0	0.0	0.0	2.16	0.0	0.0	2.64	2.76	2.50
2	P	.0	.0	.4094	.0	.0	.0	.3183	.0	.0	.0082	.4939	.4573
	M	0.0	0.0	74.5	0.0	0.0	0.0	75.0	0.0	0.0	84.0	75.0	85.7
	S	0.0	0.0	3.48	0.0	0.0	0.0	3.48	0.0	0.0	2.24	3.48	3.10
3	P	.0	.0	.3337	.0	.0	.0	.4093	.0	.0	.0047	.1192	.0011
	M	0.0	0.0	104.0	0.0	0.0	0.0	98.0	0.0	0.0	92.0	101.0	105.3
	S	0.0	0.0	4.08	0.0	0.0	0.0	4.08	0.0	0.0	2.64	4.08	3.50
4	P	.0	.0	.0217	.0	.0	.0	.0420	.0	.0	.0090	.1558	.0217
	M	0.0	0.0	110.0	0.0	0.0	0.0	121.0	0.0	0.0	116.0	118.0	123.6
	S	0.0	0.0	4.44	0.0	0.0	0.0	4.44	0.0	0.0	2.88	4.44	3.70
5	P	.0476	.0476	.0547	.0476	.0	.0	.0292	.0	.0303	.0044	.0010	.1766
	M	132.0	132.0	129.0	132.0	0.0	0.0	132.0	0.0	144.0	134.0	136.5	140.7
	S	3.04	3.04	4.56	3.04	0.0	0.0	4.56	0.0	4.68	4.56	4.56	3.90
6	P	.0195	.0195	.0252	.0195	.0	.0	.0070	.0	.0358	.0592	.0025	.0255
	M	149.0	149.0	144.0	149.0	0.0	0.0	151.0	0.0	159.0	148.5	152.8	156.7
	S	3.12	3.12	3.42	3.12	0.0	0.0	4.68	0.0	3.12	3.12	4.68	3.90
7	P	.0758	.0758	.0002	.0758	.0	.0	.0011	.0	.2216	.1060	.0047	.0179
	M	157.0	157.0	168.1	157.0	0.0	0.0	167.0	0.0	173.0	167.0	168.1	171.8
	S	3.12	3.12	3.98	3.12	0.0	0.0	3.31	0.0	4.17	4.68	4.68	3.90
8	P	.0475	.0475	.0019	.0475	.0010	.0010	.0005	.0010	.2895	.2139	.0048	.0353
	M	168.5	168.5	181.0	168.5	178.9	178.9	183.0	178.9	187.0	183.0	182.4	185.9
	S	3.12	3.12	3.04	3.12	3.90	3.90	3.04	3.90	4.56	4.68	4.56	3.80
9	P	.0629	.0629	.0010	.0629	.0747	.0747	.0001	.0747	.1405	.1537	.0024	.0258
	M	196.0	196.0	195.8	196.0	192.6	192.6	195.8	192.6	200.0	193.5	195.8	199.1
	S	2.96	2.96	3.75	2.96	3.70	3.70	2.96	3.70	4.32	3.78	4.44	3.70
10	P	.2989	.2989	.0060	.2989	.1921	.1921	.0006	.1921	.1055	.1986	.0019	.0807
	M	205.3	205.3	208.4	205.3	205.3	205.3	208.4	205.3	212.0	209.5	208.4	211.4
	S	4.32	4.32	4.20	4.32	3.60	3.60	3.36	3.60	3.58	2.88	4.20	3.50
11	P	.2367	.2367	.0088	.2367	.2053	.2053	.0010	.2053	.1092	.0965	.0025	.0978
	M	217.3	217.3	220.2	217.3	217.3	217.3	220.2	217.3	225.8	223.0	220.2	223.0
	S	4.08	4.08	3.96	4.08	3.40	3.40	3.96	3.40	3.84	2.84	3.96	3.30
12	P	.1043	.1043	.0100	.1043	.1949	.1949	.0020	.1949	.0194	.0264	.0042	.0391
	M	228.5	228.5	231.2	228.5	228.5	228.5	231.2	228.5	236.4	230.0	231.2	233.8
	S	3.84	3.84	3.72	3.84	3.20	3.20	3.72	3.20	2.40	3.46	3.72	3.00
13	P	.0800	.0800	.0092	.0800	.2669	.2669	.0019	.2669	.0482	.0117	.0040	.0217
	M	239.0	239.0	241.5	239.0	239.0	239.0	241.5	239.0	246.4	236.5	241.5	244.0
	S	2.88	2.88	3.36	2.88	2.90	2.90	3.36	2.90	2.16	2.32	3.36	2.80
14	P	.0200	.0200	.0111	.0200	.0665	.0665	.0016	.0665	.0015	.1005	.0032	.0008
	M	248.8	248.8	251.2	248.8	248.8	248.8	251.2	248.8	255.8	246.0	251.2	253.0
	S	2.08	2.08	3.12	2.08	2.60	2.60	3.12	2.60	2.40	2.08	3.12	2.50
15	P	.0	.0	.0029	.0	.0010	.0010	.0007	.0010	.0015	.0009	.0013	.0005
	M	0.0	0.0	258.0	0.0	258.0	258.0	260.2	258.0	264.5	260.0	260.2	262.0
	S	0.0	0.0	1.84	0.0	2.40	2.40	2.37	2.40	2.20	2.74	2.27	2.20
16	P	.0	.0	.0	.0	.0	.0	.0	.0	.0015	.0	.0	.0
	M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	272.8	0.0	0.0	0.0
	S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.20	0.0	0.0	0.0

Table 3. (Continued)

===== PARAMETER =====

AGE	+P+ |M| +S+	1972 Q1	1972 Q2	1972 Q3	1972 Q4	1973 Q1	1973 Q2	1973 Q3	1973 Q4	1974 Q1	1974 Q2	1974 Q3	1974 Q4
0	P	.0	.0017	.0	.0	.0	.0	.0	.0028	.0068	.0029	.0	.0
	M	0.0	30.9	0.0	0.0	0.0	0.0	0.0	42.6	48.3	38.9	0.0	0.0
	S	0.0	2.20	0.0	0.0	0.0	0.0	0.0	2.50	2.70	2.20	0.0	0.0
1	P	.0010	.0141	.2432	.2243	.0	.0187	.0412	.0021	.1529	.0527	.4872	.0
	M	70.2	62.0	60.5	64.9	0.0	53.9	57.0	64.9	65.0	67.0	55.5	0.0
	S	2.70	2.64	2.58	2.50	0.0	2.64	2.76	3.60	3.24	2.64	2.50	0.0
2	P	.0010	.0356	.5135	.0005	.0	.0183	.5995	.1342	.5775	.1722	.1571	.0109
	M	90.7	75.5	79.5	85.7	0.0	75.5	77.0	87.0	84.0	84.0	79.5	87.0
	S	3.20	3.36	3.48	3.10	0.0	3.36	3.10	4.46	3.84	3.36	3.48	2.48
3	P	.1712	.0700	.1750	.0005	.0	.0483	.2428	.0303	.1878	.0175	.1889	.0378
	M	110.0	95.7	100.0	105.3	0.0	95.7	102.5	102.0	112.0	95.0	95.0	110.0
	S	3.50	3.96	4.08	3.50	0.0	3.96	3.46	4.17	3.74	2.64	4.08	2.80
4	P	.0068	.0140	.0085	.0005	.0	.1373	.0534	.2247	.0556	.0743	.0481	.4066
	M	128.0	121.0	123.0	123.6	0.0	117.0	127.5	117.0	134.0	111.0	126.0	124.0
	S	3.80	3.03	3.74	3.70	0.0	4.32	3.10	4.04	3.04	4.14	4.44	4.44
5	P	.0055	.1051	.0147	.0005	.1084	.1642	.0047	.1348	.0020	.0394	.0176	.1843
	M	144.8	141.0	134.0	140.7	144.8	139.0	143.0	139.0	144.8	134.0	141.0	138.0
	S	3.90	3.04	4.56	3.90	4.62	4.56	3.64	5.62	4.68	4.56	4.49	4.68
6	P	.1315	.0281	.0161	.1514	.0167	.0442	.0187	.0166	.0027	.0016	.0112	.0344
	M	160.6	154.0	145.0	156.7	160.6	155.0	154.0	156.7	160.6	149.0	151.0	156.7
	S	3.90	4.68	3.15	3.90	4.68	4.68	3.85	3.74	4.68	4.68	3.47	3.12
7	P	.0123	.0373	.0004	.1514	.0744	.0544	.0018	.0494	.0015	.0452	.0061	.0185
	M	175.4	171.0	168.1	171.8	175.4	173.0	169.0	171.8	175.4	166.0	169.0	171.8
	S	3.90	4.50	4.68	3.90	4.49	4.37	4.68	4.47	4.68	3.53	4.68	4.19
8	P	.0014	.2329	.0029	.1514	.3071	.1147	.0033	.1061	.0049	.0922	.0013	.0809
	M	189.2	187.5	182.4	185.9	189.2	187.0	186.0	187.0	189.2	176.0	181.0	185.9
	S	3.80	3.12	3.89	3.80	4.56	3.12	3.04	3.38	4.56	4.68	4.56	4.56
9	P	.2685	.1526	.0016	.1063	.1983	.1477	.0067	.1448	.0083	.1094	.0035	.0629
	M	202.2	197.0	195.8	199.1	202.2	195.0	195.0	198.0	202.2	195.0	195.0	199.1
	S	3.60	2.96	4.44	3.70	4.32	3.80	4.44	4.30	3.01	3.56	2.96	4.44
10	P	.1466	.0454	.0007	.0441	.0397	.0695	.0020	.0165	.0008	.0639	.0045	.0805
	M	214.4	207.0	208.4	211.4	214.4	204.5	208.4	209.0	214.4	206.0	208.4	211.4
	S	3.40	3.03	4.20	3.50	4.08	3.90	4.20	2.24	4.08	3.75	2.80	3.52
11	P	.0452	.0567	.0021	.0005	.1038	.0342	.0028	.0555	.0041	.0979	.0025	.0833
	M	225.8	217.3	220.2	223.0	225.8	217.3	220.2	223.0	225.8	217.3	220.2	223.0
	S	3.20	4.08	3.96	3.30	3.84	4.08	3.54	4.75	2.56	4.08	3.96	3.30
12	P	.0438	.0649	.0058	.1514	.0831	.0668	.0060	.0492	.0016	.0807	.0189	.0
	M	236.4	228.5	231.2	233.8	236.4	228.5	231.2	233.8	236.4	228.5	237.0	0.0
	S	3.00	3.84	3.72	3.00	3.60	3.84	3.72	3.08	3.60	3.74	2.84	0.0
13	P	.0260	.0405	.0071	.0243	.0240	.0327	.0055	.0096	.0005	.0888	.0067	.0
	M	246.4	239.0	241.5	244.0	246.4	239.0	241.5	244.0	246.4	239.0	243.0	0.0
	S	2.70	3.48	3.36	2.80	3.24	3.48	3.36	2.69	3.09	3.48	3.36	0.0
14	P	.1384	.0783	.0052	.0005	.0309	.0134	.0071	.0163	.0005	.0379	.0168	.0
	M	255.8	248.8	251.2	253.5	255.8	248.8	251.2	253.5	255.8	248.8	251.2	0.0
	S	2.40	2.08	3.12	2.50	2.88	2.68	3.12	3.60	2.88	3.12	3.12	0.0
15	P	.0010	.0122	.0032	.0005	.0160	.0223	.0043	.0101	.0002	.0267	.0297	.0
	M	264.5	258.0	260.2	262.4	264.5	258.0	260.2	262.4	264.5	258.0	258.5	0.0
	S	2.20	2.88	2.39	2.20	2.64	2.88	2.26	2.11	2.64	2.33	2.76	0.0
16	P	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3. (Continued)

===== PARAMETER =====

AGE	+P+ !M! +S+	1975 Q1	1975 Q2	1975 Q3	1975 Q4	1976 Q1	1976 Q2	1976 Q3	1976 Q4	1977 Q1	1977 Q2	1977 Q3	1977 Q4
0	P	.0	.0	.0002	.0	.0049	.0001	.0006	.0016	.0028	.0007	.0008	.0
	M	0.0	0.0	36.8	0.0	48.3	30.9	36.8	42.6	48.3	30.9	36.8	0.0
	S	0.0	0.0	2.30	0.0	2.70	2.20	2.30	2.50	2.70	2.20	2.30	0.0
1	P	.0005	.0001	.1924	.0005	.0192	.0004	.0564	.0137	.0174	.0002	.0205	.0
	M	70.2	53.9	57.5	64.9	71.0	53.9	57.0	69.0	70.2	53.9	60.0	0.0
	S	2.70	2.20	2.06	2.50	3.24	2.20	2.11	3.00	3.24	3.17	2.76	0.0
2	P	.0007	.0009	.6931	.0196	.2727	.0028	.1994	.0336	.1839	.0018	.3847	.0
	M	90.7	75.5	75.5	85.7	90.7	75.5	78.0	85.0	95.0	75.5	79.0	0.0
	S	3.20	2.80	2.85	3.10	3.84	3.36	2.80	3.72	3.84	4.03	3.18	0.0
3	P	.0030	.0050	.0289	.0261	.1888	.0173	.7135	.2213	.4301	.0257	.0710	.3576
	M	110.0	95.7	104.0	105.3	110.0	95.7	96.8	102.0	111.0	97.0	104.0	103.0
	S	3.50	3.96	4.08	3.50	4.20	3.96	2.97	4.20	4.20	4.75	4.08	4.20
4	P	.0030	.0091	.0638	.0383	.3577	.0242	.0002	.4483	.0752	.0395	.4114	.1923
	M	128.0	115.0	120.0	123.6	128.0	114.6	119.1	115.0	128.0	115.0	124.0	125.0
	S	3.80	4.32	4.44	3.70	4.56	4.32	4.44	4.44	4.56	5.18	4.21	4.06
5	P	.0033	.0248	.0025	.0170	.0613	.0133	.0009	.0319	.0919	.0075	.0396	.1843
	M	144.8	137.0	134.0	140.7	144.8	132.3	136.5	137.0	144.8	132.3	141.0	140.7
	S	3.90	3.04	3.04	3.90	4.68	4.56	4.04	4.68	4.68	5.45	4.56	4.68
6	P	.0989	.0005	.0038	.0011	.0015	.0037	.0003	.0827	.0809	.0129	.0107	.0247
	M	160.6	148.9	152.8	156.7	160.6	148.9	152.8	155.0	160.6	148.9	152.8	156.7
	S	3.90	4.68	4.40	3.90	3.12	4.68	4.68	4.68	4.68	5.62	4.68	4.68
7	P	.0010	.0026	.0013	.0446	.0	.0037	.0003	.0186	.0073	.0050	.0159	.0512
	M	175.4	164.4	168.1	171.8	175.4	164.4	168.1	171.8	175.4	164.4	168.1	171.8
	S	3.90	4.68	4.68	3.90	3.12	4.68	4.68	4.68	3.12	3.42	4.68	4.68
8	P	.0270	.0092	.0002	.1580	.0	.0046	.0001	.0088	.0041	.0078	.0007	.0183
	M	189.2	179.0	182.4	185.9	189.2	178.9	182.4	185.9	189.2	178.9	182.4	185.9
	S	3.80	3.12	4.56	3.80	4.28	4.68	4.56	4.05	4.56	5.62	4.56	4.56
9	P	.1315	.0291	.0007	.0869	.0055	.0164	.0007	.1370	.0027	.0165	.0036	.0253
	M	202.2	189.0	195.8	199.1	207.0	192.6	195.8	199.1	202.2	198.0	195.8	199.1
	S	3.60	2.96	4.21	3.70	2.88	4.44	4.44	3.65	4.32	2.37	4.44	4.06
10	P	.3578	.2252	.0005	.0578	.0078	.0289	.0012	.0062	.0009	.0163	.0074	.0350
	M	214.4	205.3	208.4	211.4	214.4	205.3	208.4	211.4	214.4	209.0	208.4	211.4
	S	3.40	4.32	4.20	3.50	4.08	4.32	4.20	4.16	4.08	3.46	4.20	3.11
11	P	.1070	.1403	.0006	.0870	.0379	.0656	.0019	.0	.0031	.0396	.0051	.0180
	M	225.8	217.3	220.2	223.0	227.0	217.3	220.2	0.0	225.8	219.0	220.2	223.0
	S	3.20	3.70	3.96	3.30	3.84	3.44	3.96	0.0	3.84	2.50	3.96	2.64
12	P	.0807	.1628	.0012	.1036	.0201	.2008	.0042	.0	.0139	.0901	.0030	.0140
	M	236.4	228.5	231.2	233.8	236.4	228.5	231.2	0.0	236.4	229.0	231.2	233.8
	S	3.00	3.84	3.72	3.00	2.40	3.65	3.72	0.0	3.60	3.55	3.72	3.60
13	P	.1196	.1868	.0031	.1860	.0074	.2876	.0048	.0	.0356	.2574	.0052	.0608
	M	246.4	239.0	241.5	244.0	246.4	239.0	241.5	0.0	246.4	239.0	241.5	244.0
	S	2.70	3.48	3.36	2.80	2.16	3.48	2.62	0.0	3.24	3.47	3.36	3.36
14	P	.0681	.1246	.0052	.0325	.0085	.2180	.0088	.0	.0365	.3273	.0104	.0034
	M	255.8	248.8	251.2	253.5	258.0	248.8	251.2	0.0	255.8	248.8	251.2	253.5
	S	2.40	3.12	3.12	2.50	1.92	3.12	3.12	0.0	2.88	3.74	3.12	3.00
15	P	.0010	.0804	.0028	.1413	.0109	.1131	.0068	.0	.0166	.1523	.0110	.0168
	M	264.5	258.0	260.2	262.4	264.5	258.0	260.2	0.0	264.5	259.0	260.2	262.4
	S	2.20	2.31	2.31	2.20	1.97	2.88	2.30	0.0	2.05	2.30	2.64	2.64
16	P	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3. (Continued)

===== PARAMETER =====

AGE	+P+ IMI +S+	1978				1979				1980			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
0		.0 0.0 0.0	.0 0.0 0.0	.0025 36.8 2.30	.0 0.0 0.0	.0005 48.3 2.70	.0 0.0 0.0	.0001 36.8 2.30	.0045 42.6 2.50	.0 0.0 0.0	.0 0.0 0.0	.0017 36.8 2.30	.0 0.0 0.0
1		.0024 70.2 2.70	.0011 53.9 2.20	.1114 64.0 2.76	.0247 64.9 2.50	.0057 70.2 2.70	.0007 53.9 2.20	.0555 63.0 3.01	.0045 64.9 2.50	.0066 70.2 2.70	.0023 53.9 2.20	.0679 63.0 2.76	.0095 65.0 3.00
2		.0747 90.7 3.84	.0024 75.5 2.80	.1993 81.0 3.48	.0247 85.7 3.10	.0421 92.0 3.84	.0007 75.5 2.80	.2166 81.0 3.61	.0045 85.7 3.10	.0794 99.5 3.07	.0085 75.5 2.80	.3906 85.0 3.48	.0307 85.7 3.72
3		.2141 110.0 4.20	.0155 98.0 3.96	.3154 101.0 4.08	.0630 100.0 4.20	.0511 111.0 4.20	.0108 95.7 3.96	.3186 102.0 4.50	.0768 97.0 3.71	.1301 114.5 4.20	.0581 99.0 2.91	.1940 102.0 4.08	.0694 103.5 4.20
4		.2119 128.0 4.56	.0276 114.6 4.32	.0926 111.0 4.15	.1226 118.0 4.44	.0411 129.0 4.56	.0308 116.0 4.32	.2671 125.0 4.47	.2420 115.0 4.20	.0318 128.0 3.04	.0951 114.6 4.32	.1250 119.0 4.44	.0335 123.6 4.44
5		.2048 144.8 4.68	.0266 132.3 4.56	.1295 133.0 4.56	.0726 139.0 4.68	.1445 144.8 4.68	.0161 132.3 4.56	.0769 133.0 3.25	.1210 123.0 4.44	.0378 144.8 4.68	.0341 132.3 4.56	.0755 134.0 4.56	.0494 140.7 4.68
6		.0477 160.6 3.23	.0227 148.9 4.68	.1102 151.0 4.68	.2240 153.0 4.68	.2544 160.6 4.68	.0365 148.9 4.68	.0080 153.0 5.62	.0403 140.7 4.68	.0317 159.0 4.68	.0660 148.9 4.68	.0170 152.8 4.68	.0634 156.7 4.68
7		.0281 175.4 4.68	.0120 164.4 4.68	.0057 164.0 3.70	.2150 166.0 3.47	.0937 175.4 4.68	.0506 164.4 4.68	.0056 171.0 5.62	.0463 156.7 4.68	.1654 175.4 4.09	.0570 164.4 4.68	.0222 168.1 4.68	.1823 171.8 4.68
8		.0051 189.2 3.04	.0037 178.9 4.68	.0010 182.4 3.04	.0658 182.0 4.56	.0152 189.2 3.11	.0407 178.9 4.68	.0022 182.4 3.85	.1803 172.0 4.68	.0654 186.0 3.04	.2239 178.9 4.68	.0136 183.0 3.04	.2714 185.9 4.56
9		.0040 202.2 4.32	.0046 192.6 4.44	.0029 195.8 4.44	.1062 199.1 4.44	.0189 202.2 4.32	.0095 192.6 4.44	.0005 195.8 2.90	.1462 185.9 4.56	.0081 199.0 2.88	.0940 192.6 4.44	.0503 193.0 4.44	.1231 199.1 3.85
10		.0079 214.4 4.08	.0125 205.3 4.32	.0010 208.4 4.20	.0533 211.4 4.20	.0159 214.4 4.08	.0158 205.3 4.32	.0017 208.4 4.24	.0407 199.1 4.11	.0133 214.4 4.08	.0342 205.3 4.32	.0076 208.4 4.20	.0506 209.0 2.80
11		.0091 225.8 3.84	.0403 219.0 2.72	.0003 220.2 3.96	.0475 223.0 3.96	.0483 227.0 3.06	.0404 219.0 2.72	.0015 220.2 4.50	.0479 211.4 4.20	.0192 228.0 2.85	.0231 217.3 3.07	.0046 220.2 3.96	.0486 219.0 3.96
12		.0336 236.4 3.60	.0850 228.5 2.56	.0017 231.2 3.39	.0050 233.8 3.60	.0708 237.0 2.62	.1121 229.0 3.26	.0032 231.2 3.79	.0121 233.8 3.60	.0526 238.0 2.52	.0480 228.5 2.85	.0048 231.2 3.72	.0477 233.8 3.60
13		.0492 246.4 2.85	.1838 239.0 3.03	.0061 241.5 3.04	.0239 244.0 3.36	.0877 247.0 2.62	.2313 239.0 3.48	.0090 241.5 3.98	.0114 244.0 3.36	.1396 246.4 3.24	.0802 239.0 3.48	.0037 241.5 3.30	.0101 244.0 3.36
14		.0682 255.8 2.88	.2651 248.8 2.68	.0111 251.2 3.12	.0034 253.5 3.00	.0754 255.8 2.88	.2712 248.8 3.12	.0192 251.2 3.74	.0 0.0 0.0	.1472 255.8 2.88	.1191 248.8 3.12	.0089 251.2 3.12	.0077 253.5 3.00
15		.0415 264.5 1.89	.2998 258.0 2.77	.0127 260.2 2.36	.0 0.0 0.0	.0409 264.5 1.79	.1342 258.0 2.27	.0144 260.2 2.53	.0 0.0 0.0	.0581 264.5 2.34	.0671 258.0 2.40	.0142 260.2 2.67	.0025 262.4 2.64
16		.0 0.0 0.0	.0 0.0 0.0	.0 0.0 0.0	.0 0.0 0.0	.0 0.0 0.0	.0 0.0 0.0	.0 0.0 0.0	.0 0.0 0.0	.0 0.0 0.0	.0 0.0 0.0	.0 0.0 0.0	.0 0.0 0.0

Table 3. (Continued)

===== PARAMETER =====

AGE	+P+ IMI +S+	1981 Q1	1981 Q2	1981 Q3	1981 Q4	1982 Q1	1982 Q2	1982 Q3	1982 Q4	1983 Q1	1983 Q2	1983 Q3	1983 Q4
0		.0013	.0	.0052	.0011	.0	.0	.0	.0	.0	.0	.0	.0
		48.3	0.0	36.8	42.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		2.70	0.0	2.30	2.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1		.0327	.0015	.1292	.0258	.0	.0	.0	.0	.0	.0	.0	.0
		70.2	53.9	66.0	69.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		3.24	2.20	3.31	3.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2		.1311	.0140	.2228	.0586	.0	.0	.0	.0	.0	.0	.0	.0
		90.0	75.5	82.0	85.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		3.84	3.36	4.18	3.72	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3		.2409	.0869	.2397	.0695	.0	.0	.0	.0	.0	.0	.0	.0
		104.0	97.0	96.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		4.20	3.96	4.90	4.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4		.2203	.0495	.1457	.0924	.0	.0	.0	.0	.0	.0	.0	.0
		125.0	114.6	110.0	117.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		4.56	4.32	4.73	3.89	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5		.0850	.0518	.1313	.1051	.0	.0	.0	.0	.0	.0	.0	.0
		144.8	132.3	134.0	137.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		4.68	4.56	5.47	4.68	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6		.0778	.0578	.0092	.2150	.0	.0	.0	.0	.0	.0	.0	.0
		160.6	148.9	152.8	156.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		4.68	4.50	4.14	4.68	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7		.0555	.0495	.0018	.1285	.0	.0	.0	.0	.0	.0	.0	.0
		175.4	164.4	168.1	171.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		4.68	4.68	2.50	4.68	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8		.0336	.0532	.0022	.0949	.0	.0	.0	.0	.0	.0	.0	.0
		189.2	178.9	182.4	185.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		4.56	4.18	4.44	4.56	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9		.0182	.0803	.0079	.0790	.0	.0	.0	.0	.0	.0	.0	.0
		202.2	192.6	195.8	199.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		4.32	4.44	5.33	4.44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10		.0095	.0245	.0104	.0606	.0	.0	.0	.0	.0	.0	.0	.0
		214.4	205.3	208.4	211.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		2.72	3.29	5.04	4.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11		.0194	.0490	.0068	.0532	.0	.0	.0	.0	.0	.0	.0	.0
		225.8	217.3	220.2	223.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		3.84	2.72	4.75	3.96	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12		.0085	.1047	.0028	.0174	.0	.0	.0	.0	.0	.0	.0	.0
		236.4	229.0	231.2	233.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		2.49	3.84	4.18	2.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13		.0269	.1104	.0028	.0047	.0	.0	.0	.0	.0	.0	.0	.0
		246.4	239.0	241.5	244.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		2.47	3.45	4.03	2.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14		.0219	.1132	.0039	.0047	.0	.0	.0	.0	.0	.0	.0	.0
		255.8	247.0	251.2	253.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		2.88	2.08	3.74	2.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15		.0188	.1335	.0050	.0047	.0	.0	.0	.0	.0	.0	.0	.0
		264.5	254.5	260.2	262.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		2.61	2.88	2.46	2.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16		.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 4. Newly estimated catch-at-age data for the western Atlantic bluefin tuna during 1960-1981.

AGE/YEAR	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
0	0	0	0	1	0	0	0	69	0	0	105
1	487	1292	7330	35917	22825	81500	163341	18153	4959	8159	66324
2	577	1540	14647	40959	35190	126228	79972	101711	35425	33849	109437
3	57	153	9573	60284	41502	43370	14485	35598	17077	27589	140712
4	904	2983	66280	46770	14533	9954	125	5804	471	2513	14434
5	2800	7976	28012	37749	49960	15719	56	4663	1152	4687	10039
6	993	1025	4414	26148	31548	9545	761	1124	2200	2153	2403
7	2139	2854	2807	6328	3812	7943	31	281	550	275	390
8	2289	2918	13889	16947	17271	16081	1567	615	4	322	156
9	2999	1758	24014	29179	25630	25330	4931	2805	1942	324	104
10	1036	1116	6938	9174	11757	7826	8159	5525	3119	1528	585
11	635	557	2661	4496	4375	3228	6056	4567	3218	1548	666
12	668	654	3499	5093	2708	4675	5727	3005	453	1187	1015
13	246	296	798	1564	530	1670	5965	882	627	1032	1051
14	217	86	327	285	700	844	3188	577	603	987	648
15+	24	62	15	15	165	473	3461	491	243	417	506

AGE/YEAR	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	5	2	0	0	43	56	35	28	6	32	325
1	71075	51123	5777	61693	48608	5653	1300	5900	2780	2377	7937
2	175269	107777	82560	21614	173763	19731	23884	10428	10806	13089	14255
3	42279	36864	33460	27971	7262	73026	9599	17533	16542	8563	18008
4	55265	1792	8384	8047	16082	5010	35027	7769	14879	6734	19771
5	424	3214	1489	2940	821	3373	4683	9549	4775	3522	13931
6	1047	3431	2724	1435	972	1149	2745	8755	2046	1881	4189
7	1922	139	541	1028	356	208	2878	1326	3007	3414	3010
8	2308	897	1078	699	232	119	304	542	1938	6112	2291
9	1320	541	1759	1070	479	1205	497	456	846	4047	2100
10	1208	215	503	1006	1918	503	732	280	507	909	1526
11	1176	515	647	876	1269	934	644	418	728	867	1156
12	1594	1316	1179	2805	1588	2836	875	642	1248	995	1168
13	1458	1546	869	1299	2307	3666	2467	1719	2285	1204	851
14	1388	1191	1058	2297	2259	3221	3480	2545	3085	2877	1388
15+	709	1209	1124	5682	2577	3866	5457	7055	5579	6862	6860

Table 5. Estimated catch-at-age data of the bluefin tuna caught by Japanese longliners in the western Atlantic Ocean during 1975-1981.

Age	Year 1975	1976	1977	1978	1979	1980	1981
0	--	--	--	--	--	--	7
1	1	136	19	77	34	90	159
2	18	400	408	58	91	293	1155
3	55	3623	4979	1034	736	2134	3613
4	84	4489	9443	2750	1533	2546	6428
5	174	3013	2166	2623	912	1020	6056
6	25	1043	1960	2855	1502	1299	3577
7	33	171	1839	1004	2548	2642	2801
8	193	105	246	467	1711	5467	2148
9	303	1059	267	302	786	2346	1703
10	1617	327	270	209	397	638	888
11	1022	692	316	374	616	693	725
12	1173	2225	654	515	1008	825	907
13	1427	2924	2040	1307	1705	1025	631
14	881	2166	2694	1831	1973	2476	1090
15+	854	1880	3254	4323	2967	4619	4119
Total	7860	24253	30555	19729	18519	28113	36007

Table 6. Estimated catch-at-age data of the bluefin tuna caught by Japanese longliners in the Gulf of Mexico during 1975-1981.

Age	Year 1975	1976	1977	1978	1979	1980	1981
6	--	--	--	--	--	--	--
7	10	16	2	2	--	--	8
8	54	30	28	2	2	4	49
9	212	133	77	8	7	8	156
10	1252	291	91	75	65	12	104
11	953	660	246	232	255	167	208
12	1097	2196	596	487	886	312	680
13	1253	2897	1826	1220	1615	913	585
14	840	2135	2682	1783	1952	2366	986
15+	730	1831	3123	4244	2903	4611	3977
Total	6401	10189	8671	8053	7685	8393	6753

Table 7. Cpue and directed effort of Japanese longline boats used for tuning terminal F for large fish.

Cpue (catch/100 hooks) in Gulf of Mexico	1977	1978	1979
Entire Gulf of Mexico	0.162	0.187	0.154
Selected area and season*	0.268	0.336	0.300
Directed effort (10^4 hooks)	**1977**	**1978**	**1979**
For Age 12-14	285.5	154.0	225.8
For Age 13-15+	362.3	250.5	276.3

* See text

Table 8. Result of tuning terminal F for large fish.

Age	Index	F	r^2
12-14	Cpue for Entire Gulf of Mexico	0.0996	0.83
	Cpue for selected area and season*	0.0442	0.81
	Directed effort	0.1050	0.81
13-15+	Cpue for entire Gulf of Mexico	0.1252	0.82
	Cpue for selected area and season*	0.0864	0.83
	Directed effort	0.1392	0.94

* See text

Table 9. Population number estimated by VPA run in the case where 0.15 is assigned as terminal F at ages of 12-14 in 1981.

*** STOCK-NUMBER AT THE BEGINNING OF THE YEAR ***

AGE/YEAR	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	599809.	875605.	727618.	594961.	582332.	550732.	667027.	420550.	536079.	302778.
2	611628.	500558.	730168.	601043.	464205.	465581.	385813.	408755.	334724.	443234.
3	493828.	510349.	416684.	596519.	464716.	355669.	274274.	249549.	249018.	247315.
4	297280.	412428.	426140.	339300.	443343.	350348.	257590.	215882.	176033.	192432.
5	291674.	247487.	341779.	295607.	240816.	357063.	283547.	215043.	175027.	146608.
6	208574.	241065.	199445.	259957.	212528.	155727.	283912.	236787.	175361.	145144.
7	158862.	173307.	200412.	162566.	193307.	148795.	121373.	236448.	196750.	144470.
8	296125.	130738.	142159.	164832.	130013.	157985.	117037.	101351.	197234.	163833.
9	77441.	245249.	106540.	106083.	122235.	92869.	117309.	96325.	84092.	164740.
10	50316.	61948.	203238.	67167.	62118.	78798.	54576.	93490.	77899.	68470.
11	16417.	41081.	50725.	163436.	47752.	41191.	58685.	38157.	73050.	62224.
12	14170.	13134.	33806.	39941.	132415.	35898.	31464.	43499.	27713.	58080.
13	3136.	11226.	10374.	25043.	28720.	108129.	25729.	21070.	33594.	22734.
14	6044.	2395.	9107.	7938.	19496.	23506.	88790.	16070.	16794.	27489.

AGE/YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	459566.	500734.	597620.	444796.	922035.	559349.	537455.	616556.	678319.	478118.
2	245459.	323473.	353527.	452576.	366248.	713930.	422915.	443762.	513794.	561180.
3	339368.	106107.	112273.	197508.	302910.	286215.	438466.	335249.	348887.	419654.
4	181440.	156172.	50361.	60354.	134522.	227528.	232439.	299780.	271265.	275429.
5	158438.	138393.	80374.	40431.	42777.	105022.	175383.	189576.	218492.	219493.
6	118185.	123185.	115213.	64201.	32411.	33049.	86972.	143413.	154075.	173796.
7	119267.	96523.	101935.	93103.	51142.	25763.	26719.	71597.	117288.	120710.
8	120419.	99267.	78868.	85017.	77272.	41781.	21194.	22129.	57177.	96760.
9	136547.	100440.	80807.	65059.	70030.	63904.	34687.	17595.	18205.	47264.
10	137304.	113959.	82691.	67001.	52739.	57518.	52941.	27875.	14243.	14791.
11	55797.	114149.	94086.	68872.	55507.	43135.	46293.	43762.	22615.	11641.
12	50560.	45996.	94271.	78118.	56935.	45565.	34870.	37814.	35965.	18508.
13	47431.	41306.	36966.	77541.	64176.	44999.	36611.	26541.	30786.	29454.
14	18048.	38657.	33171.	29467.	63974.	52417.	35481.	27239.	19920.	24147.

AGE/YEAR	1980	1981
1	235369.	374852.
2	396821.	194426.
3	458883.	319522.
4	335441.	375490.
5	216494.	274042.
6	178976.	177611.
7	143302.	147775.
8	98082.	116582.
9	79055.	76352.
10	38707.	62343.
11	11891.	31502.
12	9060.	9142.
13	14321.	6661.
14	22519.	10864.

Table 10. Fishing mortality coefficients estimated by VPA run in the case where 0.15 is assigned as terminal F at ages of 12-14 in 1981.

*** FISHING MORTALITY COEFFICIENT ***

AGE/YEAR	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	0.000888	0.001640	0.011101	0.068169	0.043755	0.175896	0.309715	0.048256	0.010185	0.029869
2	0.001030	0.003395	0.022163	0.077248	0.086327	0.349159	0.255699	0.315590	0.122643	0.087013
3	0.000126	0.000327	0.025444	0.116768	0.102501	0.142632	0.059395	0.168953	0.077782	0.129738
4	0.003319	0.007896	0.185738	0.162849	0.036430	0.031548	0.000530	0.029793	0.002937	0.014381
5	0.010567	0.035820	0.093651	0.149956	0.255928	0.049248	0.000216	0.023994	0.007210	0.035515
6	0.005226	0.004692	0.024452	0.116234	0.176506	0.069237	0.002937	0.005226	0.013771	0.016365
7	0.014839	0.018120	0.015450	0.043449	0.021782	0.060081	0.000230	0.001335	0.003090	0.002098
8	0.008507	0.024681	0.112724	0.118980	0.156441	0.117633	0.014763	0.006676	0.000022	0.002174
9	0.043221	0.007896	0.281334	0.355136	0.259056	0.351601	0.046959	0.032310	0.025520	0.002174
10	0.022774	0.019875	0.037956	0.161171	0.230827	0.114708	0.177879	0.066719	0.044670	0.024681
11	0.043144	0.014915	0.059013	0.030479	0.105324	0.089378	0.119438	0.139809	0.049324	0.027580
12	0.052834	0.055885	0.119820	0.149803	0.022621	0.153084	0.220985	0.078392	0.018044	0.022545
13	0.089455	0.029182	0.087700	0.070610	0.020332	0.017052	0.290642	0.046806	0.020561	0.050850
14	0.040000	0.040016	0.040016	0.040016	0.040016	0.040016	0.040016	0.040016	0.040016	0.040016

AGE/YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	0.171165	0.168114	0.098000	0.014305	0.075798	0.099602	0.011559	0.002327	0.009575	0.006371
2	0.658684	0.878181	0.402184	0.221519	0.066566	0.307503	0.052299	0.060539	0.022392	0.021248
3	0.596123	0.565224	0.440712	0.204048	0.106163	0.028114	0.200233	0.031776	0.056419	0.043983
4	0.090828	0.484276	0.039635	0.164223	0.067558	0.080299	0.023842	0.136299	0.031776	0.060768
5	0.071678	0.003319	0.044670	0.041084	0.078011	0.008583	0.021248	0.027351	0.048866	0.024071
6	0.022469	0.009346	0.033073	0.047417	0.049553	0.032616	0.014534	0.021095	0.064049	0.012932
7	0.003548	0.022011	0.001488	0.006371	0.022163	0.015221	0.008507	0.044899	0.012398	0.027580
8	0.001411	0.025749	0.012474	0.013924	0.009956	0.006065	0.006142	0.015144	0.010414	0.022087
9	0.000833	0.014458	0.007362	0.029945	0.016823	0.008202	0.038643	0.031319	0.027733	0.019722
10	0.004692	0.011635	0.002861	0.008202	0.021019	0.037117	0.010414	0.029106	0.021706	0.038185
11	0.013161	0.011330	0.005989	0.010338	0.017357	0.032692	0.022316	0.016212	0.020409	0.070686
12	0.022163	0.038567	0.015373	0.016594	0.055275	0.038795	0.092964	0.025597	0.019722	0.076485
13	0.024529	0.039330	0.046730	0.012321	0.022392	0.057640	0.115700	0.106926	0.062904	0.088463
14	0.040016	0.040016	0.040016	0.040016	0.040016	0.048180	0.104332	0.150032	0.150032	0.150032

AGE/YEAR	1980	1981
1	0.011101	0.023400
2	0.036659	0.083427
3	0.020561	0.063515
4	0.022163	0.059166
5	0.017967	0.057106
6	0.011559	0.026131
7	0.026360	0.022469
8	0.070457	0.021706
9	0.057487	0.030479
10	0.025978	0.027122
11	0.082893	0.040932
12	0.127602	0.150032
13	0.096245	0.150032
14	0.150032	0.150032

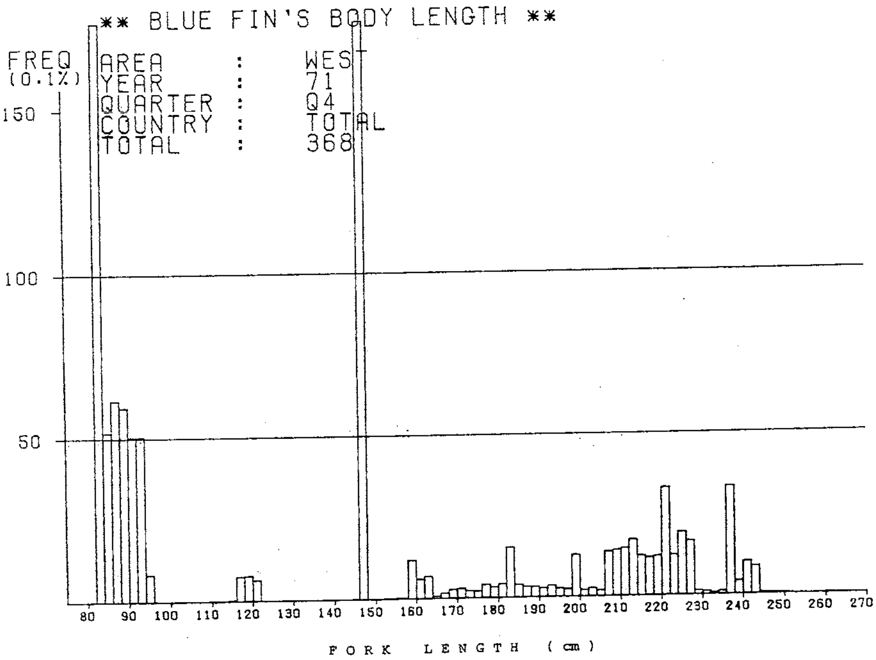

Fig. 1-1 The quaterly catch-by-size histogram in which case the modified NORMSEP was not applied (the teeth of a comb type).

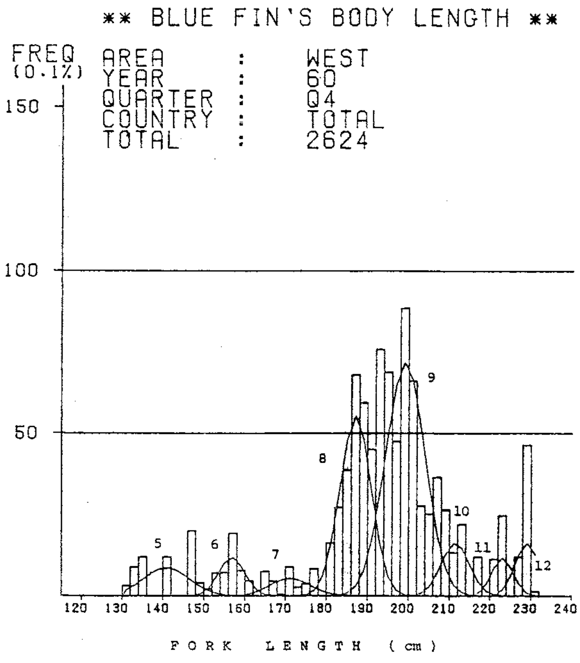

Fig. 1-2. The quaterly catch-by-size histogram and fitted normal curves (the aged group type).

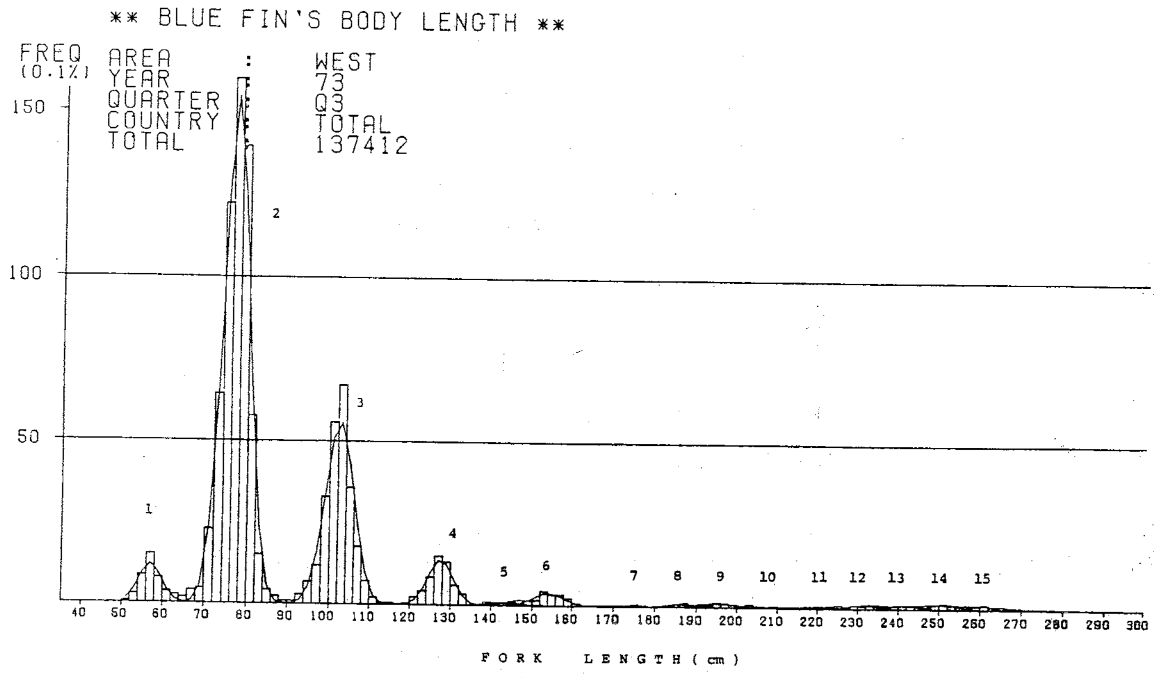

Fig. 1-3. The quaterly catch-by-size histogram and fitted normal curves (a typical quater three type).

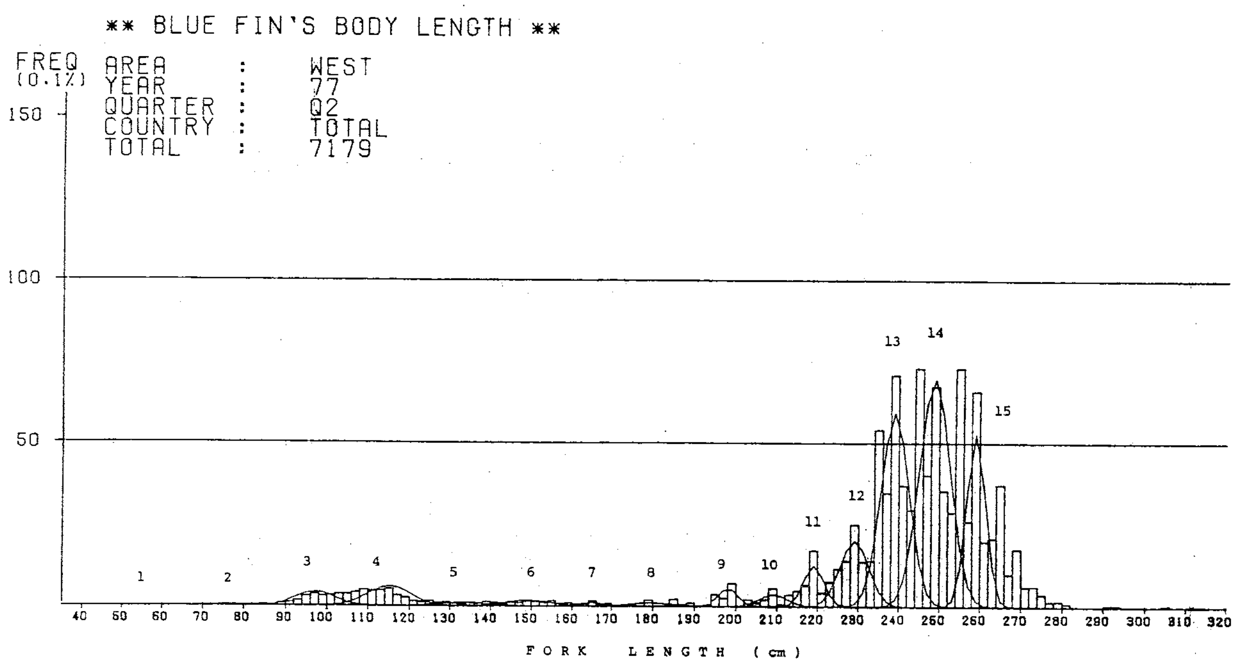

Fig. 1-4. The quaterly catch-by-size histogram and fitted normal curves (the fewer young fish type).

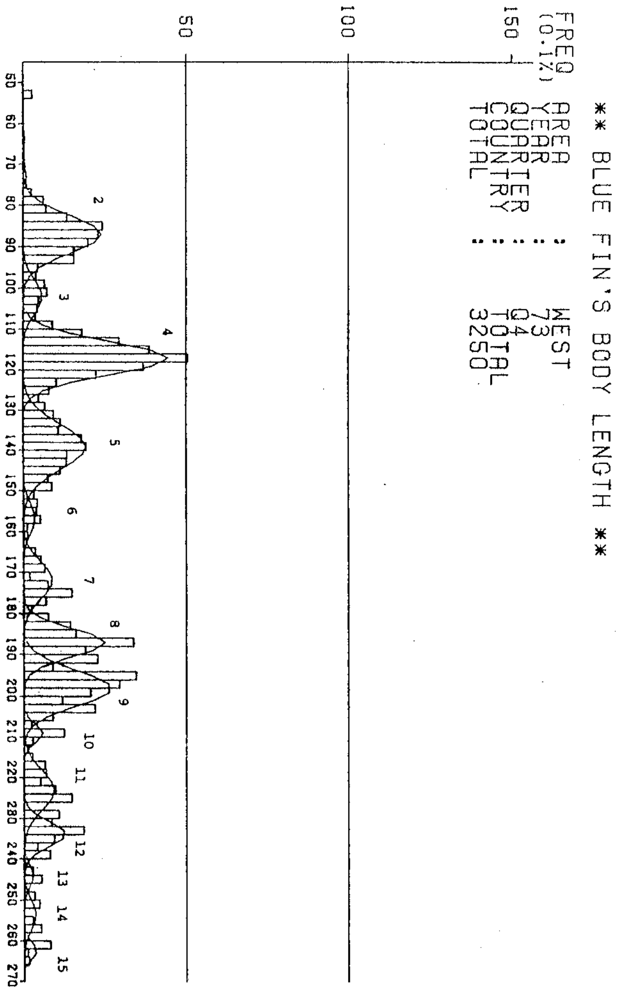

Fig. 1-5. The quaterly catch-by-size histogram and fitted normal curves (the flat type).

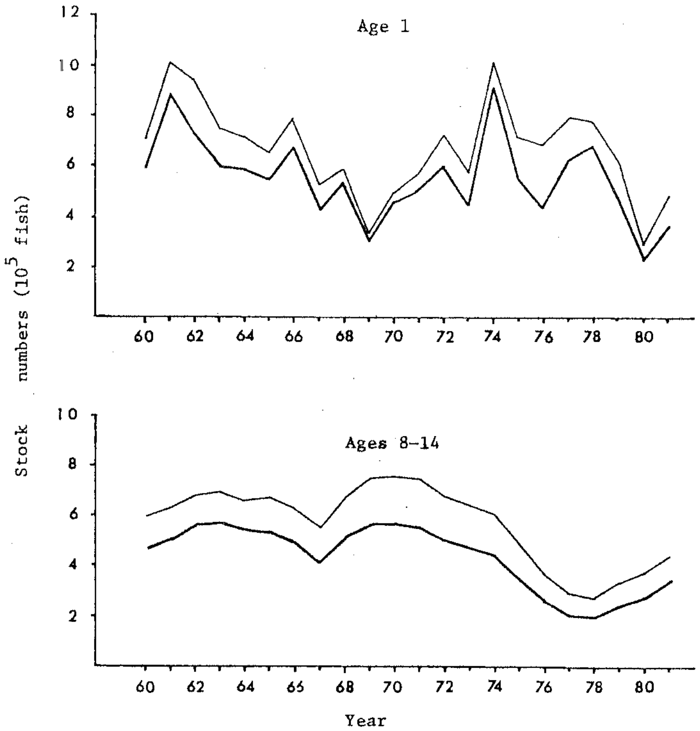

Fig. 2. Trends of stock numbers for age 1 (upper) and ages 8-14 (lower) bluefin tuna in the west Atlantic.

Fine and thick lines denote the stock numbers estimated from the cases of terminal F=0.10 and 0.15, respectively.

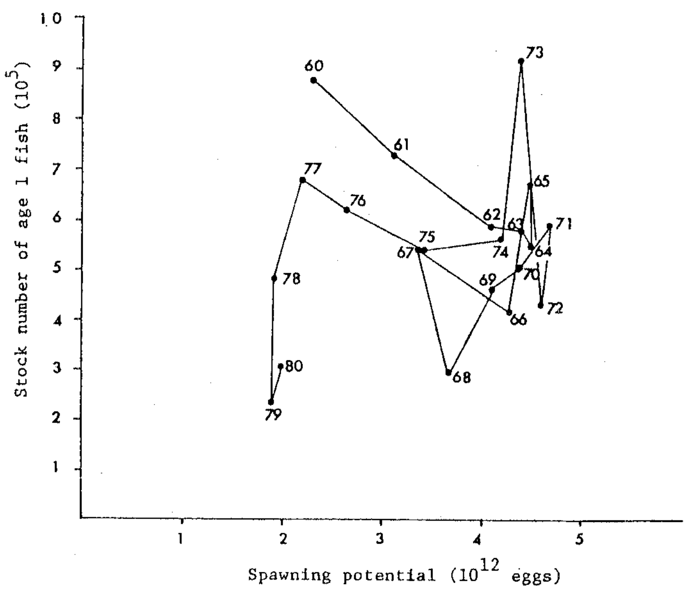

Fig. 3. Stock-recruit relationship of the west Atlantic bluefin tuna expressed as spawning potential of a year (numbers in the Figure) vs stock number of age 1 fish in the next year.

Both variables are calculated from the case of terminal F=0.15.

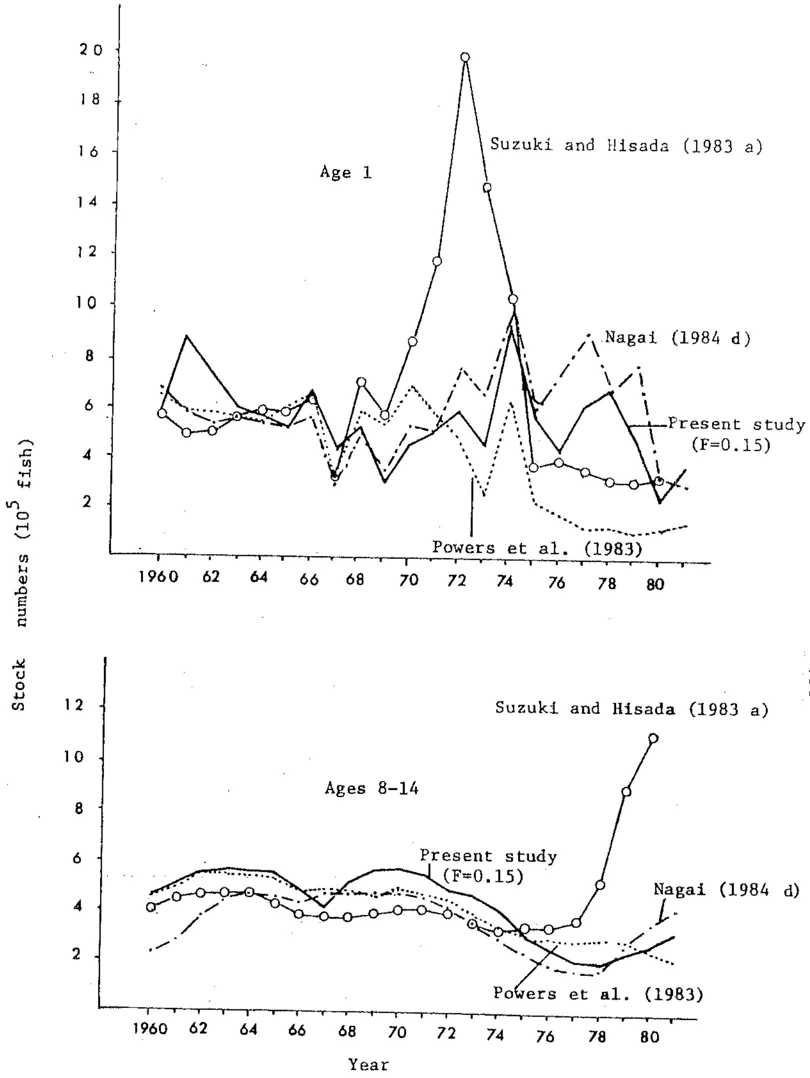

Fig. 4. Comparison of trends of stock numbers for age 1 (upper) and ages 8-14 (lower) bluefin tuna in the west Atlantic estimated in the recent VPA.