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ICCAT Conservation Measures for Bluefin Tuna

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Introduction

In 1974, the International Commission for the Conservation of Atlantic Tunas (ICCAT), recommended regulatory measures for bluefin tuna (Thunnus thynnus thynnus) in the Atlantic Ocean. Since ICES has been showing very strong concern with the status of bluefin tuna stocks, a summary of the actions taken by ICCAT and a brief background of these actions are presented in this report.

Scientific Studies on Bluefin Tuna

Since its founding in 1969, ICCAT scientists have been closely watching the conditions of stocks of the various species of tunas. The Standing Committee on Research and Statistics (SCRS) has immediate responsibility for the study. Based on the findings of the SCRS scientists, the Commission recommended, at its Council meeting held in 1972, a regulatory measure to limit the minimum size of yellowfin tuna (Thunnus albacares) which can be legally caught. The regulation has been in effect since June, 1973.

At its 1973 meeting, the ICCAT scientists also showed serious concern with the status of bluefin tuna stocks. At the 61st Statutory Meeting of ICES (Lisbon 1973), the ICES scientists also expressed some concern with the bluefin tuna stock conditions. Since then, all the scientific findings and papers concerning bluefin tuna were exchanged between the scientists of the bluefin tuna Working Groups of the both organizations.

Finally, by mutual agreement of the Chairmen of both ICES and ICCAT Working Groups on Bluefin Tuna, a joint meeting was called on September 29, 1974, at Charlottenlund, Denmark. The Report of this meeting was presented at the 62nd Statutory Meeting of ICES, held in Copenhagen immediately following the joint meeting, and at the SCRS and Council meetings of ICCAT held in Madrid, in November, 1974.

In the meantime, the Unites States of America circulated a note sixty days prior to this ICCAT meeting (in accordance with Rule 8 of the ICCAT Rules of Procedure) indicating its intention to propose, during the Council session, recommendations concerning the conservation of bluefin tuna. During the SCRS meeting, held together with the Council meeting, the scientists carefully studied the report of the Joint Meeting of ICES/ICCAT Bluefin Tuna Working Groups and considerably extended the studies on bluefin tuna. The pertinent section of the SCRS Report (1974) is attached herewith as Appendix.

The scientific conclusions indicate that the catch per effort for bluefin tuna has been declining in recent years, while many of the fisheries are based on very old fish and the number of relatively young fish entering these fisheries has significantly declined. This may be due to the increase in catches of smaller fish. The scientists agreed that the reduction of fishing effort to the small sized bluefin will increase the total catch. They recommended that the long-term benefits in terms of increased catches of larger fish will be greatest if the reduction of effort applies mostly to one-year, and to a lesser extent, to two-year old fish. The avoidance of these very small fish in the commercial fishery might be implemented by enforcing the size limit. An appropriate limit in the northwest Atlantic might be 6.4 Kgs.

Regulations Recommended by ICCAT

Panel 2, set up within ICCAT to discuss the management measures for temperate tunas, held sessions at the same time of the Council meeting in Madrid, November, 1974. The United States proposed two measures to protect bluefin tuna in the Atlantic Ocean.

These, as later modified at the Council, are as follows:

Proposal* of the United States Concerning Atlantic Bluefin Tuna

In view of the Report of the Standing Committee on Research and Statistics (SCRS/74/2 — Annex 9 to the Proceedings), and the expression of concern by several members of the Commission, it is proposed that the Council be requested to take the necessary action to propose to the members of the Commission, as is provided in Rule 9, paragraph 8 of the Rules of Procedure, the following:

First — That the Contracting Parties take the necessary measures to prohibit any taking and landing of bluefin tuna *(Thunnus thynnus thynnus)* weighing less than 6.4 kg.
Notwithstanding the above regulation, the Contracting Parties may grant tolerances to boats which have incidentally captured bluefin weighing less than 6.4 kg., with the condition that this incidental catch should not exceed 15 % of the number of fish per landing of the total bluefin catch of said boats or its equivalent in percentage by weight.

Second — That as a preliminary step, the Contracting Parties that are actively fishing for bluefin tuna *(Thunnus thynnus thynnus)* of those that incidentally catch it in significant quantities shall take the necessary measures to limit the fishing mortality of bluefin tuna to recent levels for a period of one year.

* Some modifications made at the Council Meeting have been incorporated.

The recommendations were adopted by the Panel and passed to the Council. The Council decided to subject these proposals to a mail-in vote of the Commission, since the recommendations of a regulation must be agreed upon by the Commission. As of the end of January, 1975, seven (7) countries, which constitute a majority of the Commission, sent in affirmative votes. According to Article VIII of the ICCAT Convention, the recommendation became effective on August 10, 1975, six months after the decision had been made, as no objection was received in the interim. Since the second measure recommended is provisional for a one-year period, it is expected that the Panel, meeting at the time of the ICCAT Commission meeting (November, 1975), will again take up this problem.

5.c. *Bluefin*

5.c.1. *Catches*

The catches of bluefin tuna in the Atlantic (including the Mediterranean) are given in Table 3. This shows that the total catch has declined from a peak of a little under 40,000 tons in 1964-65 to about 12,000 tons in 1973. The recent trends have varied between fisheries. The surface (purse seine and baitboat) fisheries on small fish have declined to about half their peak catches, while most fisheries on large fish (particularly the Norwegian purse seiners and the traps along the coast of the Iberian Peninsula and Morocco) have declined to a very low level. The catches of Japanese longliners in the Atlantic have declined by about 11,000 tons from the peak in 1964-65. However they took good catches of some 3,000 tons in the Mediterranean in 1973-74.

5.c.2. *Stock separation*

There is still uncertainty about the degree of separation between the tuna caught in the Mediterranean and the Atlantic, and between the eastern and western Atlantic. Recent tag returns have confirmed that trans-Atlantic migration of both large and small bluefin occurs, and may be appreciable in some years. However most tag returns, even after several years, occur on the same side of the Atlantic as the point of tagging. Therefore it may be convenient, and not incorrect, to treat the Atlantic bluefin as, in many ways, a single stock. However it is probable that any management action (or failure to take action) will be most clearly felt among the fisheries on the same side of the Atlantic as the action is taken, but will also affect to some extent the fisheries on the other side.

5.c.3. *Status of stocks*

5.c.3.1. Because there are very marked differences in the distribution of different sizes of bluefin, and in the fisheries on different sizes, it is necessary to treat different size groups individually. Catch rates of younger fish (1 to 5 years old) taken in the surface fisheries have, over the past decade or more, fluctuated around the same levels. Estimates of the number of young fish recruiting into these fisheries have been made, and show some variation, with no consistent trend in all sets of estimates. In the western Atlantic, the 1973 year-class seems to have been good. The present estimates of recruitment are far from satisfactory, and better estimates are badly needed.

5.c.3.2. The older fish however have declined, although quantitative data, e.g. reliable measures of catch per unit effort, are generally lacking. The best c.p.u.e. data are probably from the Japanese longline fishery, but these can be seriously affected by the degree to which the vessels direct their attentions to bluefin or to other species. Counts from aircraft of giant bluefin passing the Bahamas suggest a decrease between 1951-53 and 1974, of a third. Catches in many fisheries have declined much more than this. It was pointed out that there are big variations in sex ratio, and some coastal fisheries in the northwest Atlantic on large fish take almost entirely males.

5.c.3.3. There have been changes in the composition of the catches of larger fish. The average size in nearly all fisheries has been increasing over a long period. Several of these fisheries are now based on very old fish (up to 20 years old or older), and the numbers of relatively young fish (6-8 years old) entering these fisheries have significantly declined. In one or two cases, e.g. the Norwegian purse seine fishery, the changes in length composition from year to year suggest that there has been virtually no recruitment to the fishery since 1960. In others, recruitment has been very low. It appears that the decline in the numbers of fish recruiting to these fisheries may be correlated, at least in the western Atlantic, with an earlier increase in the fisheries on small or medium fish —as would be expected in a qualitative sense. The quantitative links between the fisheries on different sizes of fish are examined in the following section.

5.c.4. *Yield-per-recruit*

5.c.4.1. The bluefin fishery is characterized by very different fishing mortality rates on different ages. The pattern of age-specific fishing mortality depends on the relative fishing effort exerted by different types of gears (purse seine, baitboats, longline, etc.) as well as the fishing tactics of each gear. This complicates the calculations of the yield that can be obtained from a given recruitment, which are normally made for a constant fishing mortality above some given age. Ideally the calculations should be made for the present pattern of age-specific F, and take into account likely changes in this pattern. This was difficult to do during the present meeting, because of uncertainty concerning the precise present situation, and likely changes in fishing tactics. Accordingly, calculations were made of an idealized fishery, with three distinct segments — 1-5 years, 6-10 years and 11 years onwards. The yields from different combinations of fishing mortality in each of these periods were calculated, and are shown in Table 4. Calculations were made for natural mortality M = 0.2 and 0.4, but the latter proved to be inconsistent with the observed history of the fisheries. With such a high natural mortality it would be impossible for fisheries on large fish (e.g. the Ibero-Moroccan trap fisheries) to have taken the large catches taken in past years. Ranges of F = 0.2, 0.4 and 0.6 were considered for large fish, but the results were insensitive to the values used, and therefore the results for F = 0.2 only are presented. The results have been expressed as the yield in weight (tons) per million recruits at one year old. This level of recruitment is within the range recently experienced, so the figures do provide some guidance to the actual catches that might be expected. Actual recent recruitment to the total Atlantic stock has been estimated, using virtual population analyses, to range between 0.4 and 1.5 million fish.

5.c.4.2. Examination of the bottom row of each part of Table 4 shows that increasing fishing mortality on the small fish causes a steady decrease in the total catch. This decrease is particularly marked for $F > 0.2$, where an extra 1,000 tons caught as small fish can cause a drop in total catch of several times as much. On the other hand for low values of F in all sectors of the fishery, a small increase in the catch of small fish causes a drop in the catch of larger fish that is not very much bigger. That is the critical factor in determining the fate of the medium and large fish in the *fishing mortality* on the small fish, rather than the actual weight caught.

5.c.4.3. This analysis confirms that the decline in the catches of older fish can be accounted for in a general way by the increase in catches of smaller fish, and that the observed drop in total catch, some two or three times the catch of small fish, is to be expected from the yield-per-recruit analyses. A more precise account requires estimates of the fishing mortality in the younger fish.

5.c.4.4. The most direct estimate of fishing mortality in bluefin comes from the results of tagging of small fish in the N.W. Atlantic. These gave estimates of F on 2 and 3 year old fish that ranged from 0.278 to 0.995, with a mean value of 0.575. These estimates imply fairly high emigration or other loss rate from this fishery. If the true loss rate is lower, then the estimate of F should be decreased. On the other hand, if correction is made for deaths at the time of tagging, the estimates of F may have to be increased.

5.c.4.5. In terms of the idealized stock, a value of 0.575 for F would imply that the fishing mortality on these small fish, if it is applied uniformly on ages 1 to 5, could be reduced to a third of its present value (i.e. to a little less than 0.2), with not much reduction in the catch by the small-fish fishery, and a very great increase in the total catch. If the true present fishing mortality is lower (say 0.4), it could still be reduced appreciably without reducing the total catch, but there would be a reduction in catch in the small-fish fishery.

5.c.4.6. In practice, the situation does not correspond exactly to the idealized stock, nor does the same fishing mortality apply to all groups of small fish. The age-composition in the small fish fisheries on the two sides of the Atlantic appears to be similar, so that it is not unreasonable to assume the mortality rates are similar. Also there does not appear to be any unexploited groups of small bluefin on either side of the Atlantic. For the present, therefore, the fishing mortality is estimated to be in the range 0.4-0.6, and is assumed to apply to all groups of small fish.

5.c.4.7. It is less reasonable to assume that this rate applies (as in the idealized model) equally to all ages from 1 to 5. On the one hand the appearance of one year-old fish in the catches is variable, and they are usually much less well represented in the catches than older fish, though they seem to predominate in the catches off Morocco, and in the U.S. sports catch. On the other hand, 4 and 5 year old fish are not now common in the catches, though this may be because few survive the intense fishery on 2 and 3 year olds, rather than because they have moved out of the fishery.

5.c.4.8. If indeed the small-fish fisheries do not exploit fully the 5 or 4 year olds, this will not make much difference to the changes in *total* catch predicted to follow a change in fishing mortality on young fish. If the present mortality is reduced, the total catch will still increase by about the same extent, but less of the benefits will be felt in the small-fish fishery itself, e.g. a reduction from $F = 0.6$ to $F = 0.4$ would reduce the long-term catch in the small-fish fishery rather than slightly increase it. In the actual fishery on small fish in the eastern Atlantic, which appears to be based only on 2 and 3 year old fish, the losses within the small-fish fishery following a reduction in effort would be appreciable.

5.c.4.9. To the extent that one-year old fish are not exposed to the full fishing mortality, the results of a general reduction in fishing mortality on small fish will be less dramatic than suggested in Table 5. The general effects will however be similar — a reduction in mortality will increase the total catch, and if the fishing mortality is at the upper end of its likely range (0.6), a quite large reduction from the present level can be made without serious long-term reductions in the catches of the small-fish fisheries, at least if they catch fish up to age 5.

5.c.4.10. The fishing mortality coefficients on the larger fish are less well known. In the past they were probably low in the western Atlantic (indeed so low that the western stock, if separate from the eastern stock, was probably under-exploited until the development of the small-fish fishery). At present they may be low in the east Atlantic because the low level of adult abundance has caused a drop in effort in many of the large-fish fisheries. If the effort remained low, there might not be much increase in total catch following a reduction in mortality in the small-fish fishery, but it seems much more reasonable to expect that, once the abundance of larger fish increases, the effort on larger fish will increase to take advantage of the larger stock.

5.c.4.11. The yield-per-recruit analyses can also be used to estimate the effect of changing the size at first capture, i.e. avoiding completely the capture of fish below a given size or age. These have shown that, unless the fishing mortality on medium and large fish is very low (which, as discussed above, will be unlikely if the adult abundance is allowed to increase) the total catch would be increased by increasing the size at first capture up to 8-10 years.

5.c.4.12. Simulation studies were also made using a more realistic vector of age-specific fishing mortalities, and estimates of the present age-composition. These confirmed the other yield-per-recruit calculations, and specifically showed that an overall reduction in fishing mortality on all sizes proportionally, will tend to increase the total catch if the present F on 2-3 year old fish is higher than about 0.35. At high levels of fishing effort, avoiding the capture of 1 and 2 year old fish would increase, the total catch. The simulation studies also showed that it would take a long time (from about 5 years for the small-fish fisheries to about 15 years) for management actions to have their full effect on the fishery.

5.c.5. *Stock and recruitment*

5.c.5.1. Considerable concern has been expressed over the long-term situation of the bluefin stock, in the light of the low level of abundance of the adult stock, and the possible effect on recruitment. The determination of the relation between adult stock and subsequent recruitment is difficult for most fish, and tuna is no exception. Analyses of the recruitment during recent years have shown no consistent trend, with most data suggesting fluctuations about a steady level. In the western Atlantic sports fishery, one-year old fish were more abundant in 1974 than in several years previously. However no clear conclusions can yet be drawn concerning the relation between adult stock and subsequent recruitment.

5.c.5.2. It is clear, however, that adult stock cannot be reduced indefinitely without effect on recruitment and, though the evidence on this is inconclusive, in the bluefin tuna the adult abundance may be approaching the point at which recruitment could be affected. If this is the case, further declines in adult stock could seriously affect the long-term state of the whole north Atlantic bluefin fishery.

5.c.5.3. In the long-term, the abundance of the adult stock is determined by the fishing mortality rates at all ages. This is shown in Table 5, which gives the biomass in thousand tons, per million recruits, of large (10+) fish for the different combination of mortalities used in the earlier yield-per-recruit calculations.

5.c.5.4. The figures decline very greatly from the top left of the table to the bottom right, and a stock exposed to heavy fishing on all ages may have a biomass less than one per cent of that of a stock fished only when old. In the long term, if a moderately high level of adult stock is desired, this can only be done by ensuring a reasonably low level of fishing mortality on all ages.

5.c.5.5. For the short term, in reference to the present situation, restrictions on the catching of small fish will have no affect on the adult stock for at least five years, — until the fish involved have reached maturity. Serious concern has been expressed by some people about the level of adult stock over the next few years. The Committee, therefore, examined the likely trends in the adult stock. Clearly the biomass of the giant fish now dominating the large fish fisheries will decrease, even if not fished, as losses through natural mortality exceed growth increments. These losses normally will be countered by recruitment of fish now of medium age (5-8) to the adult stock. The magnitude of this recruitment is expected to be small, because these fish were exposed to heavy fishing when young. In recent years, these ages only appear in any numbers in the Spanish baitboat fishery and in the Japanese longline fishery in the eastern Atlantic. It is possible that they are so few that the adult stock will decline even further; on the other hand, it appears from some analyses that the fishing mortality on small fish in 1968-71 was somewhat lower than in the preceding period. In that case recruitment to the adult stock in 1975-78 might be expected to be rather better than earlier (though still low), and the adult stock could be maintained at its present level, or even increase slightly, if the fishing mortality on these fish does not change appreciably. However, it appears that higher prices are resulting in an increase in effort on large bluefin in the western Atlantic. On balance, therefore, unless action is taken to control the catches of large fish, it is likely that the abundance of large fish will decline over the next five years. The effect of such a decline on subsequent recruitment cannot be predicted with any confidence.

5.c.6. *Management actions*

5.c.6.1. Two actions have been considered by the ICES/ICCAT group, which were:

"*a*) short-term reduction of fishing intensity on giant fish, to protect spawning fish,

b) long-term reduction in purse seine fishing of young fish to permit escapement of maturing fish."

In discussing these proposals it was considered that examination should also be made of the effect of reducing fishing of small fish by other gears.

5.c.6.2. The consequences of the first are not entirely certain. In the short run, it is clear that because among these fish natural mortality exceeds growth, there will be some loss of catch. The long-term effects depend on the changes in adult stock and subsequent recruitment. If, even without such a measure, the adult stock would not fall below the 1973 level, recruitment would be likely to be maintained, and there would be no benefit. On the other hand, without controls, the adult stock might fall enough to have serious consequences on recruitment, which could take drastic controls in future years to remedy, and in that case a reduction in fishery on large fish, or at least a limit on effort to the present level, could be beneficial in avoiding serious losses. If the Commission takes the view that it should minimize risk by insuring against possibly serious losses, it should consider such controls. It should also be noted that any action to protect the spawning stock would not be effective in the long term if the fishing mortality on juveniles is high.

5.c.6.3. The consequences of the second action depend on the ages of the fish affected. Long-term benefits, in terms of increased catches of larger fish, will be greatest if the reduction of effort applies mostly to one-year old, and to a lesser extent, 2 year old fish. It is technically possible in the commercial fishery to avoid one-year old fish, while still catching 2-5 year olds, and to do so would increase the total catch by several tons for each ton by which the catch of one-year old fish is reduced. The avoidance of these very small fish in the commercial fishery might be implemented by enforcing a size limit. An appropriate limit in the northwest Atlantic might be 6.4 kg.

5.c.6.4. However the present catch of one-year old fish in the commercial fisheries is not large though in some years U.S. sports fishermen make large catches of small (mostly one-year old) fish, which may total as many as 100,000 fish. Also it appears technically difficult to avoid 2-year old fish, while still fishing for the older groups of small fish. An appreciable increase in the escapement from the small-fish fishery, and in the recruitment to the mature stock, can only be achieved by a more general reduction in fishing mortality on the small fish.

5.c.6.5. The yield-per-recruit analysis suggests that if the current fishing mortality is as high as estimated from tagging, then the fishing mortality could be reduced by at least half, without a great long-term reduction in the catch of small fish, and with substantial increases in the catches of large fish. The reductions in the catch of small fish will be only minor if the fishery does now, or can in the future, exert a significant fishing mortality on the 4 and 5 year old fish.

5.c.6.6. The fishing mortality may be difficult to estimate and control directly, and the control may have to be effected by a catch limit. The limit that has to be imposed to achieve any desired reduction in mortality in the 1975 or later seasons will depend on the stock abundance in those seasons. If a catch limit is applied at a time of falling stocks, without taking account of the reduction in stock, it may be quite ineffective in limiting fishing mortality. Fortunately, it appears that in the northwest Atlantic, the 1973 year-class was relatively good, and the catch, and presumably the purse seine effort, was lower than the average of past years. Thus the abundance in 1975 is likely, if anything, to be higher than recent averages, and a catch limit set at say 25 % below the 1973 level would ensure that the fishing mortality would be reduced by at least 25 %. Similarly, any other reduction in effort that the Commission might adopt as a target could be achieved by an approximately proportional reduction in catch. If this were done, and provided recruitment is average or better, there should be some increase in abundance, so that the catch quota to achieve a 25 % effort reduction could be increased in future years, or a further reduction in effort achieved with little reduction in catch.

5.c.7. *Future activities*

5.c.7.1. Improved analyses of the state of bluefin stocks, and better advice on the results of management measures, are made very difficult by the absence of basic data from several important fisheries. The need for improved sampling was stressed by the ICES/ICCAT working group, which recommended a minimum standard of at least 500 fish/fishery/year of large and 1,000 fish/fishery/year for small fish. In view of observed differences in sex ratios, and the importance of age data, sampling should also include information on the sex of the fish, and collections of otoliths made. It was noted that a technique has been developed by U.S. scientists for the easy collection of otoliths from giant bluefin. It was also reported that Japan is arranging for direct sampling on board longliners, which will provide more reliable data, with better detail on the time and area of capture. The Committee therefore strongly *recommended* that all countries catching bluefin should implement a sampling scheme to at least the standard suggested by the ICES/ICCAT group.

5.c.7.2. Data on catches and effort are also partly unsatisfactory Statistics of catch are incomplete for some fisheries and for nearly all fisheries improvements in effort data are needed, and for many it is still unclear what measure of c.p.u.e. provides the best index of abundance. The Committee therefore *recommended*:

a) that all countries not yet reporting full catch and effort data should do so as soon as possible, and

b) that studies should be made to determine the best indices of c.p.u.e to use, especially in the large-fish fisheries.

5.c.7.3. Better information is needed on the stock structure of Atlantic bluefin. Tagging has given good information on the movements of fish in the western Atlantic, and similar work is needed for the eastern Atlantic. In addition it appears that morphometric studies (on the size of the second dorsal fin) may be useful in separating stocks of groups of fish. The Committee, therefore, *recommended*:

a) that tagging of small (especially 0- and 1 to 2 group) fish in the eastern Atlantic and Mediterranean should be intensified,

b) that further studies should be made of the usefulness of morphometric measurements as a method of stock separation.

5.c.7.4. In addition to identifying the above actions to improve the supply of basic information, the Committee also noted that further analyses could be made of existing data, other than the analyses reported in documents presented to the meeting, and some made during the meeting. Specific studies that should be made, and reported to the next session of the Committee, include:

a) further studies using the method of cohort analysis for each side of the Atlantic,

b) better estimates of recruitment, at one-year old, using c.p.u.e. data, tag returns and cohort analyses,

c) further estimates of yield-per-recruit, using a more detailed breakdown of age-specific fishing mortality,

d) studies of the relation between adult stock and recruitment, using the recruitment estimates obtained under *b*),

e) estimation, from c.p.u.e. data and cohort analysis, of the trends in abundance of each age-group.

Table 3. Bluefin Tuna[1] Catch (Thousand metric tons) in the Atlantic Ocean, 1963-73

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
TOTAL	30.1	38.5	35.0	24.9	32.3	22.1	21.1	18.3	23.4	13.5	12.5
Atlantic	26.0	32.7	29.3	19.2	22.4	14.3	11.8	12.1	16.5	8.0	9.0
Mediterranean	4.1	5.8	5.7	5.7	9.9	7.8	9.3	6.2	6.8	5.5	3.5
Subtotals[7]											
Longline	8.1	12.8	9.8	3.1	3.3	1.8	0.7	0.4	4.6	0.7	1.6
Cuba	2/	2/	0.1	0.5	2.4	1.4	0.5	0.2	—	—	—
Japan	7.8	12.6	9.6	2.5	0.8	0.3	0.1	0.1	1.5	0.6	1.4
Baitboat[1]	5.2	6.0	7.4	9.6	9.1	9.1	6.8	5.0	4.5	2.2	1.9
France	1.6	2.8	1.9	2.8	2.2	1.9	1.8	1.7	2.6	1.9	1.0
Spain	3.1	2.7	5.2	6.8	6.9	7.0	4.9	3.3	1.7	0.3	0.9
Purse Seine	6.2	7.0	6.2	2.2	4.2	1.7	2.1	4.9	5.0	2.5	2.2
Canada	0.3	0.6	0.5	...	...	...	...	1.2	0.9	0.3	0.6
Norway	0.2	1.5	2.5	1.0	1.9	0.9	0.9	0.4	0.6	0.1	0.1
U.S.A.	5.7	4.9	3.2	1.2	2.3	0.8	1.2	3.3	3.2	2.1	1.5
Sports[6]											
Canada	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.2	0.2
Traps	4.7	5.2	5.4	3.4	4.6	2.0	2.3	1.9	0.7	0.2	0.5

1. Portuguese Island catch is excluded.
2. Included in yellowfin.
3. Italian catch reported in Atl. excluded due to double counting.
4. Southern bluefin tuna *not included*.
5. Some minor countries' data still missing (Algeria, Greece, Libya, Malta, Turkey).
6. U.S. Sport catch data not available.
7. Breakdown consists of major fishery only.

Table 4. Catches of bluefin tuna, in tons per million recruits at 1 year old, under different fishing mortalities on small and medium fish ($M = 0.2$, F on large fish = 0.2)

(a) F on medium fish = 0

F on small fish		0	0.1	0.2	0.4	0.6
Catch	Small	—	4.062	6.086	7.195	6.903
	Medium	—	—	—	—	—
	Large	16.796	10.187	6.179	2.273	836
	Total	16.796	14.249	12.265	9.468	7.739

(b) F on medium fish = 0.2

F on small fish		0	0.1	0.2	0.4	0.6
Catch	Small	—	4.062	6.086	7.195	6.903
	Medium	14.763	8.954	5.431	1.998	735
	Large	6.179	3.748	2.273	836	308
	Total	20.942	16.764	13.790	10.029	7.946

(c) F on medium fish = 0.4

F on small fish		0	0.1	0.2	0.4	0.6
Catch	Small	—	4.062	6.086	7.195	6.903
	Medium	19.956	12.103	7.341	2.700	993
	Large	2.273	1.378	836	308	113
	Total	22.229	17.543	14.263	10.203	8.009

(d) F on medium fish = 0.6

F on small fish		0	0.1	0.2	0.4	0.6
Catch	Small	—	4.062	6.086	7.195	6.903
	Medium	21.680	13.149	7.976	2.934	1.079
	Large	836	507	308	113	42
	Total	22.516	17.718	14.370	10.242	8.024

Table 5. Biomass of large fish under different patterns of fishing mortality

	F (large fish) = 0.2				F (large fish) = 0.6			
	F on medium fish							
F on small fish	0	0.2	0.4	0.6	0	0.2	0.4	0.6
0	84.0	30.9	11.4	4.2	52.2	19.2	7.1	2.6
0.1	50.9	18.7	6.9	2.5	31.6	11.6	4.3	1.6
0.2	30.9	11.4	4.2	1.5	19.2	7.1	2.6	0.9
0.4	11.4	4.2	1.5	0.6	7.1	2.6	0.9	0.4
0.6	4.2	1.5	0.6	0.2	2.6	0.9	0.4	0.1