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A PROPOSAL TO MANAGEMENT OF BLUEFIN TUNA STOCK IN THE WESTERN ATLANTIC OCEAN

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SUMMARY

Past stock assessments on western Atlantic bluefin tuna were reviewed. Recent discussions on various aspects on the management of the stock were also scrutinized to evaluate the validity of the current bluefin regulation, which led us to the opinion that the regulation may generate difficulty in future stock assessment and non-rational use of the resource. A proposal was made to re-examine the current framework for improvement in monitoring the stock.

RESUME

Les évaluations antérieures du stock de thon rouge de l'Atlantique ouest sont passées en revue. Les récents débats sur divers aspects de la gestion du stock sont également passés au crible pour juger de la validité des réglementations actuelles du thon rouge, ce qui nous amène à penser que la réglementation pourrait entraîner des difficultés pour les évaluations futures du stock, ainsi qu'une exploitation non-rationnelle de la ressource. Une proposition est formulée à l'effet d'examiner de nouveau le schéma actuel d'amélioration du suivi du stock.

RESUMEN

Se examinaron anteriores evaluaciones de población del atún rojo en el Atlántico Oeste. Igualmente, se examinaron recientes debates sobre varios aspectos de la ordenación de poblaciones, con el fin de evaluar la validez de las actuales regulaciones sobre el atún rojo. En nuestra opinión, estas regulaciones podrían dificultar futuras evaluaciones de población y ser causa de un uso poco racional del recurso. Se propune la realización de un nuevo examen destinado a mejorar la vigilancia sobre las poblaciones.

Introduction

Atlantic bluefin tuna are caught by a variety of types of fishing gear. The diversity of harvesting methods makes it almost impossible to standardize fishing efforts directed to the stock. Therefore, analyses of catch-at-age data have played major role in studies of stock assessment of the species. In the past ten years, cohort analysis has been widely adopted by many biologists participating on the Standing Committee of Research and Staticstics, SCRS, of the International Commission for the Conservation of Atlantic Tunas, ICCAT (Caddy 1975, Parks 1976, 1977, Shingu and Hisada 1976, 1977, Tylor et al. 1977, 1978, 1978, Parrack et al. 1979, Bard 1979, Bard and Cort 1979, 1980, Parrack 1980, 1981, 1982, Nichols 1980, Farrugio 1981, Cort 1982, Phares and Crow 1983, Suzuki and Hisada 1983, Powers et al. 1983, Nagai 1984b). But individual studies often presented significantly different results, and revealed themselves to be not highly reliable. Serious disagreement among biologists existed with regard to the strict regulation of fisheries in 1981, which unfortunately left a poor impression regarding the impartiality of scientific studies themselves (Fonteneau 1983), in addition to confusion in the industry (ICCAT 1983).

The ICCAT organized two workshops in 1983 at Trapani, Italy in May, and at Tsukuba and Shimizu, Japan, in August and September, with the goal of improving data collection and analysis methodology. At the workshops, biologists clarified the important points to be taken into account for application of cohort analysis to the stocks under discussion. The workshops re-confirmed the effectiveness of cohort analysis, and presented ways to improve the application of this method to the bluefin tuna stocks. Biologists also noted, however, that it is very difficult to recompile and analyse data, and accordingly did not think it possible to reach a reliable conclusion before November 1984. In any case, the SCRS held in Madrid in October and November in 1983, could not provide any new comment on the status of western Atlantic bluefin tuna to the Eighth Regular Meeting of Commission.

The total catch of bluefin tuna in the Atlantic Ocean had been on the decrease from a peak of 28,300 metric tons in 1976 to about 19,000 tons in 1979, but was relatively stable since then. The western Atlantic Ocean has continuously produced about 6,000 tons of bluefin tuna annually from 1977 through 1981 after regulations went into effect in 1975 aiming at protecting young fish. The very strict regulatory measures for all fisheries was introduced for 1982 fishing season and reduced the catch to 1,433 tons (ICCAT 1984a). Remarkable disagreement in the biological interpretation of recent changes in catch and stocks resulted in a relaxation of the measure for 1983, which was extended one more year with no adequate biological explanation. Some fishermen view the measures unnecessarily strict, and might feel some doubt about the conclusions of biological studies. Seemingly they become reluctant to quickly provide catch and effort records that have long formed the raw data for stock assessment. The small amount of catch allowed to fisheries has also made it difficult to obtain sufficient size data measured on board fishing vessels which were significant source for estimation of catch-at-age statistics. Furthermore the current allowed catch appears insufficient to monitor the stocks in the light of the results from following researches. The present authors are deeply concerned of shortage of information in future, and they present their views here to hopefully improve data collection.

1. Existing methods of stock assessment and thier problems

1-1. Basic requirements for cohort analysis

Cohort analysis is appropriate for assessing stocks of bluefin tuna due to its ability to provide stock number, recuruitment, fishing mortality rate, etc. It does not depend on a series of effective fishing efforts or standardized indices of catch-per-unit of effort, CPUE. However, this method does assume a full understanding biological characteristics of the species such as heterogeneity of the species population, natural mortality coefficient, etc. Furthermore, it requires series of accurate catches in number at age, and either fishing coefficient or stock number in the last year of the series. These requirements were not necessarily fulfilled in the survey of bluefin tuna stocks (Doubleday 1984).

Here it should be noted that estimates of the fishing mortality coefficient in the last year, or terminal-F, do not seriously affect the evaluation of stock number in the early years of the series, but remarkably alter that in the later years and the resultant predictions. Taking as examples, two papers on the cohort analyses of the stock under discussion presented at the 1982 SCRS meeting, Powers et al. (1983) and Suzuki and Hisada (1983), which caused a serious dispute, the major errors occurred in the estimates for the years after 1970.

The nature of cohort analysis appears in a comparison of the estimates of stock number at age 1 given in the above two papers and those submitted to the 1983 SCRS meeting by Nagai (1984b). These figures reflect one general feature of this type of analysis, even though these papers involve several shortcomings such as neglect of variation of growth in converting body length composition into catch-at-age, which caused these analyses not to be taken up at the meeting.

Figure 1 indicates fairly good agreement among the three estimates of the stock number until 1968, but substantial differences thereafter. This is reflected in the correlation coefficients between the three estimates of stock number for the periods of 1960-1968 and 1969-1980. In the nine years prior to 1968, the lowest coefficient is 0.32 between Suzuki and Hisada (1983) and Nagai (1984b), but apparently higher than that for the 12 years in and after 1969. Similar differences appeared in the correlation coefficient between Powers et al. and Suzuki and Hisada, from 0.626 in the early years to 0.328 in the later years. The correlation coefficient, 0.801 in the early years, is found to be statistically significant at a probability of one percent, but in the later years that value plummeted to 0.015.

This characteristics of cohort analysis indicates that the accumulation of data stabilizes the estimates of stock number, mortality rates and other key parameters for the assessment and prediction of the exploited fish populations. Without the possibility to obtaining accurate terminal estimates of either the fishing mortality rate or stock size from data collected until 1981, it appears necessary to continue collecting catch, effort and size data from sizable fishing operations. As confirmed at the Shimizu Meeting (ICCAT 1984a), the adjustment of fishing operations with changes of behaviours due to age makes it impossible to estimate such a value of CPUE as representing abundance of the whole population, while the CPUE data in some fisheries may still appropriately indicate change in the stock size.

1-2. Structure of population

Some assessment studies are based on the assumption that the population of bluefin tuna in the Atlantic Ocean and Mediterranean Sea comprise two sub-populations each distributed in the eastern and western sectors and divided almost equally at the centre of the Ocean. Regional difference of availability of catch statistics makes it expedient to put emphasis on the western stock as distinct from its eastern counterpart. However,it is evident that the eastern and western stocks intermingle with each other as clearly shown by the recapture of tagged fish after they were released on the other side of the Ocean, and by compensation of age groups between the two sides (Rivas 1976, Brunenmeister 1980).

The current question to estimating the ratio of mixing may require a long time for any conclusion to be reached. The SCRS Workshop held in Shimizu in 1983 concluded that the X-ray analysis of micro-elements in hard parts as a likely method to establish the frequency and periodicity of transatlantic migrations, and suggested that responsible biologists determine the cost of a small number of fish by November 1984 (ICCAT 1984a).

1-3. Stock-recruit relation.

Regarding Atlantic bluefin tuna, the stock numbers of 1-age fish, estimated by cohort analysis, were compared with the relative abundance of eggs spawned in preceding years. According to Farrugio (1983) the stocks in the eastern Atlantic Ocean and Mediterranean Sea stayed on the right ascending slope of Ricker's curve for ten year classes between 1966 and 1975. Brunenmeister (1983) showed a positive linear regression of sizes of recruitment of 1960 to 1979 year classes in the West Atlantic Ocean in terms of the number of spawning stocks. Powers et al. (1983) came up with a sigmoid curve showing the same relation for the 1961 to 1979 classes. On the other hand, no relation was recognized between stock and recruitement of the 1960 to 1979 year classes either in the West Atlantic Ocean (Suzuki and Hisada 1983), or in the East Atlantic Ocean and the Mediterranean Sea, or the Atlantic areas (Kume and Suzuki 1983). Excluding the estimates for recent classes after 1970, which are liable to be affected by the choice of the terminal-F, no stock-recruit relation appears in the aforementioned sets of data. In addition, no other tuna stock showed signficant stock-recruit relation. Instead, the catch of small southern bluefin tuna was on the increase until 1982, in spite of serious concern of the decline of spawning stocks (Anonymous 1983).

Bluefin tuna may have peculiarities in stock-recruit relations from the other tuna species not in that the size of recruit stays at certain levels for different sizes of parent stocks but in that markedly strong recruits may arise irrespective of abundance of spawners. This view seems to reflect biological reasons. A female bluefin tuna discharges a large number, sometimes reaching 10 millions, of very small eggs of one mm in diameter, and accordingly the species must have a very high mortality rate in the early stages of life. In other words there may be rather rare chance for bluefin tuna spawned in a given area to successfully survive the critical stages. For other tuna species, the wide area and duration of spawning activities should reduce width of year-to-year fluctuation of the sizes of recruitment due to favorable environmental conditions expected in some spawning grounds or season in the whole ranges. For the Atlantic bluefin tuna, with limited spawning grounds in the Gulf of Mexico and the waters around Sicily and a short spawning period of about two months, high survival rates cannot be guaranteed every year, but favorable environmental conditions in the early stages of life may result in rare but enormously large recruits. The wide fluctuation in year class strength may be also attributed to that bluefin tuna spawn in the higher latitude than the other species of tuna, where the oceanographic conditions show remarkable seasonal and annual variations, and are less stable in the sapwning season than in the tropical waters.

As a matter of fact, Tiews (1978) reported the rise and collapse of bluefin tuna fishing in the North Sea which produced 6 000 to 10 000 tons of fish from 1950 through 1962, when dominant year classes represented distinct modes in the body weight composition of the catch (Figure 2). According to him, it is unlikely that the fishing activities depleted the stocks in the light of the successive catch of same year classes. The long history of exploitation in the northwestern Pacific Ocean has clearly indicated success and failure of year class strength of bluefin tuna therein (Figure 3). It may not be economically viable to conduct specifically designed observations of mortality at the very early stages of life. Rearing experiments of tunas now undertaken in various parts of the world (Arena et al. 1980, Hisada et al. 1984) would provide practical means for clarification of mechanisms underlying the fluctuation in the early survival patterns of the species, combined with oceanographic observation of the spawning and nursery grounds.

1-4. Biological parameters.

Powers et al. (1983) compiled estimates of natural mortality coefficient and growth parameters. These estimates appear reasonable at present, but left room for further consideration of other factors such as sexual and geographical differences in growth curves. It should be also noted that the conventional method for converting size composition to the catch-at-age figures tends to result in underestimation of abundance of dominant year class because of the neglect of variation of growth within age groups. Biologists recognized the necessity of refining the conversion method at the Shimizu Workshop (ICCAT 1984a), and commenced the study in several research institutes.

1-5. Accuracy of estimated length composition

The ICCAT recommended to measurement, as a rule, by 500 to 750 individuals in each category classified by country, species, fishing gear, fishing season and fishing area, at the inception of the SCRS activities (Miyake and Hayasi 1972). In those days emphasis of research activities was placed on yellowfin tuna not on bluefin tuna, but the measurements on the latter species substantially increased after 1970 (Nagai 1984a). Nevertheless, the period of twelve years accounts only 40 percent of the species's common life span, which extends over thirty years. The shortcoming in the duration of data collection, badly hampers studies of stock assessment of this species. The joint effort of SCRS biologists along the recommendations at the Shimizu Workshop and the 1983 SCRS Meeting have provided the best available set of information. For the time being, the stock assessment must depend upon the data produced by the SCRS and ICCAT Secretariat.

2. Review of the assessment and management of bluefin tuna stocks

At the inception of the ICCAT, yellowfin tuna attracted the prime concern for fishery regulation. Within a few years after, the assessment indicated only a very limited effect of the then expanded longline fishing on the species, the Commission's interest shifted from yellowfin tuna to bluefin tuna. The management of bluefin tuna by the Commission began with restricting harvest of small fish. Considerable discussion at the SCRS Meeting held in November 1974 resulted in the conclusion that the status of stocks was to be observed carefully (ICCAT 1975, p. 76). The CPUE's of young fish from ages of one to five fluctuated but maintained a certain level, but a remarkable decline occurred in the measurements of large fish for more than ten years. The low growth coefficent indicates the possible increase of total yield by total regulation of exploitation of young fish of one and two years old. The size of recruitment did not appear to depend upon their parent stock size. In the western Atlantic Ocean, stocks of small fish did not show any sign of decrease, and one-age fish for recreational fishery was the most abundant in 1974 for the past five to six years, in spite of the thinning of large fish. The SCRS indicated a concern about the possible decrease in reproduction over the short run, even if the fishery would stop taking bluefin tuna, due to probable over-exploitation of the year classes forming the large-sized stocks caused by intense fishing activities in preceding years. Furthermore, the anticipated boost in price would attract additional fishing activities directed toward large bluefin tuna. Eventually the SCRS tentatively suggested lowering the fishing intensity for the spawning stocks and adopted a long-term measure to reduce the catch of small fish by purse seine fishery. With regard to the long-term measure, the conservation of one-age fish is especially urgent through regulating the catch of fish less than 6.4 kg in body weight. In order to respond the serious problem of data shortage for stock assessment, on-board measurement of body length was encouraged, as introduced by the Japanese longline fleet. Panel 2 of the Commission examined the recommendation of the SCRS at the Third Regular Meeting, and the Canadian and U.S. delegates proposed limiting catch of 6.4 kg or lighter fish and increase of fishing for large and medium fish (ICCAT 1975, p. 47).

In the 1975 SCRS Meeting, biologists again suggested that bluefin tuna stocks have been on a continuous decline, and need regulation of fishery as recommended in the the previous meeting, even though the 1973 class still prospered in their third year of life as two-age fish. Panel 2 of the Commission noted the variation in the fishing mortality depending on size of the fish exploited, the high fishing coefficient for young fish in the latest 10 to 15 years in the western Atlantic Ocean, the probable reduction of fishing intensity for bluefin tuna in the eastern Atlantic Ocean, and then anticipated decrease in reproduction after the successive declines of large- and medium-sized fish. The Canadian and U.S. delegates emphazied the need to reduce fishing intensity for bluefin tuna stocks (ICCAT 1976, p. 65). Canada enforced the size regulation for fish less than 6.4 kg and reduced fishing effort by ceasing to issue new entrance permit, limiting the fishing season, and imposing domestic catch quotas (ICCAT 1976, p. 33, 171). The U.S. reduced fishing intensity, by closing the seine fishery for small fish on 15 August, and the harpoon, hand-line and trap fishery on 21 September (ICCAT 1976, p. 218). France also introduced a control on the amount of catch (ICCAT 1976, p. 34). Japan prohibited fishing operations by its nationals in the Mediterranean Sea from 21 May to 30 June, for protecting the spawning adults, in April 1975 prior to the ICCAT regulation. Since August 1975, Japan introduced further regulation to limit bluefin tuna below 10 percent of the total catch of each longline vessel (ICCAT 1976, p. 188). Furthermore, a domestic regulation was imposed for the operations in the Gulf of Mexico, and the quota was decreased in 1981 (ICCAT 1981, p. 80).

In spite of these efforts at regulations, the SCRS held in 1981 concluded that the bluefin tuna stocks in the western Atlantic Ocean were depleted to such a low level that they would continue to shrink even with no fishing activity (ICCAT 1982, p. 129). According to the Commission's decision, the delegates of the countries involved discussed on the possible management measures and agreed to reduce the total catch to 1,160 tons which was then considered as the minimal amount for monitoring the status of bluefin tuna stocks in the western Atlantic Ocean (ICCAT 1983, p. 38). In 1982, the SCRS Meeting received two sets of cohort analayses which differed in terms of the evaluation of stocks in the latest years as already mentioned. As a result of serious discussion, the allowable catch was increased to 2,660 tons, twice as much as that for 1982 (ICCAT 1983, p. 89). Table 1 shows the allocations of allowable catch to each type of fishery.

After two joint meetings held in 1983, at Trapani in May and at Tsukuba and Shimizu in August and September, the biologists started cooperative work to refine the data series and the methodology for assessing bluefin tuna stocks. The 1983 SCRS Meeting could not provide any positive conclusion to the present status of stocks, except that "some interesting observations for the western Atlantic Ocean" for "that the strong 1973 cohort has entered the Gulf of Mexico spawning area in 1983" and for "that the 1982 cohort seems abundant". The Commission agreed to extend the regulatory measures for one year until 1984.

3. Proposal for assessment and management of the stocks

After serious discussion, biologists of the SCRS and the ICCAT Secretariat have been cooperating in the compilation of data and in improving survey techniques and data analysis. Eventually it is very likely that major data series taken in the years prior to 1982 are going to be made available to the biologists of member parties. The next problem for the stock assessment is a fact that duration from the inception of survey activities of the ICCAT in 1970 to the intoduction of the very strict regulation in 1982 is very short compared to the life span of the species under discussion. Now the emphasis of the survey should be directed toward continuation and improvement of the collection and analyses of catch, effort and size data from major types of fisheries which would represent the distribution and abundance of bluefin tuna stocks at diverse stages in their life history, rather than to continue and divide the data in the previous years into further fine space and time divisions.

There appears a concern that current regulation has impeded data collection in some fisheries. Mentuzals and Hurley (1983) pointed out that the "temporal and spatial patterns of catch and of effort reflect subarea quotas rather than local abundance or availability, due to the strict quota control" introduced in 1982. Size data collected aboard Japanese longliners reduced remarkably in 1982 compared with the preceding years. Increase of quota for 1983 appears to have improved adequacy of catch and effort data to reflect abundance and availability of the fish on the Canadian coast. But the relaxed allowable catch is still a bit less for better understanding status of the stocks in the off-shore waters which were long evaluated by catch, effort and size data of longline fishing. Eventually the Atlantic bluefin tuna resources will not be properly utilized nor properly monitored under the current regulation.

The Shimizu Workshop also discussed possibility of adequately assessing bluefin tuna stocks in the Atlantic Ocean by means independent of conventional analysis of catch, effort and size statistics, such as an acoustic survey of spawning adults, quantitative collection of eggs and larvae, aerial observation of young fish, tagging experiments, etc. (ICCAT 1984a). However, assessing the stocks under discussion by these methods is improbable, with the possible exception of well organized tagging experiments.

Attention should be placed on the limitation of CPUE data of bluefin tuna for indexing the change of stocks only from the stable periods of operations, not over the whole years from which the data were obtained, due to its year-to-year shifts of fishing grounds and fishing season. Robson (1966) introduced the factorial analyses to examination of the CPUE data. His method is applied to the assessment of demersal fish stocks in the North Pacific Ocean (Kimura 1981, Stocker and Fournier 1984, Low and Berger 1984), where the fishing vessels are operated every year almost in the same places and same seasons. In 1983, this method was tried for the analysis of CPUE data of bluefin tuna in the West Atlantic Ocean (Southeast Fisheries Center 1984). But the species show not only significant seasonal migration but also remarkable shift of migratory patterns depending on year. These changes indicates importance of interaction term between month and season that reflects seasonal migration of the fish, and other interaction terms between year and month, and between year and sea area corresponding to year-to-year shifts of fishing seasons and fishing grounds. However, increase of number of interaction terms may bring it impossible to solve the multinomial equations in his method due to increase of number of unknown parameters over the data from the fishery with lack of observations in particular months or particular areas in some years. Stratification of data can solve the problems either through selecting the data from years when the fishing vessels operated in the same seasonal and areal extents, or those from the major fishing grounds which could differ depending on year. A method proposed by Honma (1974) tries to solve the problem by introducing the concept of the "average years", but it involves some shortcomings for applying to bluefin tuna (Honma et al. 1984). The analysis of CPUE's may have significance as a supplement to the cohort analysis for assessment of the stocks under discussion (ICCAT 1984a).

Statistics compiled by recent cooperation under the ICCAT indicate a decrease of catch of bluefin tuna from 1976 to 1979 and a slight recovery in the following years in the whole areas under consideration covering the Atlantic Ocean and the Mediterranean Sea (Figure 4). Here it should be noted that the decline of catch in the late 1970's occurred mainly in the eastern sectors and that the catch stayed at a constant level around 6,000 tons in the west. Such a stabilization also occurred in CPUE's of large fish in the spawning ground in the Gulf of Mexico (Honma et al. 1984) and some other fishing grounds (Suzuki 1984). Furthermore, the 1973 class still appears strong in 1983, and the next strong class seems to have occurred in 1982. These observations suggest it is no longer necessary to fear that the stocks will decline even if not fished at all as assumed in 1981.

The aforementioned findings indicate it most practical for the purpose of monitoring bluefin tuna stocks to collect and analyse the statistical data from major fisheries. The catch allowed for these fisheries (Table 2) were allocated according to the anticipated degree of contribution to the stock assessment among the concerned parties early in 1982. Since the monitoring catch was applied for three years from 1982 to 1984, the performance would provide the means to evaluate the usefulness of the resultant catch, effort and size statistics.

At this point the present authors would like to express their personal views brought forward further discussion on the assessment of bluefin tuna. Recreational fisheries have caught young fish but the analysis needs unconventional techniques because of the specialized performance of operations as tried by Nichols (1984). Furthermore, the analysis of data needs particular attention on the diversity of fishing skill. According to personal communication with scientists who are familiar with the tuna purse seine fishery off eastern coast of U.S., rapid technical advance inclusive of searching for fish schools makes the CPUE data very unlikely to reflect the abundance of fish. The auhtors would like to find some means to use the data together with size composition of the catch by this type of fishery that is one of major producers of bluefin tuna. The U.S. longliners, originally aiming at broadbill swordfish, represent the only significant fishing activity with access to the spawners of bluefin tuna in the Gulf of Mexico. It could be very useful to seek out systematic means to compile and analyse the catch and effort data of the fishery in addition to the size data. It is not necessary to repeat the usefulness at the Canadian data that has continuously indicated the distribution and abundance of bluefin tuna having immigrated to the northern boundary zone of the geographical range for a period of years, with probable exception of 1982. Similarly, Japanese longliners have provided catch, effort and size statistics which have been widely used for stock assessment and other ecological studies of not only bluefin tuna but also other tuna and billfishes in the offshore waters. Details of the statistic are often sought even after the introduction of strict limitation on fishing activities which have made it less reliable for reflection of distribution and abundance of the fish due to the very small amount of catch. It appears very effective for the purpose of advancing stock assessment to substantiate data collection, and also accelerating the reporting systems, by appropriately increasing the allowable catch for each type of fishery, taking into acount the anticipated degree of contribution to stock monitoring, and also the impact of their activities on the size of recruitment and on the yield per recruit. A reasonable extent would be the average catch for the last several years prior to 1982 in the West Atlantic Ocean exclusive of the fishing grounds for young fish and sapwning grounds.

It is axiomatic that regulatory measures of fishing must be based on not only biological reasoning, but also socioeconomic consideration of the concerned countries. Therefore, frank exchange of views is essential from various standpoints in order to conserve bluefin tuna as well as develop the fields of fisheries and biology.

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Table 1. Correlation coefficients between three estimates+ of stock size of 1-age bluefin tuna in the West Atlantic Ocean for 1960-1968 and for 1969-1981.

Period	Duration	Pe/SH	Pe/Na	SH/Na
1960-1968	9 yrs	0.79*	0.89**	0.57
1969-1981	12 yrs	0.57	0.12	0.12

+ Three estimates are those given by Powers et al.(1983), Suzuki and Hisada (1983) and Nagai (1984b).

Statistical significance as a probability is indicated as: * less than 5 % and ** less than 1 %.

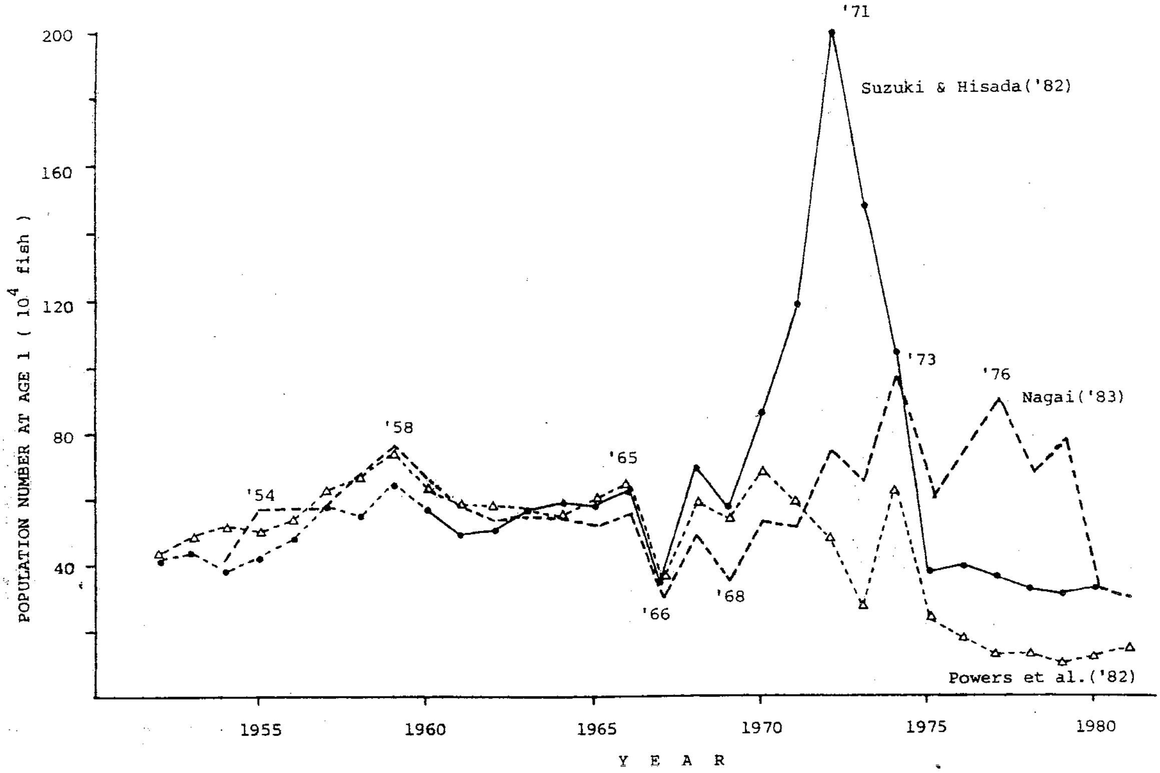

Figure 1. Three estimates* of stock size in number of fish of 1-age bluefin tuna in the West Atlantic Ocean, 1952-1981.

* Three estimates are those given by Powers et al. (1983), Suzuki and Hisada (1983) and Nagai (1984b).

Table 2. Allowed catch for scientific monitoring of bluefin tuna for different types of fisheries of Canada, Japan and the United States in the West Atlantic Ocean, 1982 and 1983.

Year	Nationality	Types of fisheries	Amount of allowed catch in tons
1982	Total		1,160
	Canada		250
	Japan	Longline	305
	United States	Sub-total	605
		Directed fisheries	
		Handgear	281
		Recreational angling	90
		Harpoon boat	39
		Incidental fisheries	
		Swordfish longline	40
		Purse seine	150
		Others	5
1983	Total		2,660
	Canada		573
	Japan	Longline	700
	United States	Sub-total	1,387
		General including handline, rod and reel, and harpoon	590
		Harpoon boat	68
		Incidental fisheries	
		Longline	132
		Purse seine	385
		Others	5
		Angling	126
		Reserve	81

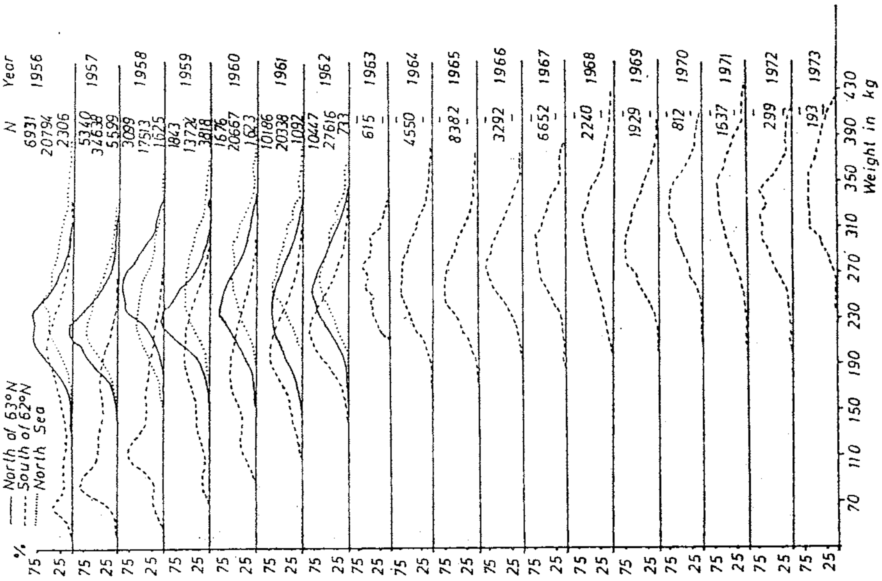

Figure 2. Size composition of Norwegian and German bluefin tuna catches by area, 1956-1973.

After Tiews (1978).

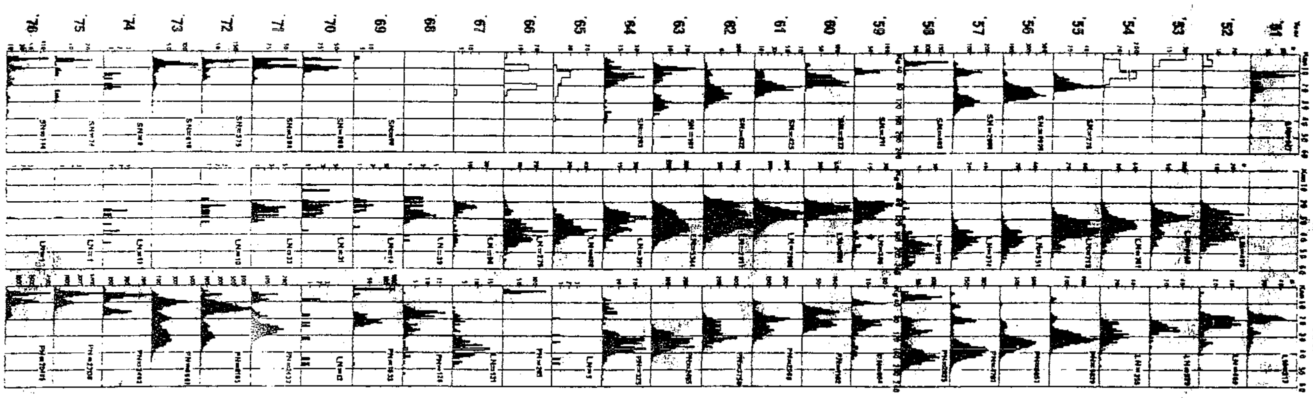

Figure 3. Body weight composition of bluefin tuna caught in three major fishing grounds around Japan, 1951-1978.

(1) Coastal waters along Honshu in the Sea of Japan, June, set net.

(2) Offshore waters east to southeast of Okinawa, May, longline.

(3) Coastal waters along northeastern Honshu in the Pacific Ocean, July, purse seine.

After Yamanaka (1982).

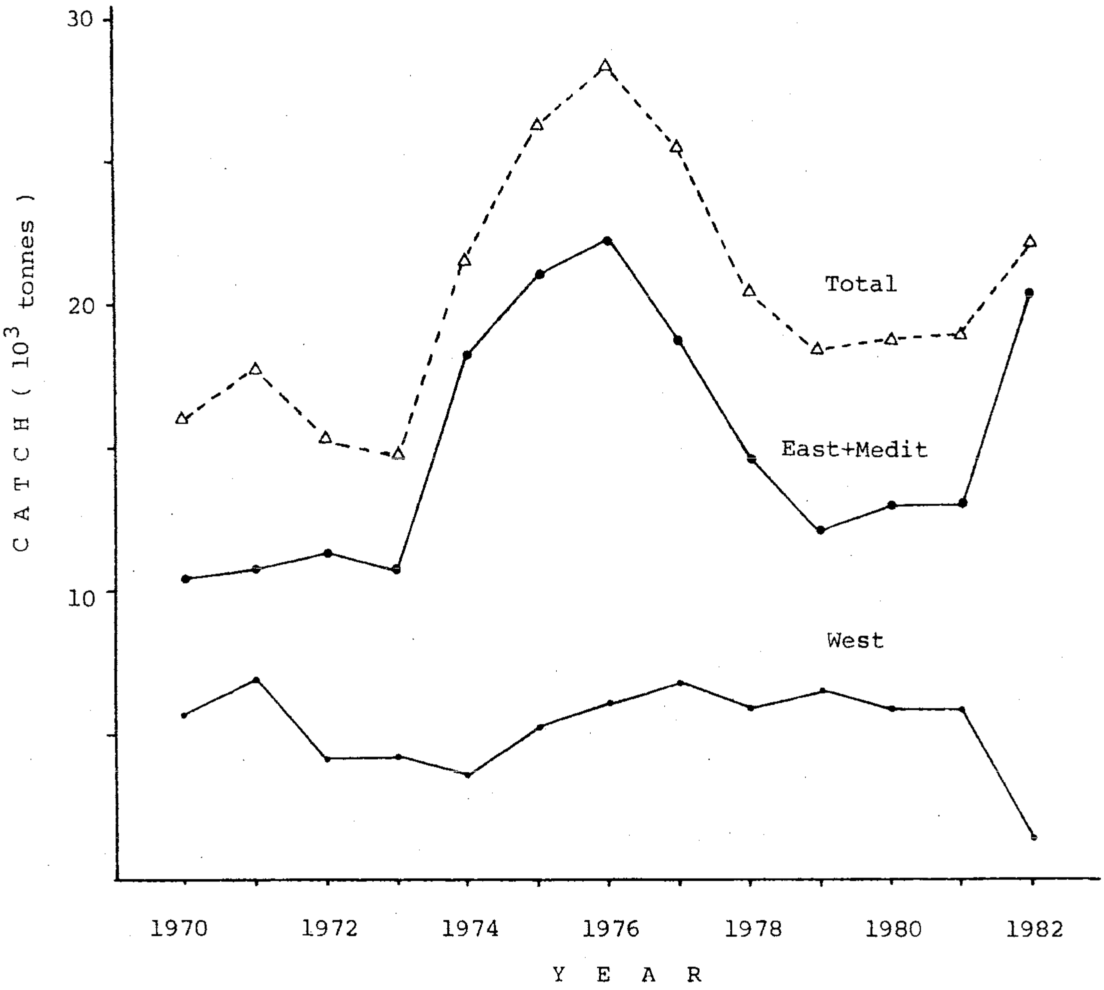

Figure 4. Amount of catch of bluefin tuna in the Atlantic Ocean and the Mediterranean Sea, 1970-1982.

Data from ICCAT (1984b).