

International Seafood Sustainability Foundation

STATUS OF THE WORLD FISHERIES FOR TUNA

SECTION B – STATUS OF THE STOCKS

This section describes the status of the stocks of the four main species of tunas – yellowfin, bigeye, skipjack, and albacore – in each of the ocean areas covered by the four regional fisheries management organizations (RFMOs) responsible for tuna fisheries, and presents a brief summary of the conservation and management measures taken for each of these species¹.

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Throughout this document, a color code is used to denote the status of the 19 stocks of tuna and whether there are management programs in effect for those stocks for which management has been recommended by the scientific committees of the corresponding RFMO. Red denotes an overfished stock for which there is no management scheme in effect; orange denotes a stock that is currently below the level at which it can support the MSY, management measures have been recommended, and such measures are in effect, yellow denotes a stock that is at the MSY level; and green denotes a stock that is above the MSY level.

1. THE EASTERN PACIFIC OCEAN

1.1. Yellowfin

Yellowfin tuna, which are distributed widely throughout the EPO, are considered to be a separate stock from yellowfin caught in the central-western Pacific. Catches during the last several years have averaged about 330 thousand tons, varying between about 440 thousand in 2002 and 182

¹ This report is based on data available on 15 April 2009

thousand in 2007. On the average (2005-2007) purse-seine vessels take almost 92 percent of the catch, longliners about 8 percent, and a variety of other gears the rest. In recent years about 60 percent of the yellowfin purse-seine catch has been taken in association with dolphins, 25 percent in unassociated sets, and the remaining with floating objects; however, there has been a recent shift from sets on tunas in association with dolphins to unassociated sets. Depending upon the type of fishing, the average size of yellowfin taken in the catch varies considerably, the largest being from the longline fishery (average weight 40 kg) and the smallest associated with floating objects (average weight 3.5 kg); yellowfin taken in association with dolphins average 22 kg and those from unassociated sets average 6 kg. In recent years catches of yellowfin, the proportion of yellowfin taken in association with dolphins, and the average weight of fish in the overall catch, have been declining.

1.1.1. Most recent stock assessment

Stock assessments for yellowfin tuna of the EPO are conducted annually by the scientific staff of the IATTC. Before the assessments are finalized and the results presented to the Commission Plenary, they are reviewed by a Working Group of international experts who are provided the opportunity to critique the analysis and provide suggestions for improvement and modification.

The following review of the status of the yellowfin stock in the EPO in 2007 is based on the assessment presented by the IATTC staff² at the 9th Stock Assessment Review Meeting in May 2008, which included data through the first quarter of 2008.

An age-structured, catch-at-length analysis, using a population model A-SCALA, was used for the assessment. It was assumed for the analysis that there is a single stock of yellowfin in the EPO. The assessment utilizes data from all gear types on catches, both retained and discarded, fishing effort, the size composition of those catches as well as assumptions about biological processes such as growth, natural and fishing mortality, recruitment, and the movement of fish throughout the area of the fishery. A-SCALA uses quarterly intervals to describe the dynamics of the yellowfin stock and provides information on a variety of quantities such as fishing mortality (the removal of fish from a stock due to fishing), recruitment (young of the year entering a fishery for the first time) and biomass (the total weight of all yellowfin >1.5 years old), that coupled with other information can be used to estimate values such as the MSY (the maximum long-term yield that can be achieved under average conditions, using the current age-specific selectivity pattern of all the fisheries combined) and the spawning biomass (the relative total egg production of all the fish in the population), which can be used to make management recommendations for the fishery.

This most recent assessment, as in previous ones, suggests that there has been a regime shift that has affected the productivity of the yellowfin population. Recruitment to the fishery was consistently greater after 1983 than before, and unusually high recruitment was estimated for 1998 through 2000. The analysis suggests that recruitment during 2002-2005 was more similar to the lower pre-1983 levels. The 2006-2008 estimates of recruitment, although yet uncertain, suggest recruitment more similar to the intermediate levels observed during 1980-1990. Trends in biomass conformed reasonably well to the trends in recruitment. Biomass hit its lowest level of 240 thousand tons during the low recruitment period of 1975-1983; after 1983 it began to increase and from 1986-1999 stayed relatively constant at about 500 thousand tons, peaking at about 850 thousand tons in 2001 as a result of the very high recruitment during 1998-2000. After 2001

² <http://www.iattc.org/PDFFiles2/SAR9-YFT-ENG.pdf>

biomass began to decline, hitting a relative low of 295 thousand tons in 2006, after which it increased, reaching nearly 400 thousand tons at the beginning of 2008.

The ratio of the spawning biomass at any particular time to the spawning biomass when the population is at the MSY level (spawning biomass ratio-SBR) has been used in some non-tuna fisheries as an indicator of the health of the stock. For these non-tuna fisheries, populations were able to produce the MSY when the SBR was in the range of 0.3-0.5, and a lower “safety valve” was considered to be 0.2. However, for tunas no such estimates are available, but by examining past trends in the SBR for yellowfin, certain judgments can be made regarding lower limits for the SBR. The SBR was at its lowest prior to 1986, remained high from 1987 through 2001, declined during 2006/2007, and then increased in 2008. As the lowest average SBR approached 0.2 during 1979/1980, and the stock subsequently showed marked increases in biomass, the IATTC scientific staff considers it prudent that the 0.2 might be used as a lower “safety valve.”

Using the average fishing mortality for 2005-2007, the MSY is estimated to be about 282 thousand tons and biomass at MSY to be about 400 thousand tons. Trends in biomass indicate that it was well below the MSY level from 1975 through 1985. After the regime shift, biomass generally remained above the MSY level reaching an all time peak of more than 800,000 tons in 2001-2002, but declined to a low of about 250,000 tons in 2006; it showed increases in 2007 and at the beginning of 2008, but the estimates are still uncertain. At the beginning of 2008, the biomass appears to have been above the level corresponding to MSY. Catches during 2005-2008 have been substantially below the MSY level, and if fishing mortality, which is currently below the MSY level, remains at current levels, biomass should continue to increase above the level required to produce the MSY. However, if there is a shift to pre-1983 conditions when average recruitment was much lower, stock productivity would be expected to decline, and a reassessment would show a more negative outlook.

Under current conditions fishing mortality would have to be increased by about 6 percent to reach the MSY level. Because the curve relating average yield to fishing mortality is very flat around the MSY level, changes in fishing effort will result in only minor changes in catch, but will result in greater changes in biomass. A number of reference levels have been used to describe the status of the stock: current catch/MSY is 0.68, current biomass/biomass at MSY is 0.96, the spawning biomass ratio at the beginning of 2008 was 0.36, which is greater than the SBR at MSY of 0.34, and current fishing mortality is less than fishing mortality at MSY. The estimates of stock size and fishing mortality relative to the MSY reference points are shown in Figure B-1. In the figure each of the dots represents an average exploitation rate over 3 years, the large red dot represents the current estimate, and the squares represent approximate 95 percent confidence intervals. These aforementioned analysis, which are the most probable with respect to representing the condition of the stock, provide an optimistic view of the status of the yellowfin in the EPO, suggesting that **the stock is not in an overfished state, nor is overfishing occurring**; these conditions are reflected in the phase plot shown in Figure B-1, which shows most of the years to be in the green zone, including the most recent, and a high degree of confidence that the stock is not being overfished, and a moderate degree of confidence that it is not in an overfished state. However, if a stock recruitment relationship is assumed, the outlook becomes a little more pessimistic, suggesting that current biomass may be slightly below the level corresponding to MSY.

Even though the IATTC analyses shows fishing mortality to be less than that required to take the MSY, and SBR to be greater than that at MSY, from a precautionary point of view, and because

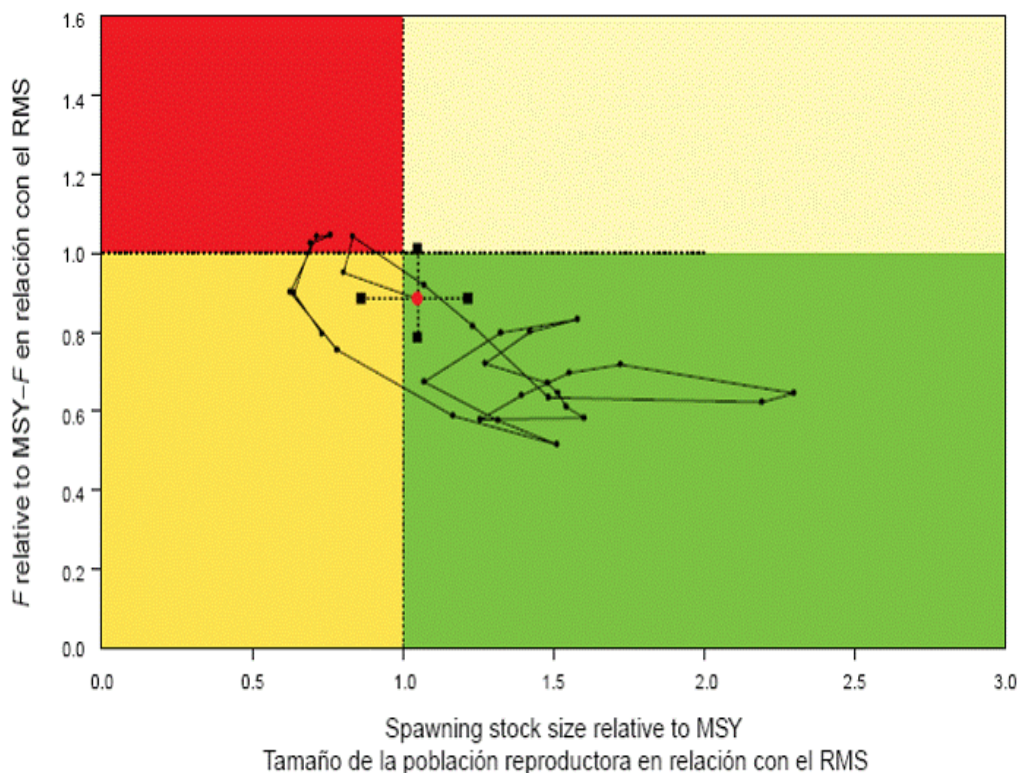


FIGURE B-1. Phase plot for stock size and fishing mortality for yellowfin tuna in the EPO relative to the reference levels (IATTC 2008).

analyses assuming a stock-recruitment relationship gives a more pessimistic view, and most likely increases in effort would not result in sustained increases in catch, but would cause the biomass to decline over current levels, the stock is classified as yellow.

1.1.2. Next scheduled stock assessment

The next yellowfin assessment will be presented by the IATTC staff to the working group of international experts in May 2009.

1.1.3. Conservation and management of yellowfin

The stock of yellowfin tuna in the EPO was first placed under management or conservation controls, in 1966, when catch quotas were set on the harvest of yellowfin tuna. In 2002 fishery the Commission moved away from setting catch quotas and established a closed fishing season. Although the closure was implemented primarily to halt overfishing and to rebuild the overfished stock of bigeye, it also served to control effort on yellowfin so as to prevent overfishing of that stock. All purse-seine fishing was prohibited in the EPO between December 1, 2002 and December 31, 2002. For 2003 this program was expanded to include a closure to purse-seine fishing for the entire EPO from August 1-September 11, and a closure for a smaller area off Central America from December 1 to 31.

The Commission approved setting a 6-week closed season to purse-seine fishing throughout the EPO for the years 2004-2007. After 4 Plenary meetings of the Commission, the member states could not agree to a conservation program for 2008, and have not agreed to one so far for 2009. During 2008, most of the nations with fleets fishing in the EPO took unilateral measures to im-

plement a closed season to purse-seine fishing. The period of closure and how it was implemented and monitored varied among countries.

The IATTC staff conducted an analysis to estimate what the impact of no restrictions might be on the stock. The population was projected forward 5 years using current levels of fishing mortality. The result of no restrictions on fishing were that SBR would decline to levels slightly lower than they currently are, to about the level corresponding to MSY.

1.2. Bigeye

Bigeye are very similar to yellowfin in appearance, and the two species are often confused; however they live longer and grow more slowly than yellowfin. In the EPO annual catches have fluctuated between 60 and 147 thousand tons over the last 30 years. Previous to 1993 nearly all of the bigeye taken from the EPO was by longline. In the early 1990s fish-aggregating devices (FADs) were used to capture bigeye; the fish caught with FADs are generally small, averaging about 8 kg, whereas the average for the longline fishery is about 55 to 60 kg. In recent years the purse-seine catch has varied between 35 and 95 thousand tons. Since the advent of purse seining for bigeye the longline catch of this species has declined from a high of about 100 thousand tons in 1991 to about 40 thousand tons in recent years. Overall the catch of bigeye from the EPO has declined from a high in 2000 of 143 thousand tons to 94 thousand tons in 2007, a 34 percent decline (Figure B-2). Although most purse-seine vessels fishing with FADs in the EPO may capture some bigeye tuna during their operations, the majority of the bigeye taken by purse seiners is landed by a small number of vessels flying mostly Ecuadorian and Panamanian flags.

1.2.1. Most recent stock assessment

The following review of the status of the bigeye stock in the EPO in 2007 is based on the as-

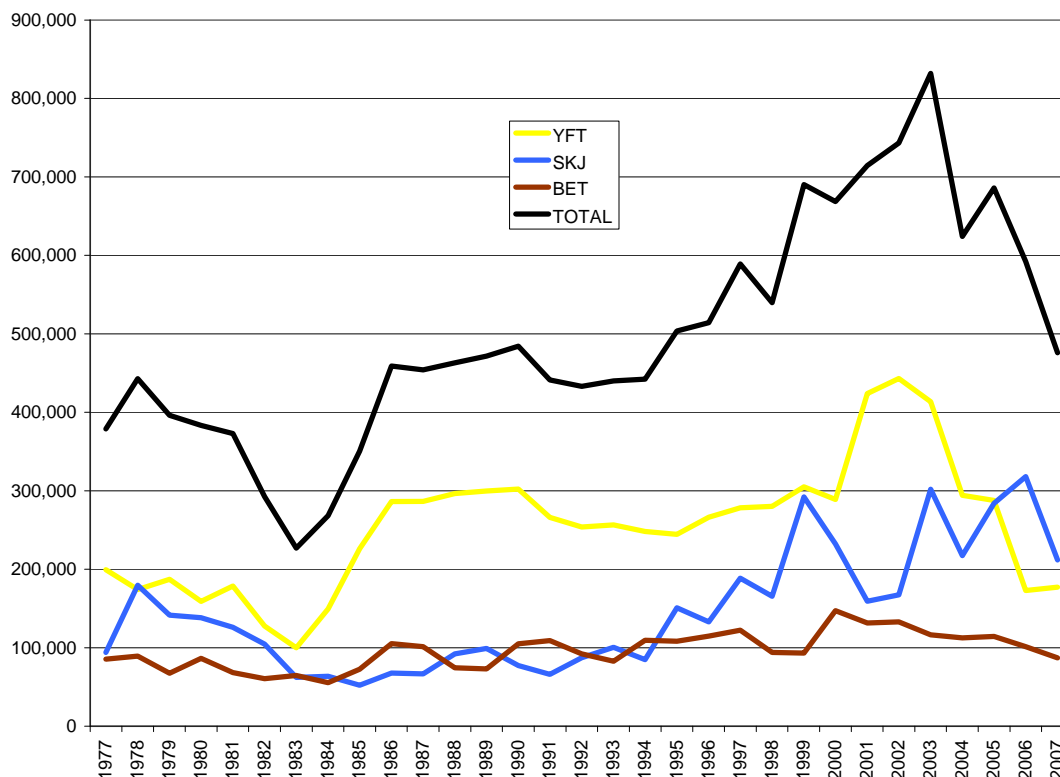


FIGURE B-2. Catches of tuna in the eastern Pacific Ocean, 1977-2007.

assessment presented by the IATTC staff³ at the 9th Stock Assessment Review Meeting in May 2008, which included data through the first quarter of 2008.

The sharp increases in the surface catch of bigeye after 1993, coupled with the decreasing catches in the longline fishery, caused concern among the member governments of the Commission. Responding to this concern the IATTC scientific staff accelerated research on bigeye. Tagging data indicate that bigeye do not often move great distances, so the fishery of the EPO is treated as an independent stock from that of the western Pacific. Based on growth and longevity data, the natural mortality rate of bigeye is believed to be less than that of skipjack and yellowfin.

For the current assessment of bigeye, the IATTC staff used the Stock Synthesis II (SS2) model rather than A-SCALA, which was used for the yellowfin assessment. The SS2 model differs somewhat from the A-SCALA, particularly in how the catch is modeled, but the general concept of fitting to many differing sorts of data is the same. A variety of data such as catch and effort, discards, indices of abundance, and size composition are used in the model to estimate recruitment, catchability, selectivity, initial population size, and age structure. Other parameters that are assumed to be known for the assessment are sex- and age-specific natural mortality, discards by age, selectivity curves for discards, mean length at age, and the steepness of the stock recruitment relationship.

The calculations of MSY and future projections under varying fishing conditions were based on estimates of average harvest rates for 2005 and 2007. Uncertainty in the output of the model stems from the fact that the observed data do not perfectly represent the population of bigeye and the model does not perfectly represent the dynamics of the population.

Results of the analysis showing trends in fishing mortality reflect greatly increased rates of mortality on small fish since the advent of FAD fishing in 1993, but only slight increases for older fish since that date.

Estimates of recruitment show a great deal of variation over the period studied; however, estimates prior to 1993 are not very reliable because few small fish were captured. The analysis shows a period of above-average recruitment in 1995-1998, which coincided with the expansion of the fisheries that take bigeye associated with FADs. This period of above-average recruitment was followed by a period of below-average recruitment in 1999-2000. Since 2001, recruitment has been above average, and was particularly high in 2005 and 2006. There is no apparent relationship between the size of the spawning stock and the strength of recruitment of young fish into the fishery.

Trends in biomass of age 3+-quarter-old bigeye show increasing abundance beginning in 1983 and a peak at about 625 thousand tons in 1986. After 1986, biomass began to decrease and reached an historic low of about 274 thousand tons at the beginning of 2005. Trends in spawning biomass follow the trends in biomass, but lagged by about 2 years. The estimate of both 3+-quarter-old fish and spawners has been increasing in recent years. In terms of sensitivity, the estimates are only affected slightly by the steepness of the stock-recruitment relationship. In the analysis the impact of the different fisheries on the depletion of the stock was simulated. The results of this analysis show clearly “that the longline fishery had the greatest impact on the stock prior to 1995, but with the decrease in effort from the longline fisheries, and expansion of the floating-object fishery, at present the impact of the purse-seine fishery is far greater than that of

³ <http://www.iattc.org/PDFFiles2/SAR9-BET-ENG.pdf>

the longline fishery on the population. The discarding of small bigeye has a small, but detectable, impact on the depletion of the stock. Overall the spawning biomass is estimated to be about 17 percent of that expected had no fishing occurred.

To determine the status of the bigeye stock the IATTC scientists use information based on the spawning biomass and the MSY. As mentioned in the preceding section on yellowfin, for some non-tuna fisheries it has been suggested that populations are able to support MSY when their SBR is about 0.3-0.5, and some are not able to produce MSY if the level is less than 0.2. Because there is no relationship between spawning biomass and recruitment, over the range of observations from the fishery, it is not possible to determine what the minimum spawning stock size should be to ensure adequate recruitment to support MSY. However, for bigeye, the SBR ($SBR = S_{\text{current}}/S_{F=0}$) can be compared to an estimate of SBR corresponding to the MSY ($SBR_{\text{MSY}} = S_{\text{MSY}}/S_{F=0}$), which is estimated to be about 0.19. Trends in SBR show that it was well above the 0.22 level until about 1993 when the purse-seine fishery on FADs developed; SBR began to decline at that time, and since 2003 has been below 0.22. At the beginning of 2008, the spawning biomass of bigeye in the EPO was near the historical low, the SBR being about 0.17, or about 9 percent lower than the MSY level.

The Convention establishing the IATTC mandates as an objective of conservation, sustaining the bigeye stock in the EPO at a level which can support the MSY. For these purposes the MSY, as done for yellowfin, can be defined as the maximum long-term yield that can be achieved under average conditions using the current age-specific patterns of fishing mortality for all the fisheries combined. Accordingly, by altering the age specific fishing mortality, the MSY can be changed. In the case of bigeye, moving the age-specific mortality to larger fish would result in a higher MSY, and visa-versa. For example, prior to the expansion of the FAD fishery in 1993, the MSY was greater than the current MSY and fishing mortality was less than that corresponding to MSY. On the one hand, for example, if bigeye fishing was restricted to only purse-seine vessels, the MSY would be about 30 percent less than it is currently estimated to be. On the other hand, if only longline gear was allowed for catching bigeye, the MSY would be 89 percent greater than that estimated for all gears combined. The MSY estimate of 81,350 tons was made from the base case assessment using all gear types and fishing mortality patterns averaged over 2005 and 2007. Recent catches have been about 8 percent greater than the MSY. Also, under current conditions the MSY could be taken with about 82 percent of the average annual fishing effort exerted during 2005-2007. This means that $F > F_{\text{MSY}}$, so **overfishing of the bigeye stock in the EPO is currently taking place**. Similarly, catches in recent years have been about 8 percent greater than MSY and the spawning biomass is currently about 10 percent less than the spawning biomass at MSY ($S < S_{\text{MSY}}$), which means that **the stock of bigeye in the EPO is in an overfished state**. These results are summarized in Figure B-3, which shows the current status of the fishery compared to reference levels for fishing mortality and stock size. The large dot represents the conditions in 2008, which show $F_{\text{current}} > F_{\text{MSY}}$ and $B_{\text{current}} < B_{\text{MSY}}$.

The IATTC scientific staff has undertaken analyses to estimate the impact of the lack of controls on bigeye fishing in the EPO. Under a scenario in which harvest rates would remain the same as they had during 2005-2007, and the closed periods remain in effect, the SBR is predicted to increase to a level slightly above that of MSY during 2009-2010 and then to decline to that below the MSY level. Purse seine catches are predicted to decline over this period, and longline catches to start declining in 2009. However, without controls, overfishing of the stock would continue and the SBR would drop to below 0.08 (SBR at MSY is equal to 0.2) by about 2012.

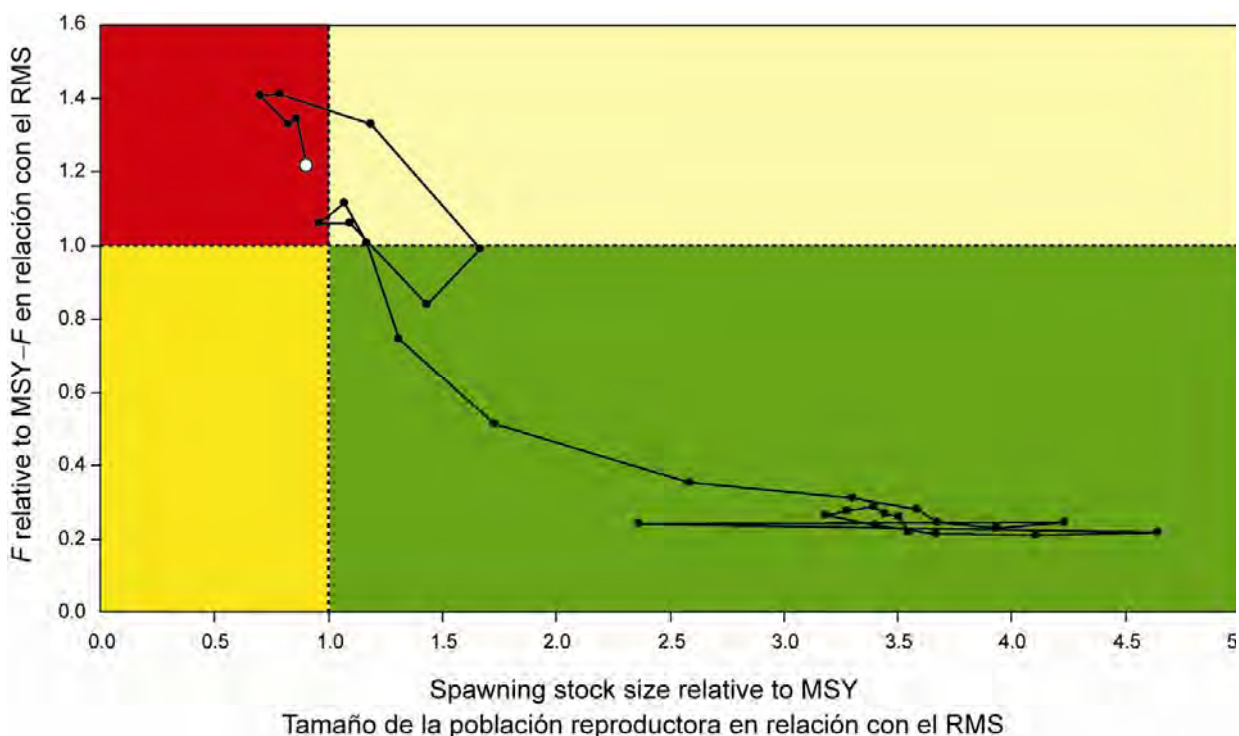


FIGURE B-3. A phase plot for stock size and fishing mortality for bigeye tuna in the EPO relative to the reference levels (IATTC 2008).

1.2.2. Next scheduled stock assessment

The next bigeye assessment will be presented by the IATTC staff to the working group of international experts in May 2009.

1.2.3. Conservation and management of bigeye

Prior to 1993 most bigeye in the EPO were taken by longline vessels, and the tuna captured were large and near the size at which they could support high yields. When the purse-seine FAD fishery began, large numbers of very small bigeye were captured. Because small bigeye were not previously available for study there was much uncertainty about how they grew, reproduced, and died. Nevertheless there was a great deal of concern expressed by the governments over what the impact of these large catches of small bigeye might be having on the abundance of the bigeye stock. Because of this concern, and notwithstanding this uncertainty, and citing their “commitment to the application of the precautionary approach, which establishes that lack of scientific evidence should not be used as a reason for not taking management measures for fisheries resources,” member governments of the IATTC recommended measures to control the catch of bigeye in the surface fishery of the EPO during 1998. Because almost all surface-caught bigeye is taken in association with floating objects, the first conservation measures for bigeye stipulated that when the surface catch in 1998 reached 45 thousand tons, all fishing on floating objects within the EPO would be prohibited. In 1998 the surface bigeye catch reached only 35 thousand tons, so the prohibition was not implemented. For 1999 the Commission recommended the same measures for controlling the surface catch of bigeye, except that it reduced the trigger for prohibiting floating-object sets from 45 thousand to 40 thousand tons. The surface catch of bigeye reached 40 thousand tons on November 8, 1999 and the purse-seine fishery was prohibited from setting on floating objects for the rest of the year. This represented the first time that conserva-

tion measures had been placed on bigeye in the EPO. The 1999 measures for controlling the catch of bigeye were applied again in 2000 and the purse-seine fishery was prohibited from setting on floating objects in the EPO after 15 September. Because of the mounting concern over the increasing catches of small bigeye, for 2001 the Commission agreed to close the fishery to floating object fishing if and when the catch of bigeye smaller than 60 cm equaled the catch of similar size fish in the 1999 fishery. Since the fishery in 2001 did not exceed the limit the fishery was not closed.

As was explained above under the discussion on yellowfin, for the 2002 fishery, the Commission moved away from setting catch quotas and established a closed fishing season. All purse-seine fishing was prohibited in the EPO between December 1, 2002 and December 31, 2002, thereby reducing the fishing mortality on bigeye as well as yellowfin. For 2003 this program was expanded to include a closure to purse-seine fishing for the entire EPO from August 1-September 11, and a closure for a smaller area off Central America from December 1 to 31.

The Commission approved a resolution setting throughout the EPO a closed season to purse-seine fishing for the years 2004, 2005, 2006 and 2007. The closure was for 6 weeks each year and a nation could choose to restrict their purse-seine vessels during one of two periods: August 1 to September 11 or 20 November to 31 December. Several attempts to implement management measures for 2008 and beyond have failed and there has been no closure to fishing for tunas in the EPO since the end of 2007.

In addition to the conservation and management measures taken for the purse-seine fishery, measures to control the harvest of bigeye by longline vessels fishing in the EPO were also implemented. The first such measures were taken in 2004 and required each member and cooperating party to take the measures necessary to ensure that its total annual longline catch of bigeye in the EPO did not exceed that taken in 2001. For 2005-2007 the following catch limits for longline vessels were set: China 2,639 tons, Japan 34,076 tons, Korea 12,576 tons and Chinese Taipei 7,953 tons; additionally, catches of longline fleets of other states were not to exceed 500 tons each. There have been no restrictions implemented for longline vessels since the end of 2007.

1.3. Skipjack

Skipjack tuna are distributed throughout most of the tropical and temperate oceans of the world. They are relatively short lived and do not grow to a large size, the average size in the world catch is probably close to 3 kg. Skipjack have a relatively high natural mortality rate and their recruitment can be highly variable; they have a high population turn-over rate and are very abundant wherever they occur with the exception of the Mediterranean Sea. Of the more than 4 million tons of tuna taken annually, skipjack accounts for about 60 percent of the total. In the Pacific, skipjack catches have averaged about 1.9 million tons over the last couple of years, with about 11 percent coming from the EPO.

Over the last two decades skipjack catches in the EPO have varied between 72 and 318 thousand tons per year. Purse-seine vessels account for about 99 percent of the total catch. Prior to the advent of FAD fishing in the early 1990s skipjack catches averaged less than 100 thousand tons per year, but after vessels began fishing with FADs the average annual catch was more than 200 thousand tons. Much of this increase was due to the use of FADs, the catches on which increased by a factor of 4 between the early 1980s and the most recent five years in the fishery, while during this same period unassociated catches increased by a factor of only 2.5. The pri-

mary utilization of skipjack is for canning, followed by the manufacture of *katsuobushi*, although the market in Japan for skipjack *sashimi* is growing rapidly.

1.3.1. Most recent stock assessment

The most recent full assessment of skipjack in the EPO was conducted by the staff of the IATTC in 2002. For the analysis the A-SCALA model was used along with data on catches, size-composition and fishing effort. The model is fitted to the observed catch, effort and size-composition data by finding a set of population dynamics and fishing parameters that maximizes the probability of having observed the catch and size data, given the amount of fishing effort generated by the fishery. In this current analysis two different applications of the model were used, which differed in the assumed forms of selectivity by size. One form of selectivity was assumed to be domed shape, which allows the existence of a population of large skipjack that are invulnerable to the fishery. The other form of selectivity utilizes an asymptotic curve, which ensures that large skipjack are fully vulnerable to the fishery, and if no large skipjack are caught the model will estimate that skipjack do not survive to be large. Because the asymptotic model should provide higher estimates of exploitation and lower estimates of biomass, the analysis will provide boundaries for the exploitation of skipjack in the EPO. For there analysis the IATTC scientists presented the results for the asymptotic model and then compared these to the dome-shaped model.

Estimates of trends in fishing mortality show that it increased from 1975 to 1981 and then decreased until 1985. Since 1985 it has generally increased, particularly since the advent of FAD fishing in the early 90s. The decrease in fishing mortality in 1981-1985 was mostly due to the fact that the demand for skipjack by canners in the Americas was low, so that vessels did not target this species during that time. Fishing mortality is estimated to be less than natural mortality and rather moderate in comparison to yellowfin and bigeye.

The recruitment of skipjack into the fishery has been estimated to be highly variable and the numbers of recruits entering the fishery do not appear to be related to the size of the spawning stock. Recruitment during 1983, 1994-1995, 1998-1999 and 2002 was high. The very high recruitment in the latter period contributed to increased biomass and a record high catch in 2003. Between 2003 and 2006 recruitment has been relatively high, about 30-40 percent greater than the long term average. The variability in biomass is shown by the analysis to be the result mostly of changes in recruitment.

In the analysis, the status of the skipjack stock is assessed by considering calculations based on the spawning biomass, yield per recruit, and MSY. SBRs were calculated for the period 1975-2003 and the trends show that they reached their lowest level during 1977-1983, about 0.15; since 1984 it has fluctuated between about 0.25 and 1.5. During the most recent years examined in the analysis it was about 0.7, which suggests that the spawning stock of skipjack is quite healthy. The analysis also indicate that the critical age (the age at which each recruit entering the fishery should be caught in order to maximize the catch from a cohort of recruits) for skipjack is less than the age at recruitment to the fishery. Therefore to maximize yield per recruit an infinite fishing mortality would need to be exerted by the fishery. Since the current assessment assumes no relationship between the size of the spawning stock and the resulting recruits, the relative yield curve would be equal to the relative yield-per-recruit curve; therefore MSY would be achieved by an infinite amount of fishing mortality. Because this cannot be realistically achieved no estimates of MSY are made for the skipjack stock in the EPO.

Because of the high and variable productivity of skipjack it is difficult to detect the effect of fishing on the population. Additionally growth and age-specific fishing mortality is poorly estimated and it is not known whether catch per day fished for purse seiners is proportional to abundance. For these reasons it is exceedingly difficult to assess skipjack tuna. The analysts caution that their results for skipjack are uncertain. The results of the modeling indicate that skipjack in the EPO is not fully exploited and can sustain current levels of exploitation, and probably catches can be increased on a sustainable basis. Nevertheless the results from the current assessment are more consistent among the various sensitivity analyses compared to earlier assessments, suggesting that they may be more reliable than the previous ones.

In May of 2007, and again in 2008, the IATTC staff presented additional analyses using an alternative approach to the A-SCALA modeling. Because the stock assessments and reference points for skipjack in the EPO are so uncertain, alternative methods to assess and manage skipjack that are robust to these uncertainties were examined. These methods, rather than using reference points based on MSY, compare current values of indicators to trends in historical indicators. Several indicators such as catch, average weight, and catch per effort were compared to the relative exploitable biomass and relative exploitation rates using reference levels based on certain chosen levels of variability about the mean values. The biomass, recruitment, and exploitation rate have been increasing over the past 20 years, while the average size of skipjack in the catch has been decreasing since 2000. These results support the conclusions from the A-SCALA analysis and suggest that there was no reason for management concern for skipjack tuna in the EPO in 2003; **overfishing of the skipjack stock was not occurring nor was the stock in an overfished state.** The analysts noted that the declining average weight of fish in the catch, which could be a sign of heavy exploitation or of greater levels of recruitment, and the increasing exploitation rate, are causes of concern and emphasized the need to closely monitor the fishery.

1.3.2. Next scheduled stock assessment

There is no schedule for the next skipjack stock assessment.

1.3.3. Conservation and management

In the paragraphs above it was noted that skipjack tuna in the EPO were not fully exploited and that increased fishing effort would on the average most likely result in sustain increases in catch. Because the abundance of skipjack in the EPO varies greatly from year to year due to natural changes in abundance and/or catchability, catches show similar variability. Though there is no need for limiting fishing mortality on skipjack, there was nevertheless, a reduction in fishing mortality as a result of the controls established for yellowfin and bigeye. The closures which were implemented in 2004-2007 for those two species were also closures for skipjack, since purse seine vessels are prohibited from fishing in the EPO during the closure. The impact of

Species	$B_{\text{current}} < B_{\text{MSY}}$	$B_{\text{current}} \approx B_{\text{MSY}}$	$B_{\text{current}} > B_{\text{MSY}}$
Yellowfin		$B_c > B_{\text{MSY}}, F_c > F_{\text{MSY}}$	
Bigeye	$B_c < B_{\text{MSY}}, F_c > F_{\text{MSY}}$		
Skipjack			$B_c > B_{\text{MSY}}, F_c < F_{\text{MSY}}$

TABLE B-1. Status of yellowfin, bigeye and skipjack in the EPO. $B_c = B_{\text{current}}$ is the current biomass, $F_c = F_{\text{current}}$ the current fishing mortality rate, and F_{MSY} and B_{MSY} are the corresponding values for levels when the population is at a level corresponding to the MSY.

these closures is a reduction in fishing mortality applied to skipjack and a corresponding de-

crease in catch. The foregone benefits from the loss of potential skipjack catch should be mitigated somewhat by the benefits the closures provide to the stocks of yellowfin and bigeye.

The status of yellowfin, bigeye, and skipjack in the EPO is summarized in Table B-1.

2. WESTERN AND CENTRAL PACIFIC OCEAN

2.1. Yellowfin

Yellowfin tuna, which are distributed widely throughout the WCPO, are considered to be a separate stock from yellowfin caught in the EPO. The catch of yellowfin peaked in 1998 at 468 thousand tons and has remained relatively stable since then; in 2007 the catch was about 432 thousand tons (Figure B-4). Purse-seine vessels took 56 percent of this catch, longliners about 17 percent, pole-and-line vessels about 4 percent, and a variety of other gears the rest. The catch by longliners has declined from a high of about 120 thousand tons in the early 1980s to about 75 thousand tons in recent years, while that of purse-seine vessels has increased greatly since the mid-1980s. Also, the catch by Southeast Asian countries, particularly Indonesia and the Philippines has increased substantially and in recent years they have accounted for about 30 percent of the yellowfin catch from the WCPO (as mentioned elsewhere in this report there is a significant lack of confidence in the data on catches of Indonesia and the Philippines, so this percentage figure may be in error, and is probably underestimated). Depending upon the type of fishing, the average size of yellowfin taken in the catch varies considerably. The longline fishery captures the largest fish, which range in size between 15-85 kg and average about 45 kg. The Indonesian and Philippines domestic fisheries capture the smallest fish, which range from 0.17-2.4 kg and average about 1.4 kg. Purse seiners capture yellowfin over the size range of 3-70 kg. Average size of yellowfin in the fishery has been declining in recent years. The greatest portion of yel-

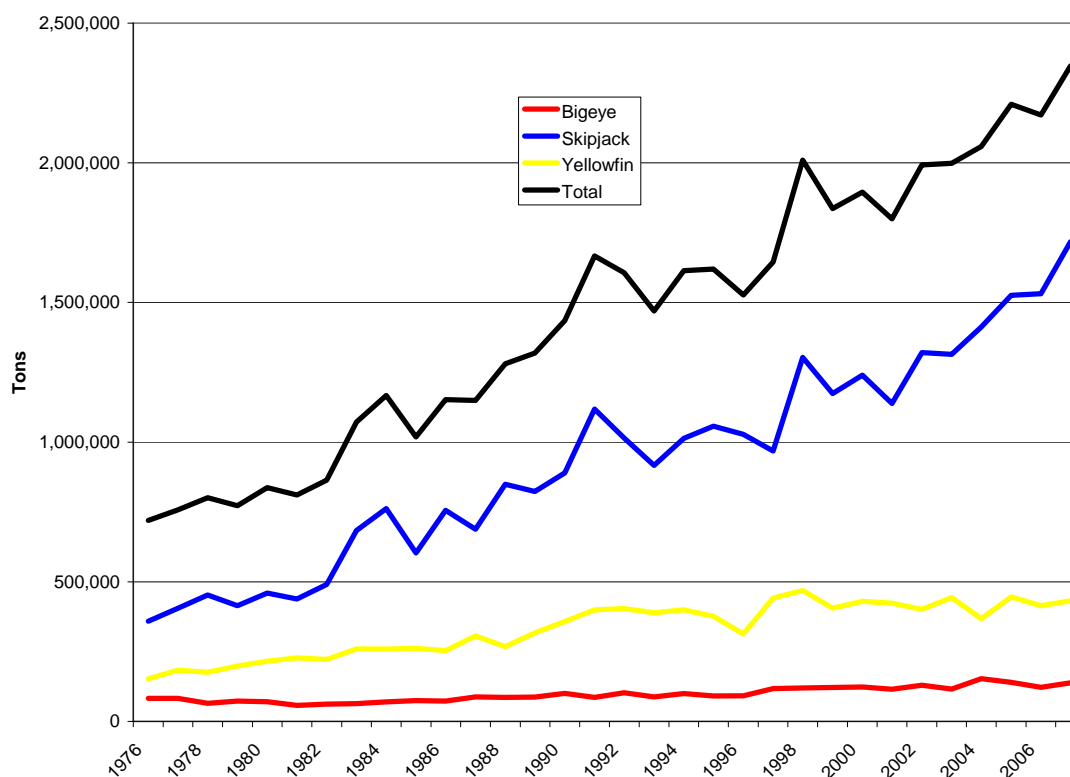


FIGURE B-4. Catches of tuna from the WCPO, 1976-2007

lowfin taken by the purse-seine fishery is taken in unassociated schools.

2.1.1. Most recent stock assessment

The key stock assessment analyses for yellowfin tuna in the WCPO are conducted by the scientific staff of the Ocean Fisheries (OFP) of the Secretariat of the Pacific Community (SPC). The most recent analysis was completed in 2007 and was reviewed by scientists participating in the 3rd Scientific Committee meeting of the WCPFC, held in Honolulu, Hawaii during August 2007.

An age-structured statistical model, MULTIFAN-CL, was used for the analysis. The model utilized catch statistical and size data for 1952-2006. The fishery was partitioned spatially into 6 regions with 24 defined fisheries and the catch was partitioned into 28 age classes. Because longline vessels have a much longer history operating in the fishery of the WCPO a time series of catch per effort measures were used as a weighting mechanism in the model. Most of the longline indices showed a strong downward trend since the early days of the fishery, and the estimates from the model may have been strongly driven by these indices.

Estimates of recruitment show a great deal of variability over the period studied, being high during the early period of the fishery, 1950-1960, then general stability until the last couple of years, during which time it has been increasing slightly. Over the range of stock size examined there appears to be no relationship with recruitment. However, there does seem to be a relationship between recruitment and oceanographic variables. A General Linear Model relating recruitment to 10 oceanographic variables accounts for 68 percent of the observed variation in recruitment. This is encouraging from the point of view of predicting recruitment.

Estimates of biomass derived from the model show relatively high levels in the early fishery, then declining in the early 1970s, a slight increase in the mid-1970s, stability through the 1980s, steadily declining until about 2005 when it began to increase. It is estimated that the impact of fishing has decreased the current level of biomass to about one-half of the biomass of an unfished population, that is, fishing mortality has caused the biomass to decline by about one-half over what it was before a fishery was initiated on the stock of yellowfin in the WCPO.

Estimates of fishing mortality show an increasing trend since the late 1980s, with recent sharp increases, particularly for juvenile fish, which is attributable to the Indonesian and Philippine domestic fisheries, as well as the purse-seine fishery. Examining the impact of the various gear types on the biomass of the stock, it was shown that the greatest impact was caused by the Indonesian and Philippine fisheries with the purse-seine fishery having the next greatest impact. The longline fishery only account for about 10 percent of the decline in abundance.

To evaluate the status of the stock the scientists examine a number of reference points related to levels of biomass and fishing mortality relative to certain reference levels. The use of reference points provides a framework for quantitatively determining the status of the stock and its exploitation level. Two types of reference points are commonly used: the fishing mortality at MSY is used as an indicator of the presence of overfishing and the biomass at MSY is used to identify an overfished state. Some of these reference points are interpreted as ratios of current biomass to biomass at MSY levels, current fishing mortality to fishing mortality at MSY, and current spawning biomass to spawning biomass at MSY. Comparing these ratios for the 2006 analysis with the current analysis shows them to be quite similar. Figure B-5 depicts the trends in the ratios of fishing mortality and biomass and shows the yellowfin stock to be above the MSY level of biomass and the fishing mortality to be less than the MSY level. For the 2007 analysis: 1) Current biomass/biomass at MSY=1.17 and current spawning biomass/spawning biomass at

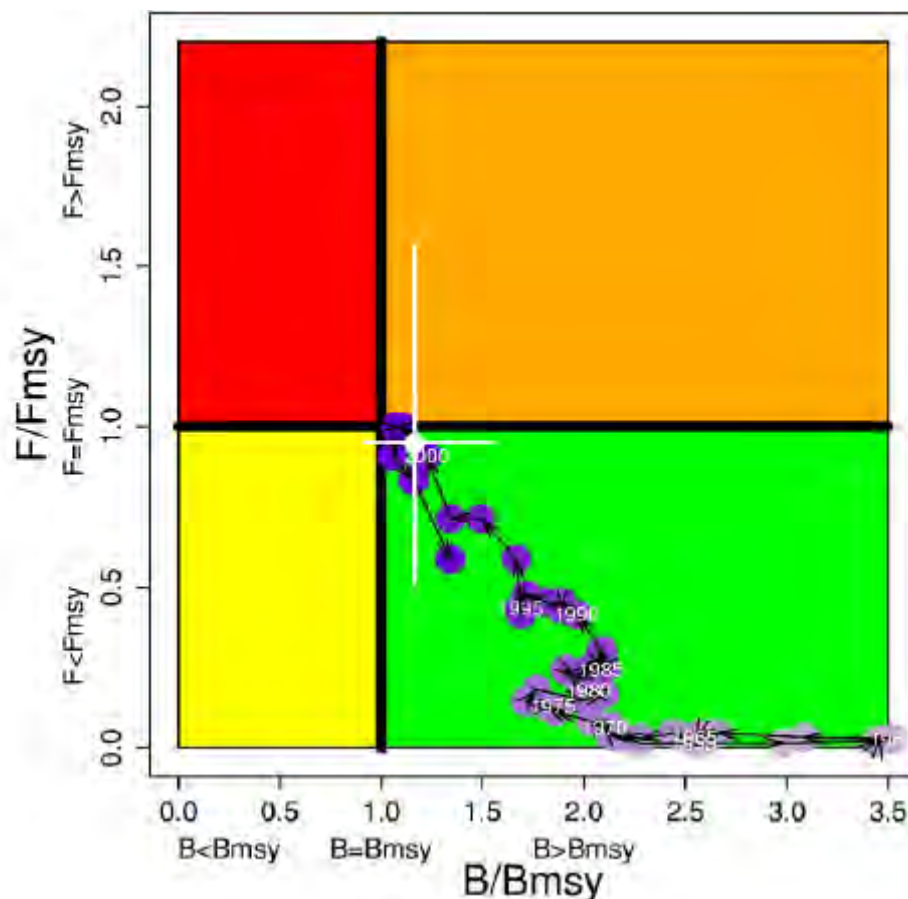


FIGURE B-5. Trend in annual stock status for yellowfin in the WCPO, 1952-2006 relative to biomass (B) and fishing mortality (F); the white bars represent the 95% confidence interval about the most recent point (WCPFC, 2007).

MSY=1.12, indicating that the population of **yellowfin is not in an overfished state**, and 2) current fishing mortality/fishing mortality at MSY=0.95, indicating the **overfishing is not occurring**. Because there is a 47 percent probability that overfishing could be occurring, it was concluded that any increase in fishing effort would not result in a sustained increase in catch. It was also concluded that the current catch from the fishery is approximately equal to the most recent estimate of MSY, which is 400 thousand tons, and that a small increase in the average size of fish in the catch would result in a large increase in total yield. Because there is a 47 percent probability that overfishing could be occurring, and because the current biomass is so close to the MSY level, the Scientific Committee at the 2006 meeting recommended that fishing mortality for yellowfin tuna be reduced by about 10 percent over 2001-2004 levels.

2.1.2. Next scheduled stock assessment

The next scheduled yellowfin assessment will be in August of 2009.

2.1.3. Conservation and management of yellowfin

The WCPFC utilizes two mechanisms for addressing the issue of conservation and management measures: 1) resolutions describing non-binding statements and recommendations addressed to members and cooperating non-members; and 2) conservation and management measures (CMM) describing binding decisions relating to conservation and management measures.

In order to monitor the number of vessels fishing in the convention waters of the WCPFC, CMM 2004-01 requires each Commission member, cooperating non-member and participating territory (CCM) to submit to the Executive Director, by 1 July 2005, particular information, including vessel specifications and call letters and signs, with respect to each vessel listed in its national record of fishing vessels entitled to fly its flag and authorized to fish in the Convention Area beyond its area of national jurisdiction. From 1 July 2005, each CCM is required to notify the Executive Director within 15 days, or in any case within 72 hours before commencement of fishing activities in the Convention Area of: 1) any vessel added to its Record along with vessels specifications; 2) any change in the vessel specification information with respect to any vessel on its Record; and 3) any vessel deleted from its Record along with the reason for such deletion.

Resolution 07/01 sets up a regional observer program (ROP), and there will be national and sub-regional programs coordinated by Secretariat. The Secretariat will achieve 5% coverage by 2012 for its own program (in addition to coverage by members) (this is changed by CMM 08-01 to 20% in 2009 and 100% in 2010, see below).

At the second session of the Commission, held in December 2005, CMM 2005-01 on the Conservation and Management Measures for Bigeye and Yellowfin Tuna in the Western and Central Pacific Ocean was approved, and in December 2008 was replaced by CMM 2008-01. The objective of CMM 08-01 is to ensure that bigeye and yellowfin tuna stocks are maintained at levels capable of producing their maximum sustainable yield and to achieve through the implementation of a package of measures, over a three-year period commencing in 2009, a minimum of 30% reduction in bigeye tuna fishing mortality from the annual average during the period 2001-2004 or 2004; ensure that there is no increase in fishing mortality for yellowfin tuna beyond the annual average during the period 2001-2004 average or 2004. For the purse-seine fishery the provisions of the CMM apply to the Convention Area bounded by 20°N and 20°S. CCM are called on to ensure that the effectiveness of these measures for the purse-seine fishery are not undermined by a transfer of effort in days fished into areas within the Convention Area north and south of 20°S. For the members of the FFA who are Parties to the Nauru Agreement (PNA), the measure are to be implemented through their domestic processes and legislation, including the Vessel Day Scheme (VDS) which limits total days fished in the EEZs of PNA members to no greater than 2004 levels.

Additionally the purse seine fishery in EEZs in the area bounded by 20°N and 20°S will be closed to fishing on FADs between 0000 hours on 1 August and 2400 hours on 30 September, during which time all purse seine vessels without an observer from the regional observer program on board are required to cease fishing and return to port. Similar measures are called for on the high seas.

As an alternative to the high seas FAD closure Members are allowed to adopt measures to reduce their catch by weight of bigeye tuna in the purse seine fishery by a minimum of 10 percent relative to 2001-2004 average levels.

CMM 08-01 calls on the Commission to consider in 2009 the development of a high seas vessel day scheme (HS VDS) to be compatible with the PNA VDS to provide a common currency for managing purse seine, with adoption at its annual session in 2010; and efforts be made to ensure that reductions in fishing effort on the high seas and in adjacent EEZs are compatible. The high seas pocket termed the “doughnut hole” (the portion of the high seas beyond the EEZs of the surrounding nations but within the area bounded by 10°N and 10°S, 135°E and 179°E) will be closed effective from 1 January 2010 unless the Commission decides otherwise at its 6th annual

meeting in December 2009. At this meeting the Commission will also consider the closure of all high seas pockets in the Convention Area between 20°N and 20°S.

CMM 08-01 also calls on CCMs fishing on the high seas to submit by July 1, 2009 management plans for the use of FADs by their vessels on the high seas. These plans are to include strategies to limit the capture of small bigeye and yellowfin tuna associated with fishing on FADs. The Commission Secretariat will prepare a report on additional FAD management options for consideration by the Scientific Committee, the Technical and Compliance Committee and the Commission in 2009 including:

- a. Marking and identification of FADs;
- b. Electronic monitoring of FADs
- c. Registration and reporting of position information from FAD-associated buoys; and
- d. Limits to the number of FADs deployed or number of FAD sets made.

The CMM also calls on the Commission to work with industry and other countries to develop and implement a 3 year program to explore methods to reduce catches of juvenile bigeye and yellowfin tuna caught in association with FADs.

To create a disincentive to the capture of small fish and to encourage the development of technologies and fishing strategies designed to avoid the capture of small bigeye and yellowfin tuna, CCMs shall require their purse seine vessels fishing in EEZs and on the high seas to retain on board and then land or transship at port all bigeye, skipjack and yellowfin tuna, excepting when in the final set of a trip, there is insufficient well space to accommodate all fish, the fish are unfit for human consumption for reasons other than size; or when serious malfunction of equipment occurs.

Purse-seine vessels fishing within the area bounded by 20°N and 20°S on the high seas and in the EEZ of one or more coastal States are required, effective 1 January 2010, to carry an observer from the Commission's Regional Observer Program, and during 2009 observer coverage for such vessels should be 20 percent.

Developing purse-seine fisheries for skipjack between 20°N and 20°S that can provide verifiable evidence of minimal yellowfin and bigeye bycatch (cumulative <2%), with 100% observer coverage, and with a legitimate development plan, are exempted from such measures as listed above.

The total catch of bigeye tuna by longline fishing gear is subject to a phased reduction such that by 1 January 2012 the longline catch of bigeye tuna is 70% of the average annual catch in 2001-2004 or 2004, and the catch of yellowfin tuna is not to be increased from the 2001-2004 levels.

This longline measure does not apply to members and participating territories that caught less than 2,000 tons in 2004. Each member or cooperating non-Member that caught an average of more than 2,000 tons of bigeye shall be subject to a 10% reduction of the catch in 2009, a 20% reduction of the catch in 2010, and in 2011 a 30% reduction of the catch. Small island developing State members and participating territories in the Convention Area undertaking responsible development of their domestic fisheries are exempt from these limits as are some fleets landing exclusively fresh fish.

The catch limit for China for 2009 and 2010 will remain at 2004 levels pending agreement being reached to develop an arrangement for the attribution of Chinese catch taken as part of domestic fisheries in the EEZs of Pacific island countries.

With respect to monitoring and control a number of provisions are included in the CMM:

- More timely and detailed provision of data by CCMs.
- The Executive Director is mandated to present a report on measuring and monitoring fishing capacity in the Western and Central Pacific Ocean for consideration at the Fifth Regular Session of the Technical and Compliance Committee.
- Each CCM shall prohibit landings, transshipment and commercial transactions in tuna and tuna products that are positively identified as originating from fishing activities that contravene any element of the Commission's CMMs, and routine monitoring is to be conducted at landing and transshipment ports to assess catch by species.

With respect to Vessel Monitoring Systems (VMS), the WCPFC will require on April 1, 2009, all vessels >24 meters in length, fishing on the high seas in the Convention area in waters south of 20°N, and east of 175°E in the Convention area north of 20°N to have an activated automatic location communicator (ALC) and participate in a Commission VMS program. The Commission's Pacific VMS program will reside on the same shoreside platform at the MacQuarie Data Center in Sydney, Australia, as does the FFA VMS program, but both will be independently operated and their data secure. By utilizing existing FFA infrastructure and software WCPFC will save significantly in infrastructure set-up costs. As with the other commissions a set of minimum standards for ALCs has been defined, and all ALCs must be tamper-proof and operating at all times. Whereas for most other RFMOs the flag state is responsible for the VMS systems and sending data to the commissions, for the WCPFC VMS, the MacQuarie Data Center sends reports on the activities of the vessels directly to the Commission. The program is essentially one of the Commission and not the member states. The Executive Director of WCPFC has indicated there could be about 600 vessels that will be required to report to its VMS, and that the Commission will be paying for transmission costs. Depending on the Communication Service Provider selected (Argos, Iridium, Inmarsat, *etc.*) costs are estimated to be around US\$14.50/month, based on 4 hourly reporting, in addition to USD \$15/month charge for the FFA service. In total costs will be about \$30/month/vessel. Costs for the other Commissions should be similar if they able to tie into an already existing system. There will be a great deal of cooperation between the FFA and WCPFC programs. Vessels currently reporting their in-zone operations to FFA will be able to continue such reporting and their data for the high-seas operations will be transferred to the WCPFC data base. Any coastal state may elect to nominate its EEZ for inclusion in the WCPFC's program.

2.2. Bigeye

Bigeye tuna are distributed throughout much of the Pacific Ocean. Tagging data show some movement of bigeye between the EPO and WCPO but the numbers are not great. Genetic studies have shown no heterogeneity among bigeye across the Pacific. Therefore, there is no strong evidence of independent stocks in the two areas, but because mixing rates suggested by the limited tag movements are very low, the stocks are considered to be independent of each other for management purposes.

In the WCPO bigeye grow fairly rapidly, reaching a maximum length of about 200 cm. Natural mortality is somewhat lower than that of yellowfin and as would be expected bigeye have greater longevity than yellowfin. Many bigeye live more than 8 years, and one tagged individual lived 14 years.

During the last decade catches of bigeye in the WCPO have averaged about 120 thousand tons

per year and varied between about 100 and 160 thousand tons per year. The 2007 catch of bigeye from the WCPO was 140 thousand tons. Historically, nearly all commercially caught bigeye were taken from the WCPO by distant water longline vessels, with catches varying between 50 and 60 thousand tons per year between 1980 and 2000. The longline catch peaked at 100 thousand tons in 2004, but have been declining since. Since the mid-1980s surface gear, particularly purse-seine vessels fishing on floating objects, has taken a significant share of the catch; between 1990 and 2000, purse-seine catches have varied between 20 and 38 thousand tons, most of which are juveniles; since 2000 catches have declined, averaging about 25 thousand tons. There is considerable uncertainty about the purse-seine catch of bigeye, which may be significantly underestimated, as well as catches of small bigeye from Indonesia and the Philippines which may amount to about 30 thousand tons or more. The majority of bigeye is taken in tropical waters, but significant amounts are captured by longline fleets fishing in sub-tropical areas, particularly near Japan and the Hawaiian Islands. Catches by small vessels in the domestic Indonesian and Philippine fisheries have been increasing in recent years and many of these fish are very small.

In recent years the landed value of the longline catch of bigeye from the WCPO was in excess of USD1,000 million per year, while the similar figure for the surface catch was closure to USD25 million.

2.2.1. Most recent stock assessment

The most recent assessment of the bigeye stock in the WCPO was presented at the fourth meeting of the Scientific Committee of the WCPFC held in Port Moresby, PNG during August 2008. The geographic coordinates of the area considered in the assessment are: 40°N–35°S, 120°E–150°W. As was the case with the yellowfin analysis, MULTIFAN-CL was used for the bigeye assessment. For the analysis, catch, effort and size data for 1952–2007 were partitioned into 40 age-classes, 6 regions and 25 fisheries defined on the basis of region, gear type, and set type. Recapture data from 8,622 tags were used in the analysis. To test the sensitivity of the estimates, three configurations of the models in which sample size (low and high) and spatial stratification (6 and 7 regions) differed were used. The 6 region model was considered the base-case analysis, and most of the conclusions were based on it.

The current estimate of MSY for the bigeye fishery is about 65 thousand tons, with a fishing effort that is about 70 percent of the current average. This estimate of 65 thousand tons is about 35 percent less than was estimated for the fishery when the longline fleet was the dominate element in the fishery.

Trends in recruitment, which is the appearance of age-1 fish in the population, showed it declining early in the fishery, continuing at a low level from 1975 to about 1992, then increasing to 2005.

Estimates of biomass show a sharp decline from 1952 through the 1960s, but relatively stable since 1970; the stability seems to have been sustained by above average recruitment. It appears that current recruitment, although poorly estimated, may be returning to the long-term average, and if it remains at that level biomass would decline rapidly. As was the case with yellowfin biomass, trends are heavily affected by the longline relative apparent abundance indices used for weighting. The ratio of current total biomass to total biomass at MSY has been increasing, which in 2006 was 1.27 and in 2007 was 1.37, and is currently 37 percent greater than the total biomass at MSY. These high estimates of total biomass are sustained by high levels of recruit-

ment. The biomass of adult bigeye are estimated to be in excess of the adult biomass at MSY by about 20 percent in 2006 and 19 percent in 2007.

Fishing mortality was shown to have increased steadily since the beginning of the fishery in 1952, and since the advent of the purse-seine fishery, the mortality of juvenile fish has increased. Currently fishing mortality on adult and juvenile bigeye is relatively comparable. The ratio of current fishing mortality to fishing mortality at MSY is estimated to be 1.32 for 2006 and 1.44 for 2007, indicating that fishing mortality is continuing to show an increasing trend.

The accuracy of the estimates of F , B and MSY are influenced by changing age specific fishing mortality resulting from decreased catches in the longline fishery, as well as being sensitive to possible changes in M and the steepness of the spawner-recruit relationship.

The longline fishery apparently has the greatest impact on depletion of the stock, followed by the Philippine and Indonesian domestic fisheries, then the tropical purse-seine fishery. As mentioned, above average recruitment since the early 1990s appears to have sustained the relatively stable biomass. If recruitment was to return to average levels there would be a rapid decline in biomass. The current level of biomass is about 28 percent of the unexploited level. Because the current level of biomass is greater than the equilibrium biomass at MSY (there is a 100 percent probability for the base case that the ratio is $>1,00$) it is considered that **the bigeye stock in the WCPO is not in an overfished state**. Because of increasing fishing effort, biomass has been declining in recent years; therefore the probability that the stock will become overfished is increasing.

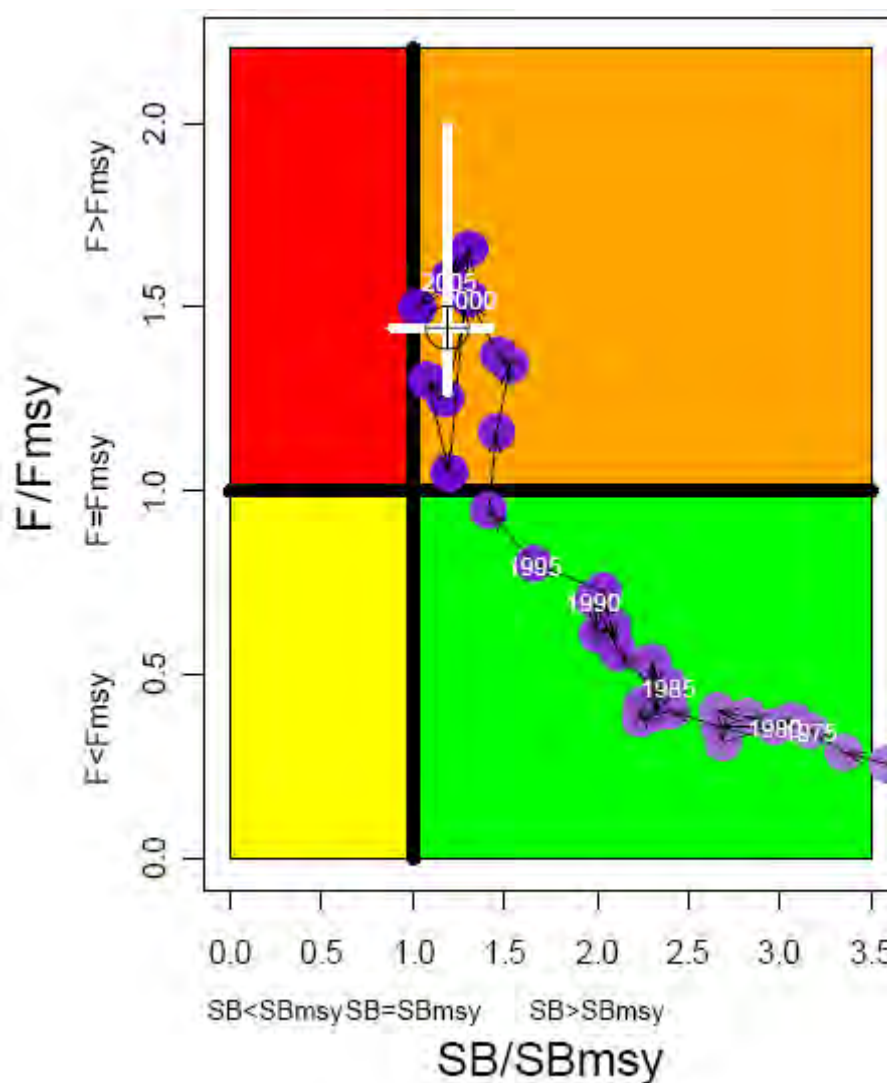


FIGURE B-6. Trend in ratios of spawning stock biomass and fishing mortality for bigeye tuna in WCPO. White bars represent confidence intervals about the 2006 point (WCPFC 2008).

Because there is a near 100 percent probability that the ratio of current fishing mortality over fishing mortality at MSY is >1.0 , it is considered that **overfishing of bigeye is occurring in the WCPO**. The trends in the biomass and fishing mortality ratios are shown in Figure B-6. While the biomass of bigeye isn't currently less than the biomass at MSY, if recruitment returns to average levels and fishing mortality is generated at 2003-2006 levels, there is a high probability that the biomass will decline below the MSY level.

2.2.2. Next scheduled stock assessment

The next scheduled stock assessment of bigeye in the WCPO will be in 2009 and will be presented at the 5th meeting of the Scientific Committee, which will probably be held in August of that year.

2.2.3. Conservation and management of bigeye

The discussions on conservation and management presented in the section on yellowfin apply to bigeye. Scientists estimated that a reduction of 31 percent in fishing mortality would be needed to maintain the biomass at the MSY level (F/F_{MSY} ratio of 1.0) and, and suggested that if F stays the same as current levels the biomass would decline to below the MSY level by 2013.

2.3. Skipjack

The purse-seine fishery for skipjack extends throughout much of the WCPO, but probably more than 80 percent of the catch is taken in equatorial waters between 20°N and 20°S, with most of the remainder being taken near Japan.

Of the total catch of 1,727 thousand tons of skipjack taken during 2007 by all fleets and all gears, purse-seine vessels accounted for about 1,500 thousand tons (87 percent). While fishing for skipjack, purse-seine vessels make either unassociated sets, which are sets made on free-swimming schools of fish, or associated sets, which are made on schools of fish that are associated with drifting objects such as logs, floating and anchored fish-aggregating devices (FADs), and animals such as large sharks and whales. Many of the sets are made on mixed schools of skipjack, yellowfin, and bigeye.

Most skipjack taken in the purse seine fishery are between 1.5 kg and 5 kg. Associated sets take smaller skipjack on the average, than do unassociated sets. The smallest skipjack are taken in the domestic Philippines and Indonesian fisheries, the average fish weighing about 0.5 kg.

For management purposes the skipjack that support the WCPO fishery are considered to be independent of those to the east of 150°W.

2.3.1. Most recent stock assessment

The most recent stock assessment of skipjack tuna of the WCPO was conducted by scientists of the OFP-SPC in 2008 and presented at the 4th regular session of the Scientific Committee of the WCPOFC. Prior to the 2008 assessment assessments were conducted in 2000, 2001, 2002, 2003, and 2005. The current assessment was compared to the earlier assessments and conclusions were in many respects similar.

The current assessment used catch, effort, length-frequency and tagging data with the MULTI-FAN-CL model. The analysis covered the area of the Pacific bounded by 20°S and 45°N, to the west by the East Asian coast, and to the east by the 150° W meridian. The area was divided spatially into 6 units, 24 fisheries, and the analysis included data from the Indonesian and Philippine domestic fisheries. About 228 thousand tag releases, for which there were about 18 thousand

returns, were used in the analysis. The results from the model analysis were used to compare with reference points, which provide a framework for quantitatively determining the status of the stock and exploitation levels. The assessment was carried out for two areas: 1) the WCPO stratified into six regions and 2) two regions encompassing the equatorial WCPO. A large biomass was estimated for the four regions north of the equatorial area, although for two of them the catches are negligible. These high levels of biomass cause a great deal of uncertainty in estimates of yield and MSY-related reference values. The equatorial model provides a more robust assessment of the stock, and is considered the principal assessment. The scope of the key conclusions is therefore, limited to the equatorial region of the WCPO skipjack fishery, which are essentially unchanged from the last three assessments.

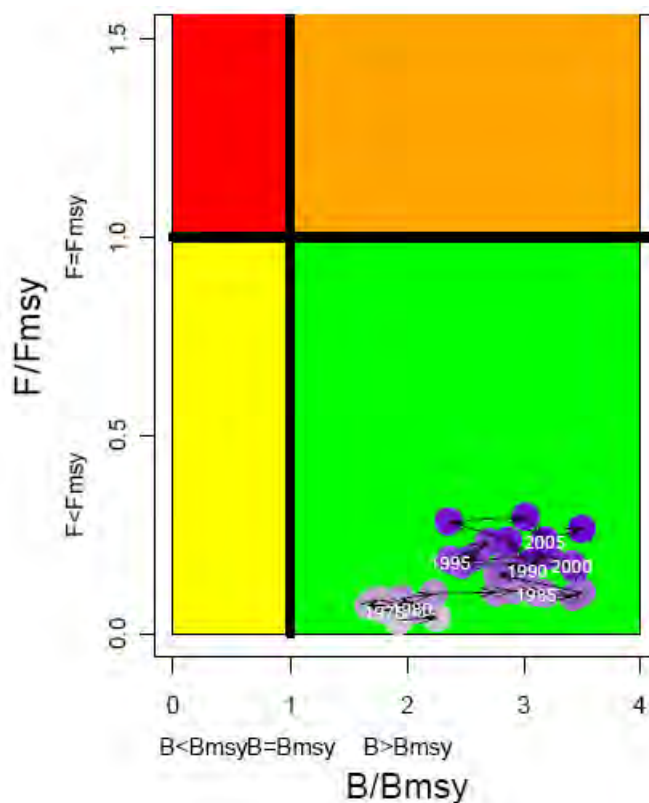


FIGURE B-7. Trend in annual stock status relative to biomass (B) and fishing mortality (F) for skipjack in the western Pacific during 1972-2006 (WCPFC 2008).

The natural mortality rate estimates for skipjack showed age specific differences with the highest rates near 2.5 for young fish, 2.0 for the older fish, and 1.2 for intermediate ages. Estimates of recruitment were highly variable, fluctuating over the study period by a factor of nearly 10. It showed a shift upward around 1985 and has remained relatively high since then, with current levels, although poorly estimated, at historic highs. During El Niño years recruitment tends to increase and the center of the population tends to move eastward with the edge of the Pacific Warm Pool. There appears to be no discernable relation between recruitment and the size of the parent stock.

The biomass of skipjack is recruitment driven, the impact of the fishery on the biomass being only about 15 percent. The equilibrium unexploited biomass was estimated to be about 10 million tons, the equilibrium biomass at MSY about 2.5 million tons for the base case and 1.4 million for the equatorial region, and the equilibrium biomass at the current level of fishing mortality about 5.8 million tons for the base case and 2.9 million for the equatorial region. The MSY that could be taken under average conditions was estimated to be about 2.3 million tons per year for the base case and 1.3 million for the equatorial region.

With respect to reference points, the ratio of the equilibrium biomass at the current levels of fishing to the equilibrium biomass at MSY was estimated to be about 3.3 for the base case and 3.0

for the equatorial region, which indicates that the stock of **skipjack in the WCPO is not in an overfished state**, in fact there is a zero probability that $B_{\text{current}}/B_{\text{MSY}}$ is anywhere near 1.0; the ratio of current fishing mortality to fishing mortality at MSY is less than 0.12 for the base case and 0.26 for the equatorial region, indicating that **overfishing of the stock of skipjack in the WCPO is not occurring** (Figure B-7).

It was concluded in the study that catch on the average would continue to change in proportion with the change in fishing effort for any range of effort that might be generated in the fishery over the foreseeable future.

2.3.2. Next scheduled stock assessment

The next stock assessment is scheduled to be completed in 2009 and to be presented at the 5th meeting of the Scientific Committee of the WCPFC.

2.3.3. Conservation and management of skipjack tuna

Species	$B_{\text{current}} < B_{\text{MSY}}$	$B_{\text{current}} \approx B_{\text{MSY}}$	$B_{\text{current}} > B_{\text{MSY}}$
Yellowfin		$B_c > B_{\text{MSY}}, F_c > F_{\text{MSY}}$	
Bigeye		$B_c > B_{\text{MSY}}, F_c > F_{\text{MSY}}$	
Skipjack			$B_c > B_{\text{MSY}}, F_c < F_{\text{MSY}}$

TABLE B-2. Status of yellowfin, bigeye and skipjack in the WCPO where $B_c = B_{\text{current}}$ the current biomass, and $F_c = F_{\text{current}}$ the current fishing mortality rate, and F_{MSY} and B_{MSY} are the corresponding values for levels when the population is at a level corresponding to the MSY.

Skipjack tuna in the WCPO are shown to be not fully exploited and increased fishing effort would on the average result in a proportional increase in catch. Though there is no need for limiting fishing mortality on skipjack, there would likely be a reduction in catch as a result of the limits on fishing effort called for in the CMM.

The status of yellowfin, bigeye, and skipjack in the WCPO is summarized in Table B-2.

2.4. Albacore in the Pacific

2.4.1.a North Pacific albacore

The distribution of albacore in the North Pacific is centered around 35° north latitude and extends from the Revillagigedo Islands, Mexico to the Gulf of Alaska in the east and from the Equator to 45° north in the western Pacific.

The northern stock may be divided into two or more sub-stocks, but the sub-stock units are not clearly defined. It is believed that albacore supporting the American coastal troll fishery are immature and that spawning of northern albacore occurs in tropical and subtropical waters mostly during the summer months (July- September). Both the northern and southern stock of albacore reaches first maturity between about 8 and 15 kg, or 3 to 6 years of age. The larvae of albacore are found widely dispersed over a significant portion of the western tropical and subtropical Pacific.

Catches of northern albacore have varied by a factor of 3+ over the years. During the mid-1970s catches averaged about 110 thousand tons and from 1977-1996 about 75 thousand tons (Figure B-8). In 1997 catches began to increase peaking at about 127 thousand tons in 1999, after which they declined to about 65 thousand tons in 2006, and then increased to about 86 thousand tons in

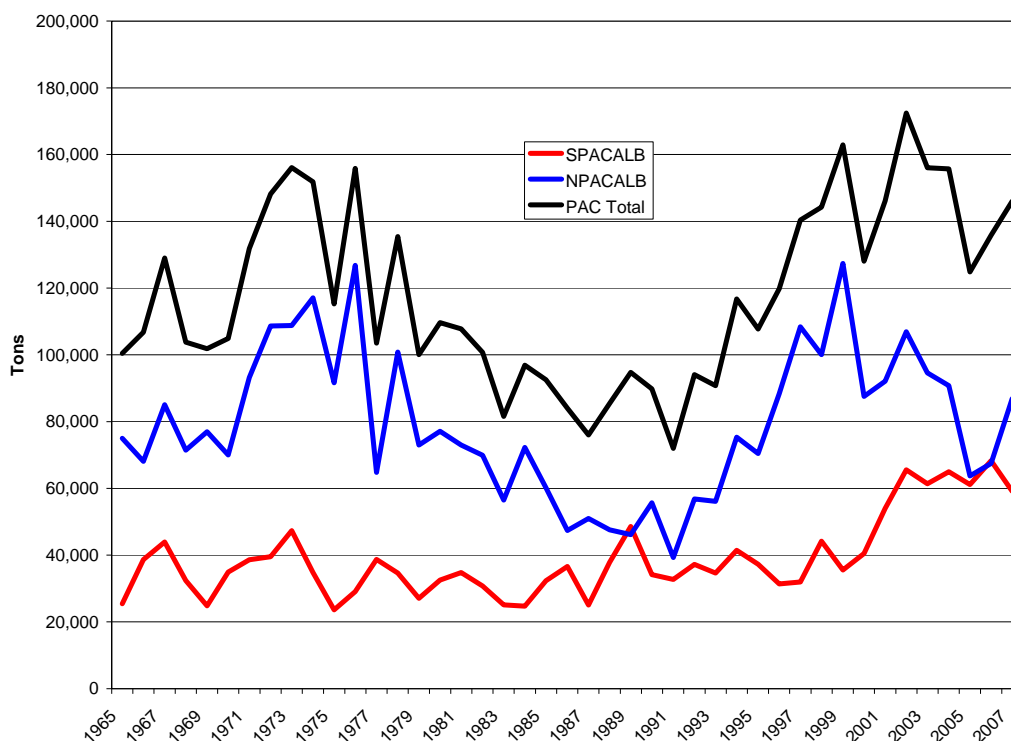


FIGURE B-8. Catches of north Pacific albacore (NPA), south Pacific albacore (SPA), and Pacific-wide albacore (Total), 1965-2006

2007. Over the last several years Japan has taken about 67 percent of the total north Pacific albacore catch, the U.S. about 16 percent, Chinese Taipei 8 percent, Canada 7 percent and several other countries the rest. About 38 percent of the catch is taken by pole and line, 22 percent by trolling; about 36 percent by longline, and the remainder by a variety of other gear types.

2.4.1.a(i) Most recent stock assessment

The most recent stock assessment was completed by the ISC Albacore Working Group Stock Assessment Workshop in December of 2006, and was reviewed by the WCPFC SC at their 3rd Session held in Hawaii during August 2007. Although stock assessments were completed using two different models, SS2 and Virtual Population Analysis (VPA), the group decided to use only the VPA results for assessing the stock status. The analysis requires catch-at-age matrices for all fisheries, length-weight relationships, estimates of natural mortality (M) and growth, and data on catch per effort to represent indices of apparent abundance for the period 1975-2003. Catch at age data from 1966-2005 was used to run the model, which was run 15 times using slightly different input data; one run was used for the final conclusions.

Trends in the fishable biomass ranged from 125 to 210 thousand tons during 1966-1994, averaging about 150 thousand tons, peaked in 1996 at 226 thousand tons, declined until 2003, and for the last two years showed increases to nearly 200 thousand tons. The current biomass is estimated to be about 7 percent higher than the 1966-2005 average. The 2004 assessment showed significantly lower estimates of biomass than the current one so there is some concern that the current analysis may be overestimating biomass.

As would be expected, the spawning stock biomass showed trends similar to the biomass trends. SSB increased from 1966 to the early 1980s to a high of about 120 thousand tons, declined to a

low of about 78 thousand tons in 1990, increasing to an all time high of about 60 thousand tons in 1994-1996, decreased for a couple of years, and then increased to its current level of about 153 thousand tons, which is about 53 percent above the overall average.

Estimates of recruitment of 1+ year aged fish to the exploitable population have varied by a factor of 5 over the years, from a low of 10 million recruits to a high of 50 million. The estimate of recruitment for the two most recent years is very close to the long-term average of 28 million individuals.

The working group used the model to make projections to 2020, using terminal year stock numbers and fishing mortality and average recruitment estimates for 2002-2004. The conclusions were that if the current level of fishing mortality and average recruitment are maintained for each year from 2007 until 2020, the biomass would decline by about 30 percent to 126 thousand tons and the SSB would decline by about 40 percent to about 92 thousand tons, which is about 20 percent greater than the lowest level seen in the fishery. The group conducted further analyses to determine what level of safeguards might be employed to ensure that the stock is not driven to dangerously low levels. They concluded that the stock was rapidly approaching full exploitation and that fishing mortality, or fishing effort on the stock should be reduce to some threshold precautionary level. Currently the biomass and the SSB are well above average levels, but the fishing mortality, if maintained at the current level of $F=0.75$, will cause the stock to decline significantly. In other words the stock is not fully exploited and is **not in an overfished state**, but **fishing mortality is high** and consideration should be given to reducing it.

Although no formal assessment was undertaken by ISC, at the March 2008 working group meeting preliminary analysis suggested that at current levels of fishing the SSB which in 2006 was at historic high levels, would return to the 1966-2005 long-term average, and by 2015 would dip below that long-term average. The working group recommended that from a precautionary point of view fishing effort in the north Pacific albacore fishery should be kept at current levels.

2.4.1.a(ii) Next scheduled stock assessment

The next schedules full assessment for north Pacific albacore will be conducted in 2010

2.4.1.a(iii) Conservation and management of North Pacific albacore

Based on the ISC report on the status of the albacore stock in the north Pacific, the Director of IATTC formulated recommendations designed to control fishing mortality on North Pacific albacore for consideration by member governments. The member governments of the IATTC, heeding the advice of its Director, approved a resolution in June of 2005 designed to limit the total level of fishing effort for North Pacific albacore in the EPO. The resolution specifically calls on IATTC Parties, cooperating non-Parties, and cooperating fishing entities (CPCs) to not allow their vessels fishing for albacore in the EPO to increase their total level of fishing effort beyond current levels. The resolution requires CPCs to report by gear type all catches of North Pacific albacore tuna taken in the EPO to the IATTC every six months. Also, the resolution calls on the Director to communicate with the WCPFC and request it to take similar measures.

In response to the request from the IATTC to take similar action for the conservation of North Pacific albacore, and based on advice from its Northern Committee, the WCPFC approved a resolution to require all CCM to take the necessary measures to ensure that the level of fishing effort by their vessels fishing for North Pacific albacore in the WCPF Convention Area is not increased beyond current levels. CCM are required to report every six months to the WCPFC the amount of North Pacific albacore taken by their vessels, and on an annual basis to report the

amount of albacore taken by weight and by each gear type. The first such report was due by April 30, 2006. The resolution calls on the Executive Director of WCPFC to communicate with the IATTC with a view to reaching agreement on a consistent set of conservation and management measures

2.4.1.b South Pacific albacore

In the South Pacific, albacore are widely distributed between the equator and 45°S, bounded in the west by Australia and in the east by South America. The highest concentrations are found in the western portion of their range. The juveniles are first available at about 2 kg to troll fisheries in the New Zealand coastal zone and a year later in the waters of the sub-tropical convergence zone STCZ near 40°S. Most spawning of southern albacore occurs in tropical and subtropical waters between about 10°S and 25°S in the Austral Summer. They reach first maturity at about 5 years of age and 11 kg. Results of tagging studies show that south Pacific albacore move extensively about the southern ocean, but with almost no returns from north of the equator. Albacore appear to slowly disperse north from New Zealand and STCZ, making seasonal migrations between tropical and sub-tropical waters. The movements tend to be related to the seasonal changes in the location of the 23-28°C sea-surface isotherms.

Japanese longline vessels first began fishing for southern albacore in 1953 after the lifting of the MacArthur Line. Catches increased rapidly and by 1965 had reached about 25 thousand tons. Between 1967 and 1985 catches were relatively stable and fluctuated around 30 thousand tons (Figure B-8). (During the late 1980s Chinese Taipei and Japanese drift net fisheries operating throughout much of the southern ocean harvested up to 22 thousand tons of southern albacore. Because of high bycatch a United Nations Resolution approved in 1989 put into effect a moratorium on pelagic drift net fishing on the high seas, which became effective in June 1992, so the fishery was curtailed.) After the exodus of the driftnet fishery, more longline vessels, particularly from Chinese Taipei, began to fish southern albacore and catches rose to about 45 thousand tons by 1998. With the addition of domestic Pacific Island longline fleets from American Samoa, Australia, Cook Islands Fiji, French Polynesia, New Caledonia, New Zealand, PNG, Samoa, Tonga and Vanuatu, catches continued to increase reaching nearly 70 thousand tons in 2006, and then declining to about 59 thousand tons in 2007.

The longline fishery can be partitioned into three main components: 1) the Pacific Island domestic longline fishery, which operates throughout the year and catches the largest albacore of any longline fishery, averaging near 22 kg, 2) the distant-water longline fishery operating in subequatorial waters during winter and spring months, catching fish averaging about 15 kg, and 3) the distant-water fishery in subtropical waters operating during late summer and autumn, catching fish averaging about 19 kg.

In recent years the longline fishery accounts for about 92 percent of the total catch of southern albacore (58 thousand tons), with Chinese Taipei taking about 12 thousand tons, Japan taking about 6 thousand tons, Korea 2 thousand and China about 4 thousand. The Pacific Island domestic longline fishery for albacore has taken an average catch of about 34 thousand tons during 2001-2006, with Fiji taking more than 25 percent of the catch; the troll fishery averages about 5 thousand tons per year, more than half being landed by New Zealand.

2.4.1.b(i) Most recent stock assessment

The most recent full stock assessment was completed in 2008 and presented to the 4th meeting of the SC in August of 2008. MULTIFAN-CL, a length-based, age-structured model, using catch,

effort, size, and tagging data from the fishery, was employed for the assessment. The fishery was stratified both spatially and temporally into 30 distinct fisheries in order to improve precision of the estimates. Data for 1952-2007 were used in the analysis, along with tagging data on nearly 10 thousand releases and about 140 returns. The area of the fishery examined was 10°S-25°S and 140°E-110°W.

Estimates of recruitment of 1+year old fish varied by a factor of nearly 5 over the years examined. It was estimated to be high during the 1960s and early 1970s, moderate thereafter until 2000, then declining until 2007. The estimated trends in recruitment are driven by the trends in catch rates for the major fisheries.

The annual trends in biomass are consistent with the trends in recruitment. Biomass was estimated to be low during the 1950s, increasing during the 1960s because of increased recruitment, moderate from 1970-2000, and then declined.

Overall, the rate of fishing mortality or exploitation was relatively low throughout the history of the fishery. During the early years fishing mortality rates were slightly higher than the later years, but subsequently declined due to increased recruitment and biomass. Recently they have increased for adult albacore due to higher catches, but are still relatively low as compared to many other tuna fisheries. The rates of fishing mortality for juvenile albacore peaked during the years of the driftnet fishery, declined thereafter, and have gradually increased with the development of the New Zealand troll fishery, although they are still at a relatively low rate.

Output from the model provides information to estimate the impact of the fishery on the biomass of the stock. The impact is measured as the difference in biomass when the stock is fished and when it is not fished. The estimates of impacts are consistent with the estimates of low fishing mortality. Adult biomass is estimated to have been reduced by about 15 percent as a result of fishing. The impact on juvenile fish is about 1 percent, essentially negligible. The impact on the component of the stock that is vulnerable to the domestic Pacific Island longline fishery is higher, and is currently about 30-40 percent. These increases are due to the increased effort by all of the longline fisheries and because they harvest only a small component of the stock, any increase in catch would cause a significant increase in the impact on the longline exploitable biomass; added to this is the impact of the lower recruitment over the last decade, which seems to be linked to oceanographic conditions (low recruitment during prolonged El Niño episodes and high recruitment during prolonged La Niña episodes).

The current analysis estimates a much lower MSY than the previous analyses, about 65 thousand compared to 180 thousand tons. For the analysis a number of reference points were examined which are useful for evaluating the impact of the fishery on the stock and its current status. Two useful reference points are the ratios of current fishing mortality to the level of fishing mortality at MSY, which for the base case is 0.44, and the ratio of current spawning biomass to the estimate of biomass at MSY, which for the base case is 2.21. Because fishing mortality is so much lower than the level that would be required to take the MSY, **the stock is not being overfished**, and because both the spawning biomass and total biomass are so much greater than it would be if the population was held at the level that could support the MSY, **the stock is not in an overfished state** (Figure B-9). The authors of this recent assessment caution that there is a great deal of uncertainty in all of the estimates that are derived from the model, particularly with respect to current estimates of F and the ratio of F/F_{MSY} , but nevertheless consider that for all credible analyses, current fishing mortality is below that required to take MSY, and current biomass is well above that at MSY.

In a subsequent study of the southern albacore stock and the impact of fishing on its status, it was concluded that while there are no biological concerns regarding the stock there are potential management issues relating to the economic viability of some of the Pacific Islands domestic longline fisheries. There was concern that any substantial increase in exploitation rates could reduce the level of biomass vulnerable to these fisheries, hence reducing catches of albacore to below economically sustainable levels for the Pacific island domestic longline fisheries. Catch rates in the domestic longline fisheries are subject to a great deal of variability, and for the longline fisheries in Fiji and French Polynesia this variability seems to be related to seasonal fluctuations in oceanographic conditions which were probably responsible for the low catch rates commencing in 2002. Additionally, these domestic fisheries, which are confined within the respective EEZ of each state, are subject to local depletion as a result of concentration of high fishing effort in localized areas. For example, it was surmised that the average catch rates in the Fiji longline fishery were reduced by about 20 percent as a result of local depletion. To ensure viable catch rates for the domestic longline fisheries the establishment of appropriate levels of target effort and catch will be necessary, and to do so will require consideration of the overall level of stock abundance, the impact of oceanographic changes on availability and vulnerability of the stock, and the extent of local depletion. It was concluded in these subsequent studies that the

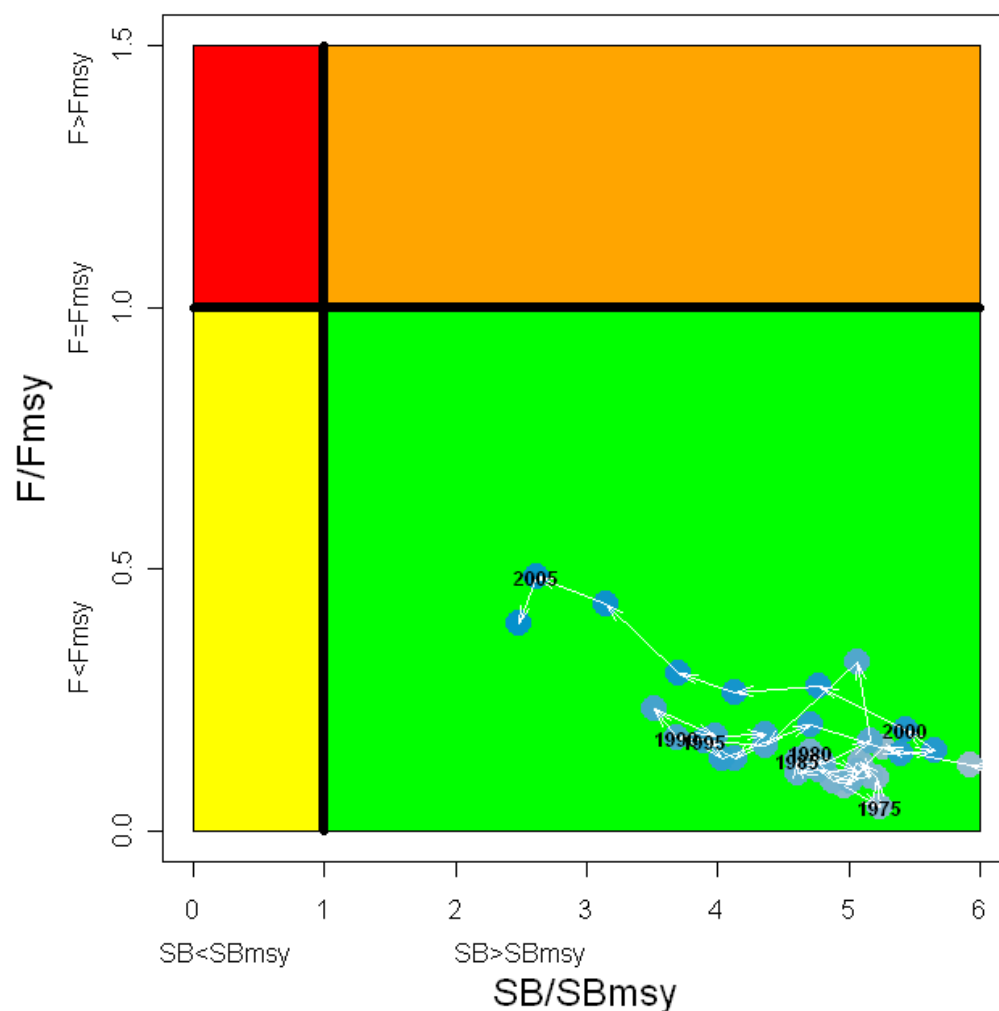


FIGURE B-9 Trend in annual 1960-2006 stock status relative to spawning stock biomass (SB) and fishing mortality (F) for south Pacific albacore (WCPFC 2008).

biological reference points used to assess the status of the stock should be modified to include an economic component that would protect the domestic Pacific Island longline fisheries from future decreases in biomass and consequent sustainable catches.

2.4.1.b(ii) Next scheduled stock assessment

The next full assessment for southern albacore is scheduled to be presented at the 5th Scientific Committee meeting to be held in August 2008.

2.4.1.b(iii) Conservation and management of South Pacific albacore

During the 2nd session of the WCPFC, held in 2005, a resolution for implementing management measures for the fishery for south Pacific albacore was approved. The resolution took note of the fact that the assessment indicated the albacore stock was in a substantially healthy condition, but because of uncertainty in the estimates derived from the stock assessments, and because increasing fishing effort might result in decreasing catch rates for little increase in catch, the economic consequences of any increases should be carefully assessed before such increases are encouraged or implemented. The resolution goes on to say that CCM shall not increase the number of their vessels above 2005 or 2000-2004 levels that are fishing for albacore in the Convention Area south of 20°S. Under certain criteria, small island developing states and territories and CCM in the Convention Area for whom albacore is an important component of the domestic tuna fishery in waters under their jurisdiction, and who wish to pursue a responsible level of development of

Species	$B_{\text{current}} < B_{\text{MSY}}$	$B_{\text{current}} \approx B_{\text{MSY}}$	$B_{\text{current}} > B_{\text{MSY}}$
N. Pacific albacore			$B_c > B_{\text{MSY}}, F_c < F_{\text{MSY}}$
S. Pacific albacore			$B_c > B_{\text{MSY}}, F_c < F_{\text{MSY}}$

TABLE B-3. Status of north and south Pacific albacore.

their albacore fisheries, would be allowed to do so without being subjected to the limits noted above.

The status of north and south Pacific albacore is summarized in Table B-3.

3. ATLANTIC OCEAN

3.1. Yellowfin

Atlantic yellowfin are distributed widely throughout tropical and subtropical waters. Surface fisheries for them occur in the eastern Atlantic between Portugal and South Africa, and in the western Atlantic between the Gulf of Mexico and southern Brazil; longline fisheries occur throughout the entire tropical and temperate Atlantic. The primary spawning ground for yellowfin is in the Gulf of Guinea, with lesser spawning activity in the Gulf of Mexico. Because tagging data show a number of trans-Atlantic migrations and longline data show a continuous distribution across the Atlantic, yellowfin throughout the Atlantic are considered to belong to a single stock for management purposes. As in other oceans, surface caught yellowfin are generally small and are found in mixed schools with skipjack and small bigeye; the larger yellowfin are taken mostly by longline fishing.

A variety of fishing gear is used to harvest yellowfin in the Atlantic, but purse-seine accounts for nearly 60 percent of the harvest, longline 19 percent, pole-and-line for 13 percent, and a variety of other gears for the remaining. The top five producers of yellowfin from the Atlantic are in descending order: France, Ghana, Spain, Panama, and the U.S.

Overall yellowfin catches in the Atlantic have declined by about 49 percent since the peak catch of 192 thousand tons in 1990, and since 2001 have declined by about 36 percent to about 97 thousand tons in 2007 (Figure B-10). Declines have been evident for pole-and-line, purse-seine, and longline vessels in both the eastern and western Atlantic. Concurrent with these declines in catch has been a decline in the number of purse-seine vessels from 44 in 2001 to 24 in 2006, and the imposition of restrictions on the amount of fishing the Ghana pole-and-line fleet is allowed to exert.

Since 1970 the overall average weight of yellowfin in the commercial catch has declined from about 20 kg to the current level of about 10 kg. Currently longline fleets catch yellowfin averaging 40 kg, purse-seine vessels about 7 kg, and pole-and-line fleets about 4 kg. The steep decline in average weight since the early 1990s is associated with the increase in fishing tuna associated with FADs.

3.1.1. Most recent stock assessment

The most recent full assessment of yellowfin tuna was in 2008 and utilized data through 2006. In that analyses the ASPIC version of a production model, and VPA and Yield/Recruit forms of age-structured models were used. For the production model mostly catch and effort data is used while age-structured models use information on the numbers and weights of fish caught by age-groups, natural mortality rates, starting or ending fishing mortality rates, and other biological parameters.

The production model analysis estimates MSY to be about 147 thousand tons and shows the 2006 fishing mortality to be 89 percent of what the equilibrium fishing mortality would be at MSY and the relative biomass to be 0.83, or the current biomass to be slightly less than that cor-

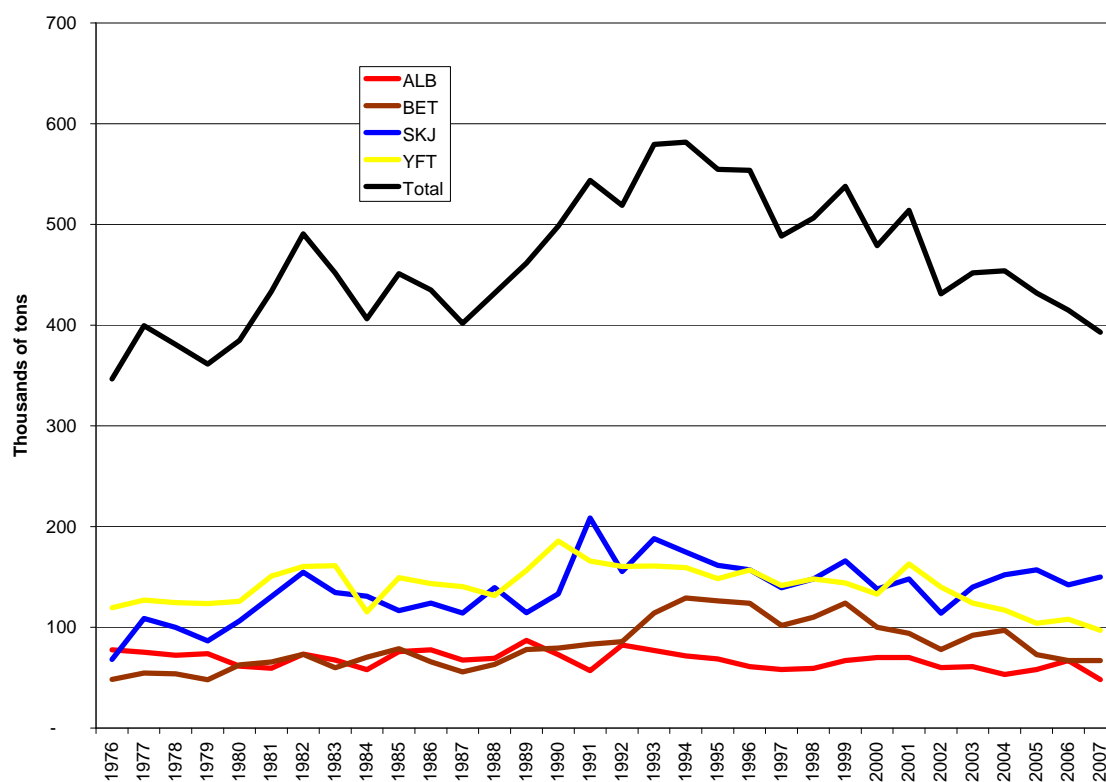


FIGURE B-10. Catches of tuna in the Atlantic Ocean, 1976-2007.

responding to MSY.

The estimate of MSY for the age-structured or VPA model was about 131 thousand tons; the same analysis estimated that fishing mortality during 2006 was about 84 percent of the level corresponding to MSY, and the ratio of the biomass during 2006 to the biomass at MSY was estimated to be 1.09, or that the biomass was about 10 percent greater than that corresponding to MSY.

Trend estimates from the VPA show that overfishing had occurred in the past, but is not occurring currently. The ASPIC modeling indicates that there has been both overfishing and an overfished state in recent years, but that overfishing was not occurring in 2006, and based on the lower catches that overfishing was likely not occurring in 2007. Examination of the distribution of these estimates from both models shows that about 40% indicate a sustainable situation, in which the stock is not overfished and overfishing, is not occurring. Catches in 2006 and 2007 are estimated to be well below the MSY levels, stock biomass is estimated to be near the MSY level, and recent fishing mortality rates are less than the MSY level. These numbers suggest declining fishing mortality and the stock increasing in abundance. However, there is uncertainty surrounding the assessment, and a 60 chance that the stock is below the MSY level.

Using the VPA model results projections were made considering a number of constant catch possibilities. These projections suggested that catches of 130 thousand tons are sustainable; catches in excess of that amount would result in overfishing. If catches are maintained at levels of about 110 thousand tons, biomass would be expected to increase to above a level corresponding to MSY. Analysis also corroborates earlier findings that if the catch of small yellowfin could reduce gains in potential yield and spawning biomass would be realized.

The current status of yellowfin based on the ASPM and VPA modeling is shown in Figure B-11, which shows bootstrap estimates of uncertainty.

Based on the 2008 assessment it appears the stock is **not currently being overfished** and though it may be in a **slightly overfished state** (catches for the past five years have been less than the MSY) it is rebuilding.

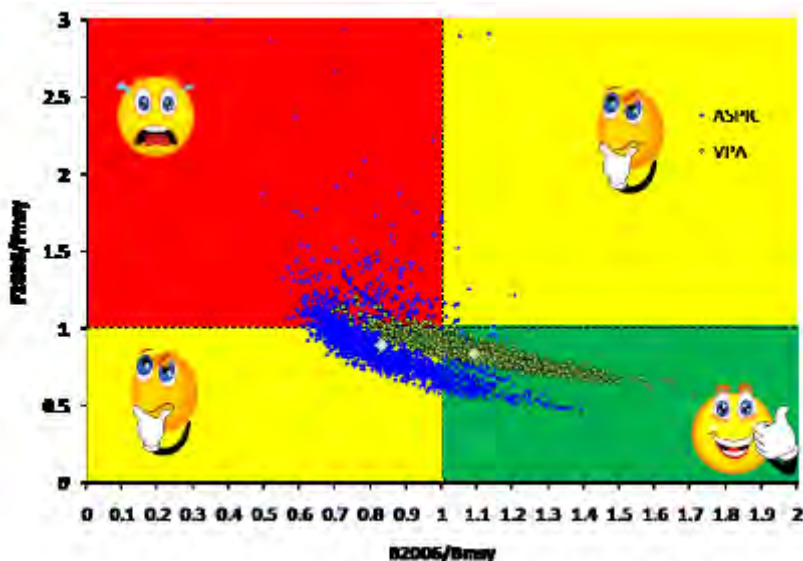


FIGURE B-11. Current status of yellowfin, showing uncertainty, based on VPA and production

models. The point estimates are shown as the large diamonds and the array of points reflect bootstrap estimates of uncertainty (SCRS-ICCAT).

3.1.2. Next scheduled stock assessment

The SCRS has set no schedule for the next full stock assessment of Atlantic yellowfin.

3.1.3. Conservation and management of yellowfin

One of the earliest management measures implemented by ICCAT was the establishment of a minimum size limit of 3.2 kg for yellowfin in 1973. The rationale behind this measure was that by protecting small yellowfin the yield per recruit and the total yield could be increased. However, after many years of observing that a large share of the catch of purse-seine and pole-and-line vessels was comprised of fish under the 3.2 kg limit, the measure was repealed in 2005.

In 1993 the Commission implemented an additional management measure stipulating that there be no increase in the level of effective fishing effort exerted on Atlantic yellowfin tuna over the level observed in 1992. Effective fishing effort is effort that is proportional to fishing mortality as compared to nominal fishing effort which does not take into account changes in efficiency. For example if a fleet spent 100 days at sea fishing in 1993 the nominal fishing effort would be 100 days. If that same fleet did not change its efficiency and in 2003 spent 100 days at sea fishing the effective fishing effort would not have changed, it would still be 100 days, the same as the nominal effort. If however, the same fleet improved its efficiency 3 percent per year, and then spent 100 days fishing in 2003, its nominal effort would still be 100 days, but its effective effort would more than 130 days. This measure has been implemented each year since 1993.

In order to protect small bigeye, in 2004 ICCAT implemented a measure to close the area in the Gulf of Guinea between the equator and 5°N from 10°E to 20°E to fishing by purse-seine and pole-and-line vessels during November in the years 2005-2008. This measure was changed for 2009 and 2010 and applied to the area bound by 4°S to 5°N, and 20° to the African coast, and for the period 1 November to 31 January. Although the intent was to protect small bigeye, the measure offers protection to small yellowfin as well, since they occur in that area during November.

3.2. Bigeye

Bigeye are distributed throughout the Atlantic Ocean between about 50°N and 45°S; they are not found in the Mediterranean. Large bigeye in the Atlantic, like bigeye in other oceans, spend much of their time during daylight hours at depth, coming to the surface more frequently at night. Small bigeye tend to spend more time near the surface, particularly when they associate with floating objects, whale sharks and seamounts. It is this behavior that makes them vulnerable to purse-seine nets. They spawn widely throughout tropical waters and as they grow larger tend to move to more temperate areas in the Atlantic. One of the major nursery grounds for juvenile bigeye is the Gulf of Guinea. Genetic information, tagging data, and the spatio-temporal distribution of catches suggest a single interbreeding population Atlantic wide.

Portuguese pole-and-line fishermen were the first to harvest bigeye on a large commercial scale; this gear continues to account for about 15 percent of the bigeye catch from the Atlantic. Japanese longline vessels began fishing bigeye in the Atlantic during the mid-1950s; longline fleets from Japan, Chinese Taipei, China and a number of other nations continue to take about 50-60 percent of the bigeye catch from the Atlantic,. Purse-seine vessels have always taken some bigeye since they first began fishing in the Atlantic in the late 1960s, but the amount was small

until the development of FAD fishing techniques; they now account for about 25 percent of the catch. Longline takes bigeye averaging 40-50 kg, pole-and-line take bigeye average about 20-30 kg, and purse-seine caught fish average 3-4 kg.

Catches of bigeye increased steadily since the 1950s and peaked in 1994 at about 132 thousand tons; they have declined steadily since then and in 2006 and 2007 were about 67 thousand tons in each year, less than half that of the peak year (Figure B-10). All of the major fisheries for bigeye in the Atlantic suffered declines in catch. The declines were concurrent with reductions in the number of purse-seine vessels and with declines in the catch rate for longline and pole-and-line vessels.

3.2.1. Most recent stock assessment

The most recent stock assessment for Atlantic bigeye was conducted in 2007 and presented at the SCRS meeting in Madrid during October 2007. Several different models, including VPA, MULTIFAN-CL, and general production models were used in the assessments. There was a range of evaluations of the stock of bigeye that resulted from the various model applications and not all of them were considered to be equally likely. Most of the conclusions regarding the status of the stock were based on general production models. The analysts noted that there were shortcomings in data for some fisheries as well as a lack of data from IUU fishing (estimated to be as high as 25 thousand tons during the 1990s), and these were considered to be cause for concern.

Using two different formulations of the production model the MSY was estimated to be 90 or 93 thousand tons. Bigeye biomass showed a sharp declining trend beginning in the late 1980s, falling below the MSY level in 1997, and has remained slightly below MSY since. The trend in fishing mortality shows a similar, but inverse pattern, increasing rapidly during the mid-1980s and exceeding the MSY level in 1993; it has remained above that level since, with the exception of 2006; F_{2006}/F_{MSY} is currently at 0.87, or less than needed to take the MSY.

Using the models to make projections of the stock under varying levels of catch it was estimated that if catches were maintained at 85 thousand tons the biomass would rebuild to the MSY level within a few years, however if catches were kept constant at 90 thousand tons or more the biomass would decline further.

On the one hand, based on the most recent assessments, the biomass of bigeye in the Atlantic Ocean is about 92 percent of the size it should be at MSY, in other words **the stock is currently in a slightly overfished state**, however, if catches remain at the 2006/2007 level the stock will

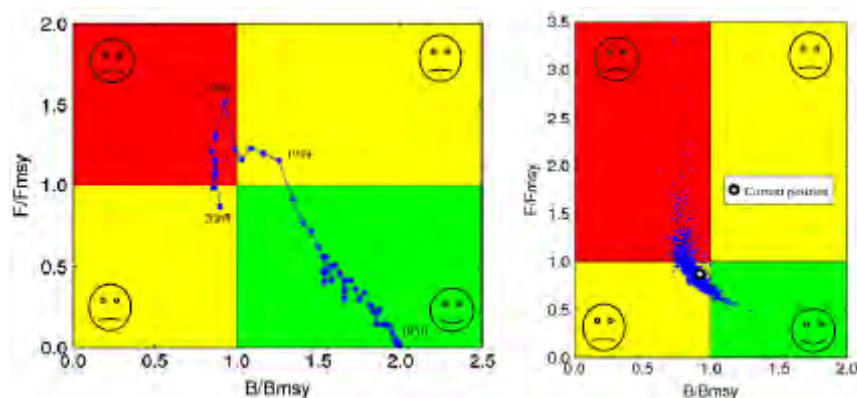


FIGURE B-12. Estimated range of stock status results for bigeye for 2005 showing time series on the left and uncertainty on the right (SCRS-ICCAT).

increase to above the level corresponding to MSY. On the other hand, since fishing mortality during 2006 was only 87 percent of what it should be at MSY and is expected to be about the same for 2007, **the stock is not being overfished**, and should be increasing slightly (Figure B-12).

3.2.2. Next scheduled stock assessment

The next bigeye assessment of Atlantic bigeye is currently not scheduled.

3.2.3. Conservation and management of bigeye

Over the years the Commission has set a number of conservation and management measures for bigeye tuna in the Atlantic. One of the first measures set for bigeye was a minimum size limit of 3.2 kg; this limit was set in 1979 in order to enhance the enforcement of the yellowfin minimum size limit, because small yellowfin and bigeye are difficult to distinguish. A large portion of purse-seine caught bigeye is below this minimum size limit, and as was done for yellowfin, the size limit was repealed because it could not be enforced.

A number of bigeye measures were introduced between 1997 and 2003 to require CPCs to keep the number of vessels, the levels of effort, and the levels of catch, to no more than 1992-1993 averages.

In 2004 a series of controls on bigeye fishing were approved and implemented for the years 2005-2008: 1) Limit the numbers of fishing vessels to less than the average number that fished during 1991 and 1992; 2) limit China to 45 longline vessels, Chinese Taipei to 98 longline vessels, Philippines to 8 longline vessels and Panama to 3 purse-seine vessels; 3) bigeye catch limits were assigned for the years 2005-2008 with the current limits being 5.9 thousand tons for China, 24 thousand tons for European Union vessels, 5 thousand tons for Ghana, 25 thousand tons for Japan, 3.5 thousand tons for Panama, and 16.5 thousand tons for Chinese Taipei; 4) a total allowable annual catch (TAC) of 90 thousand tons; and 5) a prohibition against fishing by purse-seine and pole-and-line vessels, as described in Section 3.1.3 above.

The Commission, in 2005, noting that Chinese Taipei vessel owners exhibited disregard for IC-CAT conservation regulations in that they laundered illegally caught bigeye from the Atlantic and participated in IUU fishing, reduced Chinese Taipei's 2006 bigeye quota from 16.5 to 4.6 thousand tons. The Commission further stipulated that 60 Chinese Taipei albacore longliners would be restricted to taking no more than 1.3 thousand tons of bigeye as a bycatch, and 15 Chinese Taipei longline vessels could engage in a directed bigeye fishery but could take no more than 3.3 thousand tons of bigeye, with no single vessel taking more than 220 tons. The Commission also ruled that there should be 100 percent observer coverage on these Chinese Taipei vessels to ensure compliance with the mandates. Because Chinese Taipei was found to have complied with the 2006 program as defined it was authorized to have no more than 64 longline vessels participate in a directed bigeye fishery during 2007, and no more than 60 vessels during 2008; observer coverage would be reduced to 10 percent.

In 2008, the measure described in section 3.1.3 above was modified: it prohibited fishing on floating objects, including FADs, from 1 November to 31 January in the area between 5°N and 4°S east of 20°W. This measure has been extended through 2010.

3.3. Skipjack

Skipjack tuna are found throughout the tropical and subtropical waters of the Atlantic Ocean between roughly 45°N and 35°S; they grow rapidly, do not live as long as other species of tunas,

and have a high population turnover rate making them more difficult to overfish than other tuna species. The population of skipjack in the Atlantic is divided into an eastern and western stock. The fishery on the eastern stock takes about 80 percent of the total catch and the western stock 20 percent. Total catches increased steadily from the 1950s to a peak of 208 thousand tons in 1991, this latter increase resulting from the introduction of FAD fishing. After 1991 catches declined to a recent low of 113 thousand tons, then increased to about 158 thousand tons in 2005, declined in 2006 to 142 thousand tons, and then increased in 2007 to about 150 thousand tons (Figure B-11). The catches in the western fishery have varied between 22 and 40 thousand tons since 1980, but have shown no increasing or decreasing trend.

In the eastern Atlantic about 58 percent of the catch is taken by purse-seine vessels, 36 percent by pole-and-line vessels, and the remainder by a wide variety of gear; for the western Atlantic the corresponding figures are 8 percent and 92 percent, respectively. The major purse-seine fisheries in the eastern Atlantic are carried out by Spain, France and Cape Verde, and for pole-and-line by Ghana, Spain, and France.

Nominal fishing effort on skipjack tuna, although not measured, is assumed to have decreased substantially in the purse-seine fishery; carrying capacity of purse-seine vessels declining from about 70 thousand tons in 1982 to less than 35 thousand tons in 2006. However during this same period, vessel efficiency was estimated to have increased on the average 3 percent per year, also total mortality in the fishery due to fishing increased somewhat.

3.3.1. Most recent stock assessment

The last stock assessment of Atlantic skipjack tuna was carried out in 1999. Based on tagging data, catch distributions, and other biological parameters, the Atlantic skipjack population is considered to be comprised of two independent, non-mixing stocks, one in the east and the other in the west, and as such, each is treated separately for management purposes.

Like skipjack in other oceans, because of difficulties in estimating directed fishing effort, continual spawning activity, difficulty in separating natural mortality from out-migration, and highly variable and dynamic growth, the SCRS has found it difficult to apply classic population dynamic models to assess the status of skipjack stocks in the Atlantic Ocean. Consequently no standardized assessment of the skipjack stocks was carried out; several fisheries indicators were used to examine changes in the stocks over time.

Although a full assessment was not completed scientists of the SCRS did make estimates of the total mortality rate for the eastern stock, which showed that after increasing up to 1995, it has been decreasing as a result of the moratoria placed on fishing surface gear in the Gulf of Guinea during the November-January period. The indices of abundance show a great deal of variability among the various fisheries, but for the FAD fishery and the Senegalese “baitboat associated school” fishery, efficiency and catch rates increased. The size of skipjack in the catch has shown a moderate decreasing trend with current average weight at about 2 kg. A simple model (Granger-Garcia), examining the rate of change in catch rates over time, suggested over-exploitation of the eastern stock could have occurred during 1994-1995, immediately after the expanded use of FADs, however, the SCRS had little confidence in this result and does not consider it to represent overfishing.

For the western stock, catch rates in the Brazilian pole-and-line fishery have been fairly stable over the last decade, while they have declined for the Venezuelan purse-seine fleet. However, it is considered that these decreases may be due to specific environmental conditions that have af-

affected the vulnerability of skipjack to the purse-seine fleet.

Standard indicators of stock condition, such as MSY, fishing mortality ratios, and biomass ratios have not been estimated for either stock; nevertheless there is **no evidence that either stock of skipjack is in an overfished state or that overfishing is occurring** (Figures B-13 and B-14).

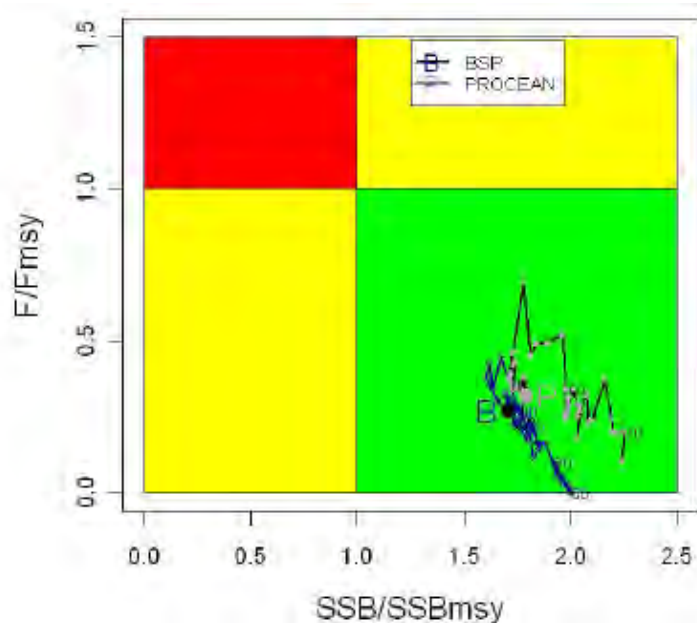


FIGURE B-13. 2007 stock status for eastern Atlantic skipjack using spawning biomass (SSB) and fishing mortality (F) indicators (SCRS-ICCAT).

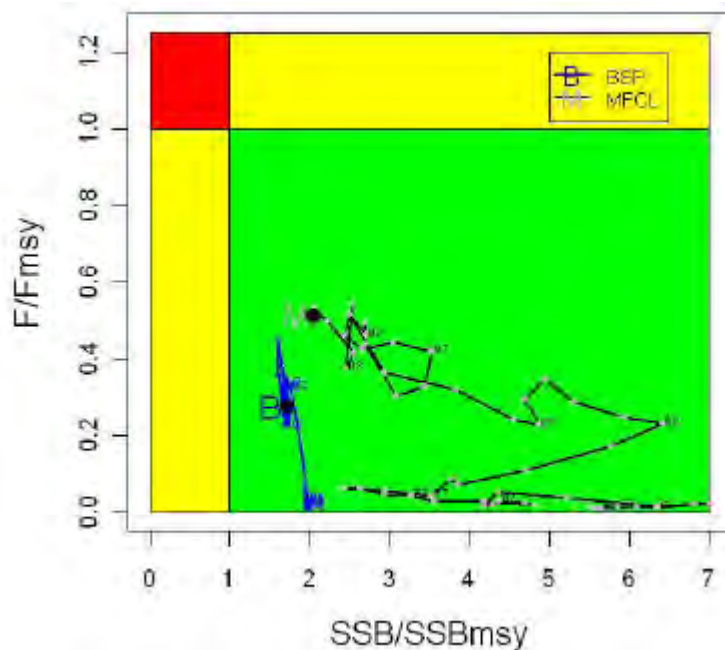


FIGURE B-14. 2007 stock status for western Atlantic skipjack using spawning biomass (SSB) and fishing mortality (F) indicators (SCRS-ICCAT).

3.3.2. Next scheduled stock assessment

There is no schedule for the next full assessment of skipjack tuna in the Atlantic.

3.3.3. Conservation and management of skipjack tuna

There currently is no specific regulation in effect for the management of skipjack, nor has the SCRS recommended any management measures for skipjack. However the moratoria applied by the Spanish and French industry closing a certain section of the fishery with floating objects during November-January from 1997 through 1999, and the ICCAT recommendation to close a similar area during subsequent years, has had an effect on skipjack catches made with FADs. The average annual catch of skipjack per boat decreased by about 18 percent as a result of the moratoria; the average annual catches by purse-seine fleets that applied the moratoria decreased by 42 thousand tons (41 percent), but the overall decrease in effort as a result of less purse-seine

Species	$B_{\text{current}} < B_{\text{MSY}}$	$B_{\text{current}} \approx B_{\text{MSY}}$	$B_{\text{current}} > B_{\text{MSY}}$
Yellowfin		$B_c < B_{\text{MSY}}, F_c < F_{\text{MSY}}$	
Bigeye		$B_c < B_{\text{MSY}}, F_c < F_{\text{MSY}}$	
Skipjack-East			$B_c > B_{\text{MSY}}, F_c < F_{\text{MSY}}$
Skipjack-West			$B_c > B_{\text{MSY}}, F_c < F_{\text{MSY}}$

TABLE B-4. Status of yellowfin, bigeye and skipjack in the Atlantic Ocean

vessels operating in the Atlantic probably contributed to this decline as well.

The status of yellowfin, bigeye, and skipjack is summarized in Table B-4.

3.4. Albacore

Albacore are distributed widely throughout the Atlantic Ocean between about 60°N and 50°S. The stocks support large surface fisheries in the Bay of Biscay, near the Canary Islands, around the Azores, and off southern Africa. Atlantic-wide catches (not including the Mediterranean) have shown a great deal of variability between 1982 and 2006, but with a slight decreasing trend. The all time high of about 85 thousand tons was taken in 1986, after which catches declined to a low of about 50 thousand tons in 2004, increased to near 60 thousand in 2006, and in 2007 declined to an all time low of 42 thousand tons (Figure B-15).

Although the distribution of albacore is continuous throughout the Atlantic, scientists consider that there is a northern and southern stock, separated at 5°N, and a separate stock in the Mediterranean Sea. It is likely that there is some mixing of young albacore from the southern stock with albacore from the Indian Ocean, although to what extent is not known. Catches from the northern and southern stock are similar and during the last 7 years the averages were 28 and 26 thousand tons respectively. Catches in the Mediterranean have averaged about 5 thousand tons per year, about half taken by longline and the other half by purse-seine vessels; Italian fleets harvest about 92 percent of the Mediterranean catch.

3.4.1. North Atlantic albacore

Most of the catch of northern albacore is made by surface fishing gear; over the last few years pole-and-line vessels accounted for 35 percent of the catch, trolling vessels for 28 percent, trawlers for 15 percent, longline about 15 percent, and purse-seine vessels for 4 percent. The Spanish surface fishery accounts for about 61 percent of the north Atlantic catch, followed by France with 17 percent, and Portugal and Ireland with 1 percent each. These primary surface fisheries

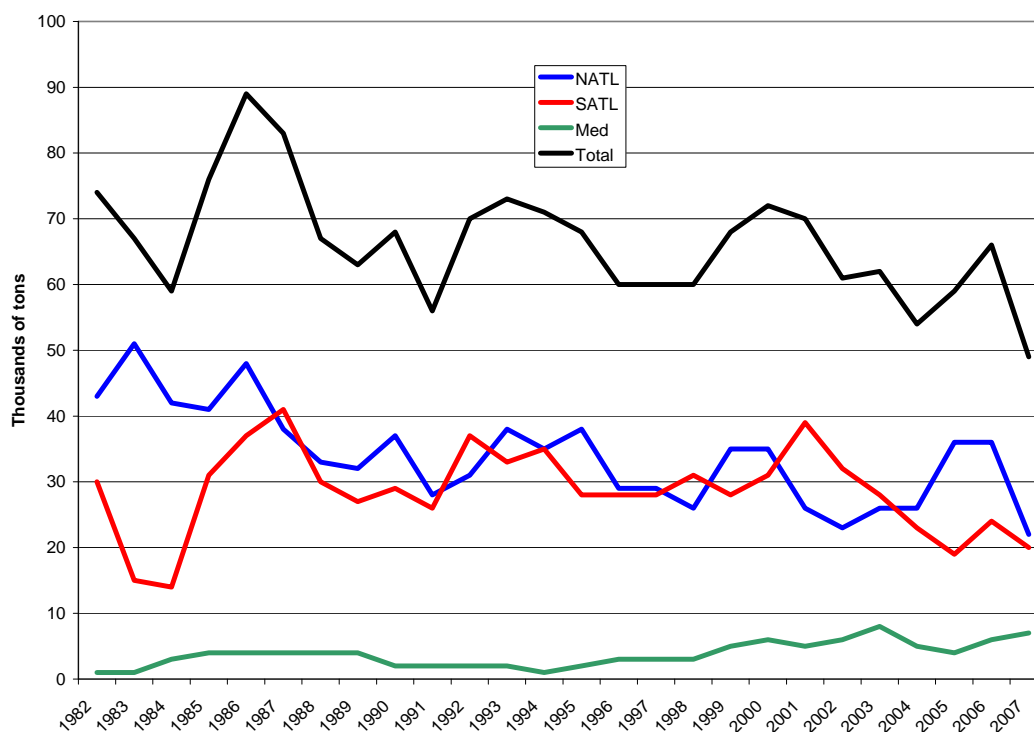


FIGURE B-15. Catches of albacore in the Atlantic Ocean, 1982-2007.

are prosecuted mainly in the Bay of Biscay and in the Azores and Canary Islands during the summer and fall, and they generally take young fish between 3 and 15 kg. Longline vessels take about 10 percent of the northern catch; Chinese Taipei accounting for 7 percent and Japan about 3 percent. Longline vessels operate throughout the year in the north Atlantic and target fish between 5 and 45 kg.

Catches of northern albacore reached about 65 thousand tons in the mid-1960s, the highest in the history of the fishery, but were declining through 2004. Since 1980 the rate of decline began to decrease somewhat, going from about 50 thousand tons in 1982 to about 23 thousand tons in 2002; after the low of 2002 catches began to increase and during 2005-2006 were about 36 thousand tons in each year, then in 2007 declined to an all time low of 22 thousand tons (Figure B-15). Some of this decline in catch is attributed to a reduction of fishing effort by several of the traditional surface and longline fisheries while the recent increase is attributed to increased effort and catch by driftnets and mid-water paired pelagic trawls. The Spanish troll and pole-and-line fleets, particularly the latter, have been increasing their catches while catches of other EC fleets have decreased. Longline catches have been decreasing, particularly in 2005 due to the restrictions placed on the Chinese Taipei fleet.

3.4.1.a Most recent stock assessment

The most recent assessment for the northern stock of albacore was conducted in 2007. For this current analysis the SCRS was able to substantially improve the estimates of catch at age which is fundamental to the modeling techniques employed. Also, improvements were made in the catch-rate analysis which is important for tuning the model with respect to estimating trends in biomass. The MULTIFAN-CL model was used in the analysis and provided a number of parameters useful in assessing the current condition of the stock.

Recruitment showed a great deal of variability among the years examined, the highest being about 20 million 1-year old recruits and the lowest about 4 million. During recent years recruitment has averaged about 8 million fish, and since 2002 it has been increasing. The most recent estimate of recruitment of about 15 million fish is the highest in recent years and is well above the long-term average. Although a high degree of confidence cannot be placed on the current estimate because the fish have only been subjected to the fishery for a short time, if the year class continues to show high recruitment as more data becomes available, population abundance in the coming years could increase.

Trends in the ratio of the fishing mortality exerted by the fishery in each year to the fishing mortality when the population is at a level capable of supporting the MSY were examined to determine if overfishing had been occurring. The results showed that with few exceptions since 1955 the ratio was greater than one, indicating that overfishing had been occurring. In 2004, the ratio was less than one, but increased to greater than one in 2005, ranging between 1.3 and 1.7.

Trends in the biomass in each year to the biomass at MSY were also examined and they showed that since 1993 the biomass had been less than biomass at MSY. However, the stock has been rebuilding and is currently about 20 percent below the MSY level ($B_{2005}/B_{MSY}=0.8$), whereas in 2000 it had been about 50 percent below the MSY level ($B_{2000}/B_{MSY}=0.5$). Also trends in the spawning biomass showed decreases since the inception of the fishery and is currently about one quarter of the level it was when the fishery first began; however, since 1997 it has been increasing slightly.

The estimates of MSY for the northern stock have varied between about 26 and 34 thousand tons, dependent upon the age-specific fishing mortality being exerted. When larger fish are taken on the average MSY tends to increase, but decreases when more small fish are harvested. The current estimate of MSY is 30.2 thousand tons. Four out of ten of the most recent annual catches have exceeded the MSY. The catch in 2007 was less than the replacement yield, which means the stock should be increasing in abundance.

Based on the current assessment **the stock of northern albacore is in an overfished state**, and

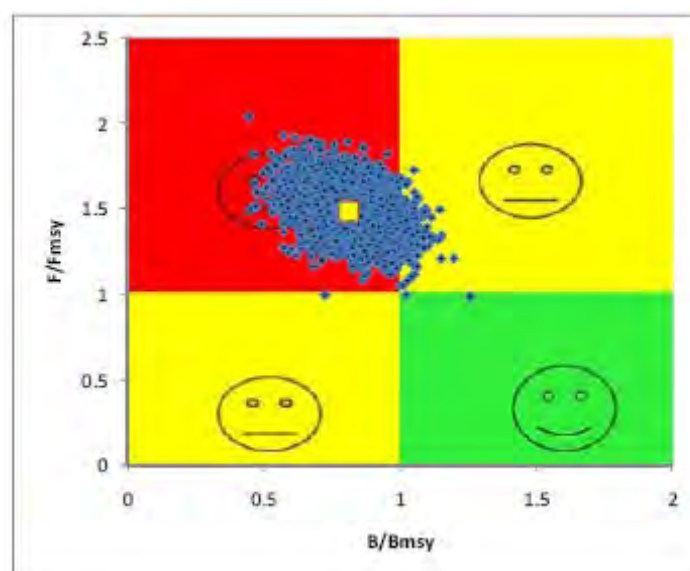


FIGURE B-16. Phase plot for North Atlantic albacore, using biomass (B) and fishing mortality (F) indicators and showing uncertainty in the 2005 point (SCRS-ICCAT).

overfishing is currently taking place, which is reflected in the phase plot shown in Figure B-16.

If fishing mortality continues high and recruitment stays average or less, biomass will continue to decrease, however, these decreases could be offset by the apparent strong recruitment and the lower TAC set for 2008 and beyond. It is important to keep in mind that the estimate of high recruitment is uncertain because the year class has been subjected to the fishery for such a short time.

3.4.1.b Next scheduled stock assessment

The next stock assessment of northern albacore will be in July 2009.

3.4.1.c Conservation and management of north Atlantic albacore

In 1998 ICCAT approved a recommendation calling on all CPCs with fleets fishing for northern albacore to limit beginning in 1999 the numbers of vessels in their fleets to no more than the average number of their vessels fishing for albacore during 1993-1995. Each CPC was required to submit a list of the vessels they authorized to fish for albacore during 1999 and to resubmit such a list of such vessels for each year thereafter. Japan was specifically requested to limit their catch of albacore to no more than 4 percent of their total longline catch of bigeye tuna. The provisions to limit fleets would not apply to nations whose fleets harvest less than 200 tons of northern albacore per year.

An additional resolution applying to northern albacore was approved by ICCAT in 2003 for application during 2004 to 2006, which restricted catches to the then current levels of catch, or a TAC of 34.5 thousand tons. A series of catch allocations were included in the recommendations: EU - 28, 712 tons, US - 607 tons, Venezuela - 270 tons, Japan - 4 percent by weight of its total longline catch of bigeye, other contracting parties - 200 tons, and non-contracting parties - 4,459 tons. The resolution also allowed for adjustments to be made for over-catches, under-catches, and transfers of under-catches to other parties. The resolution also sustained the measures for limitation of the number of vessels authorized to fish for northern albacore. A resolution was approved in 2006 extending all of these measures through 2007.

In 2007 the Commission, following the best scientific advice of the SCRS, established a TAC of 30,200 tons for 2008 and 2009; of this the EU was allocated 25,462 tons, the U.S. 538 tons, Venezuela 250 tons, Chinese Taipei 3,950 tons, and Japan was urged to limit its catch to 4 percent of its total bigeye catch in the Atlantic. If the TAC is continued to be followed the stock should increase to the AMSY level of sustainability.

3.4.2. South Atlantic albacore

Catches of albacore in the south Atlantic have varied between a high of 41 thousand tons in 1987 and a low of 15 thousand tons in 1984. From 1988 to 2003 catches were relatively stable, averaging 30 thousand tons per year; they peaked in 2001 at 39 thousand tons, began to decline reaching a low of 19 thousand tons in 2005, increased in 2006 to 24 thousand tons, and then decreased to 20 thousand tons in 2007 (Figure B-15).

During recent years, south Atlantic albacore landings have been primarily attributable to four fisheries: surface pole-and-line fleets from Namibia and South Africa and longline fleets from Chinese Taipei and Brazil. Over the last few years longline fleets have taken nearly 68 percent of the catch from the south Atlantic, most of which Chinese Taipei captures. Catches by the Brazilian longline fleet, which fished mostly off the east coast of South America and exceeded 4

thousand tons per year, have recently declined by nearly 90 percent. This decrease in the Brazilian catch was likely attributable to the exodus of Chinese Taipei longline vessels previously fishing under special arrangements with Brazil. The Chinese Taipei fleet operates throughout the south Atlantic and targets fish between 5 and 35 kg; some of the Chinese Taipei catch is from a directed albacore fishery and some is taken as a bycatch in the bigeye and swordfish fishery.

Surface fisheries in the south Atlantic account for about 30 percent of the catch, Namibian and South African pole-and-line fleets taking most of this catch. These fisheries operate mainly during October to May and capture juvenile and sub-adult fish between 7 and 16 kg. The South African catch has decreased by about half over the last several years while the Namibian catch doubled in 2006. The decline in South African catches apparently have been attributed to a decrease in the availability of albacore in the inshore waters of South Africa and unfavorable foreign currency exchange rates which have caused a general decrease in the number of pole-and-line vessels active in the fishery. However, there is some question regarding the validity of the catch statistics. It is possible that some South African catches are reported as Namibian catches.

3.4.2.a Most recent stock assessment

The most recent stock assessment for southern albacore was conducted during 2007 and reviewed at the October 2008 meeting of the SCRS. A similar analysis to that completed for the northern stock was carried out for the southern stock; MULTIFAN-CL was used in the assessment. The catch rates used to tune the model showed a decreasing trend for the longline indices, but stability in the case of the surface fisheries.

As was the case for northern albacore, the estimate of recruitment for the most recent year class of the southern stock entering the fishery was above average, although confidence in the estimate will remain low until the year class is subjected to fishing for another year or two.

The biomass has shown a general decreasing trend as would be expected as exploitation increases, but at the end of 2005 was very near the MSY level, the point estimate being more than 90 percent of that level, with a range of .71-1.16.

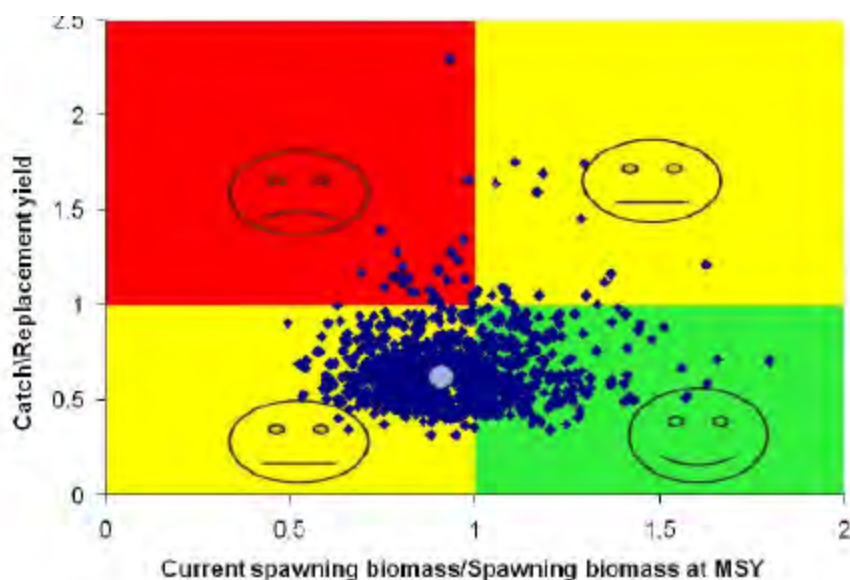


FIGURE B-16. Phase plot for south Atlantic albacore showing uncertainty in 2005 point (ICCAT).

The ratio of current fishing mortality to fishing mortality at MSY shows that in recent years it has been less than 1, and in 2005 was 0.6, or only 60 percent of the AMSY level.

The current estimate of MSY is 33.3 thousand tons, ranging between 29.9 and 36.7 thousand tons. Only one out of the last ten years has exceeded the AMSY estimate, and over the last four years none of the catches have exceeded the replacement yield of 28.8 thousand tons. This implies that biomass should be increasing and if current levels of catch are maintained, will soon exceed what it should be at MSY, if it hasn't already.

Based on these analyses, **the southern stock of albacore is not being overfished, but conservatively speaking, it may be in a slightly overfished state** (Figure B-16). It should be noted however, that since catches have been substantially below the replacement yield and fishing mortality below the MSY level for an extended period, it is likely that the stock is not in an overfished state

3.4.2.b Next scheduled stock assessment

The next stock assessment of south Atlantic albacore will be in July 2009.

3.4.2.c Conservation and management of south Atlantic albacore

In 2004 ICCAT approved a resolution designed to limit the catch of albacore south of 5° North to no more than 30,915 tons, which was based on the then best estimate of MSY. The resolution stipulated that if the catch in 2004 exceeded 29,200 tons, the TAC of 30,915 for 2006 would be reduced by the excess of the overage. Likewise if the 2005 catch exceeded the 2006 TAC, the 2007 TAC would be reduced by the overage. Also, CPCs that caught no more than 100 tons during 1992-1996 would be allowed to increase their catch by 10 percent. The current TAC for south Atlantic albacore is 29,200 tons. For 2009-2011 the TAC was set for 29,200 tons; and again, if the catch in 2008 exceeds the 29,900 tons the catch in 2009 shall be reduced by the full amount of the excess. If the catch in any year until 2011 should exceed the replacement yield of 28,800 the conservation measures for southern albacore should be reviewed. Those CPCs that caught less than 100 tons during 1992-1996 are subjected to an annual catch limit of 100 tons, and those catching more than 100 tons to a catch limit of 110 percent of their average catch during 1992-1996. In the case of Japan, it shall endeavor to limit its catch of southern albacore to 4 percent by weight of its total longline bigeye catch in the Atlantic south of 5°N.

The status of north and south Atlantic albacore is summarized in Table B-5.

Species	$B_{current} < B_{MSY}$	$B_{current} \approx B_{MSY}$
North Atlantic Albacore	$B_c < B_{MSY}, F_c > F_{MSY}$	
South Atlantic Albacore		$B_c < B_{MSY}, F_c < F_{MSY}$

TABLE B-5. Status of north and south Atlantic albacore.

4. INDIAN OCEAN

4.1. Yellowfin

Yellowfin are found throughout the Indian Ocean. There is probably some limited exchange of individual yellowfin between the eastern Indian Ocean and western Pacific, however, this exchange is not sufficient to preclude considering yellowfin in the Indian Ocean as a single stock for purposes of management.

Yellowfin catches prior to 1984 were relatively minor, averaging about 40 thousand tons, but in 1985 with the transfer of French and Spanish purse-seine vessels to the Indian Ocean catches shot upwards. By 1992 catches exceeded 300 thousand tons and between then and 2002 averaged about 325 thousand tons. In 2003 catches took an upward jump and peaked at 497 thousand tons in 2004, declining in 2005 to 476 thousand tons, again in 2006 to 400 thousand tons, and again in 2007 to 317 thousand tons, a nearly 40 percent decline over 2003 (Figure B-17). Until the advent of purse seining, longline vessels accounted for the major portion of the catch, but over the last decade they have been taking about 20 percent of the catch, as have been drift-nets. Although they fish throughout the Indian Ocean, longline vessels expend most of their fishing effort in the western half. During the same time period, purse-seine fleets have on the average taken about 45 percent of the catch. Purse seiners fish mostly in the western portion of the Indian Ocean between about 10°N and 20°S, and from the African coast to about 80°E Longitude. About half of the yellowfin purse-seine catch is taken with FADs and half in school sets. As in other oceans, FADs capture small yellowfin averaging about 5 kg while the average size of yellowfin in schools sets is close to 25 kg; most of the purse-seine catch is made up of age-0 and age-1 yellowfin (Figure B-18). Longline captures yet larger yellowfin, most fish being age-3. The smallest fish are taken in the pole-and-line fishery and the troll fishery and are mostly age-0. Gill nets capture mostly age-1 fish. The yellowfin fishery in the Indian Ocean is unique in that about 30 percent of the catch is taken by artisanal fisheries, and of this amount most is by gill nets.

4.1.1. Most recent stock assessment

Scientists from IOTC member countries work jointly through the IOTC Working Party on Tropical Tunas (WPTT) to assess the status of the yellowfin stock in the Indian Ocean. Over the years

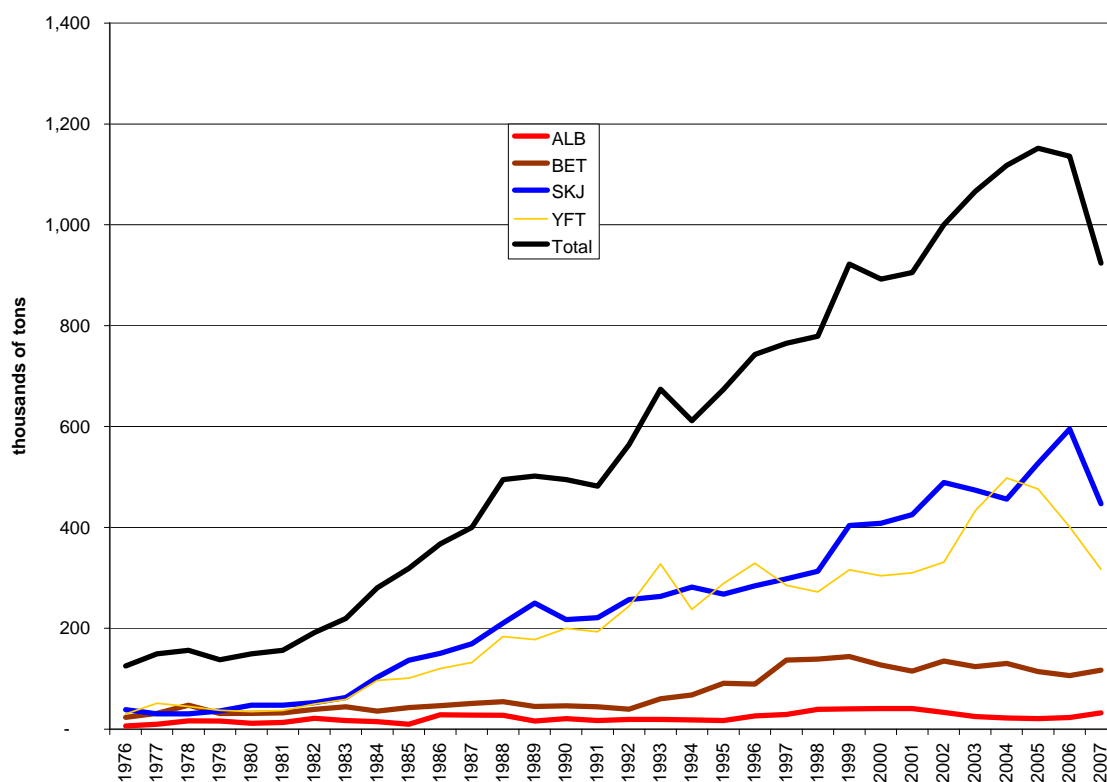


FIGURE B-17. Catches of tuna in the Indian Ocean, 1950-2007.

there have been a number of documents dealing with the assessment of yellowfin. These papers are available on the IOTC website. One of the earliest papers presented at the WPTT was in 2002, and reported on an analysis using an age-structured production model (ASPM). The results of that study estimated that the yellowfin stock could support an MSY of about 290 thousand tons and that the ratio of the then current fishing mortality to fishing mortality at MSY was less than 1, and that the ratio of the then current biomass to biomass at MSY was greater than 1; this implies that overfishing was not occurring at that time and that the stock was not in an overfished state. However, because the catch in 2000, the most current year in the series being analyzed at that time, was 320 thousand tons, which was greater than MSY, the authors of the study cautioned that consideration should be given to recommending limits on either catch or fishing effort in order to ensure that the stock was not driven below a level corresponding to the MSY. No action was taken at that time by the Plenary.

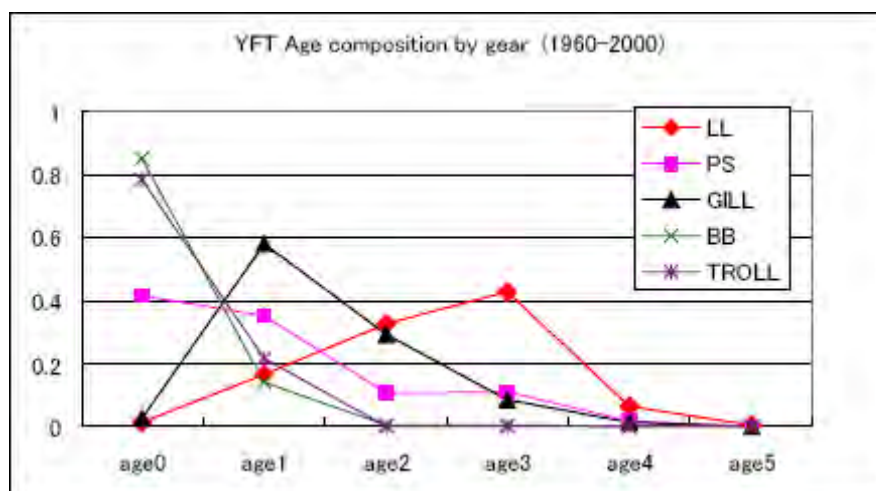


FIGURE B-18. Age composition of yellowfin tuna by gear type (from IOTC)

In 2007 there were 3 different partial assessments for yellowfin presented at the WPTT meeting: a Stock Synthesis II analysis (SS2), an ASPM analysis, and a Pella-Tomlinson production model analysis using a Bayesian framework.

For the SS2 study, catch, catch per unit of effort, and length data for 1965-2005 were used, along with estimates of natural mortality, growth, maturity and fecundity, and length-weight relationship. The model estimated trends in biomass and spawning biomass, recruitment, and fishing mortality. Recruitment of age-1 yellowfin into the fishery varied between 1 and 2 million fish per year, but showed no trends. Fishing mortality showed a sharp increase after the movement of the purse-seine fleet into the region. The ratio of the fishing mortality in 2005 to the fishing mortality at MSY was greater than 1, implying over the long-term an unsustainable fishery. Virgin biomass, which was estimated at 2.8 million tons, showed a downward trend since 1975, with a sharp decrease since 2004; the ratio of the 2005 biomass to the biomass at MSY was greater than 1, implying the stock is not in an overfished state. The MSY estimate for the fishery was about 310 thousand tons. One would conclude from this analysis that the yellowfin stock was not in an overfished state, but because fishing mortality was greater than what it should be for harvesting the MSY, unless reduced, overfishing would cause the stock to decline below the MSY level.

The ASPM analysis is an extension of general production modeling that utilizes age-specific indices of relative abundance. In their analysis the authors utilized catch, effort, and age-specific

data for 1960-2005, and a vector of the natural mortality rate that was 0.8 for age-1 fish and 0.6 for the older ages. A number of runs using different input variables were made, but one was chosen and utilized as a base case. The results for the base case analysis were similar to the SS2 analysis. The ratio of 2005 fishing mortality to fishing mortality at MSY was substantially greater than 1, and the ratio for the biomass was near 1. The conclusions to be drawn from this analysis are similar to the conclusion drawn for the above analysis. The stock was not in an overfished state, but it would become so unless fishing mortality was reduced.

For the Pella-Tomlinson production modeling analysis, catch and catch per unit of effort from the Japanese and Chinese Taipei longline fleets were used, along with a framework of Bayesian priors. Two runs of the model were made, one using the Chinese Taipei catch per effort and the other using the Japanese data. The results of the model runs differed so significantly that the authors cautioned they should not be used for drawing conclusions about the status of the stock.

The working group on yellowfin tuna was unable to determine for certain whether the unusually high catches in 2003-2005 were due to increases in recruitment resulting in a greater biomass of fish, or whether biomass did not change but due to oceanographic changes the fish became more vulnerable during those years. The conclusions made at that time were that the yellowfin stock was not in an overfished state, but overfishing of the stock was likely occurring.

The most recent assessment completed in 2008 gives a slightly different story, depending once again on the reasons for the very high catches in 2003-2005. If the extraordinarily high catches during that period were due to increases in recruitment resulting in an increase in biomass, then the stock was probably not being overfished; however, if recruitment during that time was average, but the fish more available and/or vulnerable to catching because of environmental conditions, then biomass would have been driven down significantly by the high catches. The Scientific Committee of IOTC has examined environmental data that leads them to favor the latter situation.

For the most recent assessment the scientists once again used a variety of models to determine the status of the stock. The assessments were difficult because of the uncertainty relating to the high catches during 2003-2006 and the conflicting trends between total catches and longline indices of abundance during the 1950s and 1960s. With respect to this latter concern, the very large removals of fish did not reflect a corresponding decrease in the indices of abundance, which fact is not consistent with production model theory.

The MULTIFAN-CL model, which is a size based, age- and spatially-structured population model, was used for Indian Ocean yellowfin for the first time in the 2008 analysis, and it offered the advantage of being able to use much of the tagging data that had been generated by the Commission over the past few years. Results from the model indicate recent levels of F were at historically high levels and overfishing occurred during 2003-2006. The estimates of F were robust to the value of steepness fixed in the model, but biomass varied with the assumed level of steepness (0.6-0.8), and at all levels of steepness $F_c > F_{MSY}$. Depending on the shape of the stock recruitment curve the MSY was estimated to vary between 250 and 300 thousand tons. For the lower values of assumed steepness the SSB is estimated to be below the MSY level and in an overfished state ($SSB/SSB_{MSY}=0.94$); however, for the higher values biomass is estimated to be above the MSY level (1.13-1.03), and the stock is not in an overfished state. The lower from 1.0 the value of steepness, the greater is the relationship between spawners and recruits; however, for most tropical tunas there is little or no evidence to show that recruitment is related to the size of the spawning stock (steepness of 1.00) over the values that have been observed for most tuna

fisheries. The model does estimate that recruitment is declining, and therefore SSB could be expected to decline over the next few years.

The SS2 model using length data, growth information, and catch-per-unit-of-effort (CPUE) estimates was also used to assess the stock. Runs of the model were made using longline CPUE values and purse-seine data separated by the method of fishing. Results from this analysis estimated the MSY to be 300 thousand tons per year and the biomass to be above the MSY level ($B_{\text{current}}/B_{\text{MSY}} > 1.00$); however, there was a great deal of uncertainty concerning these results.

A simple surplus production model analysis was conducted using CPUE data from the Japanese and Chinese Taipei longline fisheries. Runs of the model were made using the combined longline CPUEs and each CPUE series separately. The different runs produced very similar re-

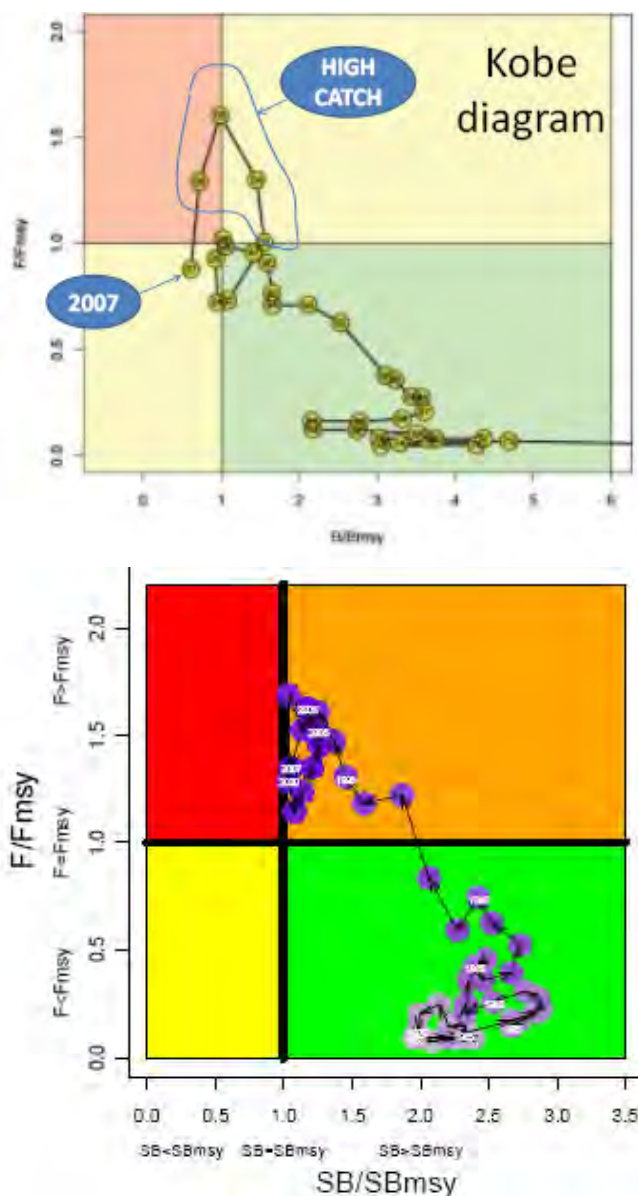


FIGURE B-19. Phase plot for yellowfin in the Indian Ocean (IOTC-WPTT); upper graph shows results from ASPM model and the lower graph shows results from the MULTI-FAN-CL model.

sults. The analyses indicated the biomass to be below the MSY level and the fishing mortality to be slightly above the MSY level.

An age structured production model (ASPM) using catch at age data and series of CPUE values was used to estimate management related parameters and trends in biomass. More than eighty different runs of the model using different formats for the fishery were made, but only three gave biologically reasonable results. The results suggested that the yellowfin stock is now entering into an overfished condition after high catches during 2003-2006, but that if catches do not exceed the 2007 level of 316 thousand tons it will recover to the SSB_{MSY} level within a few years.

The overall conclusion to be drawn from the foregoing information is: 1) the stock of yellowfin tuna in the Indian Ocean is slightly above, or just below the MSY based reference points (Figure B-19) with B_{2007}/B_{MSY} ranging from 0.93 to 1.13, and SB_{2007}/SB_{MSY} ranging from 0.61 to 1.18, suggesting it is close to or has recently entered an overfished state, and 2) estimates of current F were above the MSY reference point in all but one of the cases examined, with F_{2007}/F_{MSY} values ranging from 0.9 to 1.60, suggesting overfishing is likely occurring. The most probable MSY estimates ranged between 250 and 300 thousand tons, although some results suggested values as high as 360 thousand tons. The 2007 catch was very near the MSY, while catches during the 2003-2006 period were substantially higher than the MSY, assuming average recruitment during that period. Although there is some question as to whether the stock is in an overfished state currently, if levels of fishing mortality generated during 2003-2006 and 2007 continue there will be little doubt that the stock will be in an overfished state. Considering all of these above factors, from a precautionary point of view the stock is considered to be in an **overfished state**, and **overfishing of the stock is currently taking place**.

4.1.2. Next scheduled stock assessment

The next assessment by the WPTT will be in Mombasa, Kenya in 2009.

4.1.3. Conservation and management of yellowfin

Until the recent assessment there was apparently no overfishing of yellowfin tuna, with the possible exception of reduced yield per recruit resulting from the FAD fishery, therefore there has been very limited action taken by IOTC with respect to the implementation of conservation and management measures for yellowfin in the Indian Ocean. Because of concern over the increasing catches of small yellowfin in the FAD fishery, and overall increases in fishing mortality, the Plenary requested in 2002 that the Scientific Committee provide them with technical advice with respect to options for managing yellowfin, particularly the possibility of time and area closures. Although there was some discussion of this in 2003 meetings, no action was taken at that meeting or in subsequent ones.

In 2003 the Commission approved a resolution recommending limitations on fishing capacity. Although this was not a directed measure towards yellowfin, it theoretically would impact that stock as well as others. The resolution also called on CPCs with more than 50 vessels in the fishery of a size greater than 24 meters in length to limit the number of their vessels to the number they had in 2003. Exceptions were made for coastal developing states that submitted development plans to IOTC. These measures were updated in 2006 and are to apply through 2009.

Once again, in 2003 the Commission established a working group to examine options for managing yellowfin tuna that could be considered in 2005. No action was taken on these management options. In essence, there has been no directed management of yellowfin tuna in the Indian Ocean.

The Scientific Committee has recommended in their report to the Commission that the catch of yellowfin tuna not exceed the average catch for the period 1998-2002 when catches were stable, prior to the exceptional years of 2003-2006, a time when the stock might have been overexploited. They also recommended that the fishing effort should not exceed the level exerted in 2007 when the catch of yellowfin tuna returned to the pre-2003 levels

4.2. Bigeye

Bigeye tuna occur throughout the Indian Ocean. They are considered a single stock, but perhaps a few individuals exchange between the Atlantic and Indian Ocean. For centuries bigeye have been harvested in small quantities by artisanal fishermen, but fishing on a large commercial scale did not develop until high-seas longline vessels from Japan began fishing in 1953 in the eastern Indian Ocean. By 1970 catches reached 30 thousand tons, most taken by longline vessels. With the development of the deep longline in 1975, catches by longline vessels increased rapidly, reaching about 100 thousand tons in the late 1980s. At about that time purse-seining on FADs caught increasingly more bigeye in the Indian Ocean. FAD fishing produced a peak catch of about 40 thousand tons in 1999 and since then has averaged about 25 thousand tons. The total catch of bigeye by all gears peaked in 1999 at about 150 thousand tons, but has been declining somewhat since then. The catch in 2005 was 114 thousand tons and in 2006 about 105 thousand tons; during these last two years longline vessels took 85 and 78 thousand tons respectively. The 2007 total catch was 136 thousand tons (Figure B-17). In addition to purse seine and longline, a variety of other methods are used to capture bigeye, including pole-and-line and gillnets, which each capture annually 1-2 thousand tons. The purse-seine fleet operates mostly in the western part of the Indian Ocean in the same general areas of the yellowfin fishery; most longline effort is also expended in the western Indian Ocean, but recently small longliners have been increasing their fishing in the eastern Indian Ocean. Purse-seine fishing on FADs catches small fish averaging about 2 kg, whereas longline vessels take large bigeye averaging about 40 kg (Figure B-20). As bigeye do not reach sexual maturity until about 20 kg, nearly all purse-seine caught bigeye are sexually immature. As in other oceans, the longline industry maintains that the increased catch of small fish by the FAD fishery has reduced recruitment of larger fish to the longline fishery and that is why the longline catch of bigeye has declined in all oceans.

A large number of nations are involved in the fishery, but two, Spain and France account for most of the surface catch, while Chinese Taipei takes the overwhelmingly largest share of the longline fishing fleets.

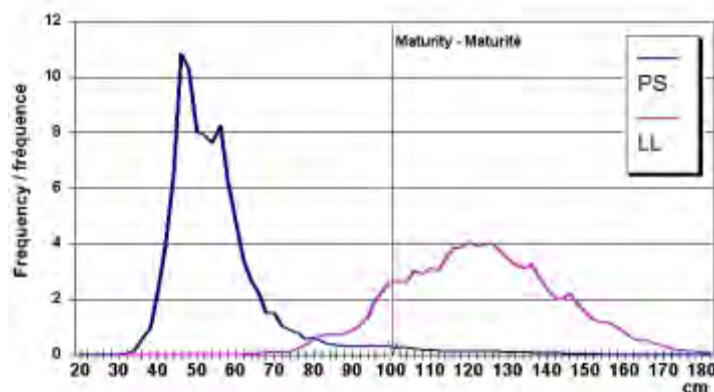


FIGURE B-20. Length of bigeye tuna taken by purse seine and longline in the Indian Ocean (From IOTC Reports).

4.2.1. Most recent stock assessment

The most recent series of assessments for bigeye in the Indian Ocean were completed and presented to the 9th session of the Scientific Committee convened in 2006 and updated in 2008. Several different models were used in the assessments and the main ones are discussed below.

An SS2 analysis used total catch and catch per unit of effort for the Japanese and Chinese Taipei longline fisheries for the years 1960 to 2004. The biological parameters, weight at 8 ages, natural mortality and fecundity were entered as known quantities into the model, and a Beverton and Holt type spawner-recruit relationship with varying values for steepness of the relationship was employed. The MSY for this analysis was estimated to be 137 thousand tons, and the fishing mortality ratio was 0.75, which is significantly less than 1 and indicates there is a lower chance that overfishing could be occurring. Similarly, the ratio of the 2004 estimate of biomass to the biomass at MSY was greater than 1, indicating the stock is not in an overfished state.

A statistical catch at age or length model (CASAL) was also used with catch and effort data for 1960-2004. Longline catch per effort estimates were used to tune the model and catch at age for the purse-seine, longline, and artisanal fisheries was also used. The results were similar to those of the other assessment models. The MSY was estimated to be about 130 thousand tons, and the current biomass was estimated to be above the MSY level. Projections were made using the levels of catch taken during the last few years, 29 thousand tons for the surface fishery and 105 thousand tons for the longline fishery. Keeping catch at these levels would cause the biomass to fall below the MSY level within the next several years.

An age structured production model (ASPM) was utilized with input data similar to that used in the SS2 analysis. A number of runs were made in which some of these input values were varied. The base-case run estimated an MSY of 111 thousand tons (95-128). Trends in the fishing mortality ratio showed it to be less than 1 ($F_{2004}/F_{MSY}=0.81$; 0.54-1.08). The 2004 spawning biomass was about 34 percent above the spawning biomass at MSY ($SB_{2004}/SB_{MSY}=1.34$, 1.04-1.64). The authors compared estimates which were made in 2002, 2004, 2005, 2006, and 2007 using the same model. The estimates were relatively consistent with each other and showed the fishing mortality ratio to increase over time, but to remain < 1.0 for most cases. This analysis does not show the stock to be in an overfished state, nor overfishing to be taking place. However, if fishing mortality is maintained at the 2004 level the SB will decline to the MSY level by 2015. The most recent estimate of the fishing mortality ratio is very near to 1, so if fishing effort increases over current levels, overfishing will occur. Also, catches between 1993 and 2005 have been in excess of the base case estimate of MSY, so that if fishing continues at this level the stock will become overfished.

All of the above analyses suggest that the stock of bigeye in the Indian Ocean **is not in an overfished state, nor is overfishing occurring**, but if fishing mortality increases to the level it was during 2004 the stock will decline to or below the MSY level within several years.

4.2.2. Next scheduled stock assessment

There is no schedule for the next bigeye assessment.

4.2.3. Conservation and management of bigeye

In 2001 the Commission called on non-members to limit their fishing effort on bigeye tuna to 1999 levels and to report to the Commission on the measures they have taken to comply with this request.

In order to improve the monitoring of catches of bigeye the Commission approved a measure, effective July 2002, requiring that all bigeye tuna when imported into the territory of a Contracting Party, be accompanied by an IOTC Bigeye Tuna Statistical Document.

The 2003 and 2006 measures to limit fishing capacity applied to all vessels, whether fishing bigeye or other species.

In 2005 the Commission agreed that CPCs shall limit their catch of bigeye tuna to recent levels of catch and to request Chinese Taipei to limit its annual bigeye catch in the Indian Ocean to 35 thousand tons.

Based on the most current assessments of bigeye the 2006 Meeting of the Scientific Committee recommended that bigeye catches should not exceed the MSY and fishing effort should not increase beyond the levels exerted in 2004, but the Commission did not implement the recommendation.

4.3. Skipjack

Like skipjack in all other oceans, the stock of skipjack in the Indian Ocean is abundant and widely distributed, but for purposes of management is considered to be a single unit. They are the smallest of the principal market species, but support the largest tuna fisheries world-wide. They are relatively short lived, most are captured within their first year of life, and because of their biological characteristics such as rapid growth, widespread spawning, high fecundity, and high mortality rate, the skipjack stock of the Indian Ocean is resilient and more difficult to overfish than other tunas.

Some skipjack are caught throughout most of the Indian Ocean but the largest part by far is taken from the western Indian Ocean between about 15°N and 20°S, and between 75°E and the mainland of Africa.

Catches of skipjack in the Indian Ocean were low until 1984 when the French and Spanish purse-seine fleets began to fish in the region; they averaged less than 50 thousand tons before 1984, but after that they jumped to over 113 thousand tons, and increased each year to a peak in 2006 of more than 600 thousand tons; the catch dropped to about 436 thousand tons in 2007. A wide variety of fishing techniques are used to capture skipjack; purse-seine vessels take about 43 percent of the total catch, pole-and-line vessels about 24 percent, gill nets about 23 percent, and a multitude of other fishing techniques take the remaining 10 percent. Much of the skipjack from the Indian Ocean is taken in association with either anchored or drifting FADS. The average size of skipjack taken with FADS is about 2.6 kg, with free schools about 3.0 kg, by the Maldivian pole-and-line fishery about 3.0 kg, and the gillnet fishery about 4.5 kg. The nation of the Maldives accounts for about 24 percent of the total catch, which is the largest harvest of skipjack from the Indian Ocean by a single nation. Spain is the next largest producer, harvesting about 19 percent of the catch and Iran is next with about 16 percent. A large number of other nations account for the remainder with most of them taking from 1-8 percent each.

4.3.1. Most recent stock assessment

No comprehensive assessment has been made for the skipjack stock of the Indian Ocean. In lieu of an assessment the WPTT has examined a number of fishery indicators to gain insight into the status of the stock: 1) Since the advent of purse-seine fishing, catches of skipjack have continued to increase with increasing effort; 2) Trends in the relative rate of catch increase show no signs that catch is diminishing; 3) Trends in catch per effort for a number of the fisheries show relative

stability since the early 1990s, although increasing efficiency could mask any significant decreases; 4) The average size of fish in the catch has not decreased; 5) The number of one-degree areas fished has remained stable since about 1990, indicating that increased catches are not a result of expansion to new areas. Based on the biological characteristics of skipjack and these various fishery indicators, it has been concluded by the WPTT that there is no immediate concern regarding the status of the skipjack stock. However, because it cannot be expected that skipjack catches will continue to increase indefinitely it has been recommended that skipjack be monitored on a regular basis. It is concluded that **the stock of skipjack in the Indian Ocean is not in an overfished state, nor is overfishing occurring.**

4.3.2. Next scheduled stock assessment

There is no schedule for the next skipjack assessment.

4.3.3. Conservation and management of skipjack tuna

Because the IOTC considers that skipjack are not fully exploited they have made no recommendations for conservation and management. Theoretically, the measures for limiting fishing effort and capacity mentioned earlier would affect the catches of skipjack since most is taken in association with FADs and in schools mixed with yellowfin and bigeye.

4.4. Albacore

Unlike the Atlantic and Pacific, which each have a northern and southern stock that are associated with an northern and southern ocean gyre, there is only one stock of albacore in the Indian Ocean, probably because there is no northern gyre, and it is distributed throughout much of the Indian Ocean, but catches are made mostly between 20 and 40°S and west of about 100°E. The heaviest concentration of captures is in a zone between roughly 25 and 35°S. In the west, there is a continuous distribution of albacore from the Indian Ocean around southern Africa into the Atlantic, which suggests interchange between the two oceans. Even though there is probably interchange between oceans, for purposes of management the albacore of the Indian Ocean are considered to be a separate stock from those in the Atlantic and Pacific. Juvenile albacore are found more frequently to the north of the subtropical convergence in cooler waters with temperatures between 15 and 18°C while larger adults probably make spawning migrations into the warmer waters east of Madagascar. Albacore grow more slowly than tropical tunas, reaching sexual maturity at about 5-6 years of age, and can live up to 10 years.

Until 1985 nearly all albacore caught commercially in the Indian Ocean was by longline. From 1950 to 1960 the catch rapidly increased to about 20 thousand tons, where it remained until 1985; in 1985 drift gill-net fishing was introduced by Chinese Taipei, and until 1992 that nation took about 20-25 thousand tons per year, but after the U.N. moratorium on this type of fishing, catches declined to a low of about 18 thousand tons in 1992. After 1992 there was a resurgence of longline fishing and catches increased rapidly to an all time high of 41 thousand tons in 2002, but began to decline thereafter and averaged about 25 thousand tons during 2005/2006/2007. Since the exodus of the gill net fleet from the Indian Ocean, longline has remained the dominant form of fishing and during the last few years has accounted for about 92 percent of the total capture from the Indian Ocean. Purse seine, trolling and pole and line account for most of the remainder. Between 1959 and 1969, Japanese albacore catches ranged between 8 and 18 thousand tons, but around 1970 their vessels began to target southern bluefin and bigeye, so albacore catches for them declined rapidly. Japan currently catches about 20 percent of the albacore from the Indian Ocean. Chinese Taipei albacore catches increased during the time that Japanese

catches were declining and they currently are taking about 50 percent of the total catch. Indonesia is a more recent participant in the longline fishery and now takes about 12 percent of the Indian Ocean catch. Surface fishing for albacore has never made up an important part of the catch. Small albacore are not important in the catch since longline vessels target larger fish averaging about 20 kg; the South African pole-and-line fishery took fish that averaged about 10 kg.

4.4.1. Most recent stock assessment

The working party on temperate tunas (WPTMT) conducted a stock assessment in 2004, using data up to 2003. A general production model was used for the analysis. Catch data for 1960-2002, and catch-per-effort data for 1960-2002 and 1963-2002 for the Japanese fishery and Chinese Taipei fisheries respectively, was applied to the model. Age specific catch-per-effort data was used for the period 1967-2002. The principal index of stock abundance used in the analysis was the catch per effort for the Japanese longline fleet. This index showed a relatively high level of 10 fish per thousand hooks in the fishery during 1960-1964, a rapid decline from 1965 to 1975 to about 2 fish per thousand hooks, stability at that level until 1988, and thereafter declining to slightly less than 2 fish per thousand hooks, but remaining stable at that level until 2002.

Several different runs of the model were made in which the combinations of data and fixed parameters used were altered. For some runs the MSY was estimated to be about 24 thousand tons; the ratio of current fishing mortality to fishing mortality at MSY was greater than 1, suggesting overfishing was occurring, and the ratio of current biomass to biomass at MSY was less than 1, suggesting the stock was in an overfished state. For other runs the biomass ratio was greater than 1 and the fishing mortality ratio less than one, indicating that the stock was not in an overfished state nor that overfishing was occurring. The results from the different runs of the model were so different from each other that little confidence could be placed in any of them.

At the 9th Meeting of the Scientific Committee, held in November 2006, the results of the 2004 analysis of the WPTMT were reviewed. Some of the data was updated, but again results among a variety of runs were highly variable and considered to be unreliable. However, it was noted that other indicators such as average size of fish in the catch and catch rates have not shown a

These analyses were updated in 2008 and an age structured production model was used to evaluate interaction between age at selection by the fishery and age at maturity and its effect on stock status. To estimate the parameters of the model total catch and CPUE of the Chinese Taipei longline for the years 1980-2006 were used. For one analysis selectivity is set at age 4 and maturity at age 5, which allows fish to be captured before they spawn, and for the other selectivity was set at age 5 and maturity at age 5 with spawning occurring before fishing. In both analyses $B_{2007} > B_{MSY}$, indicating the stock was not in an overfished state and that $F_{2007} < F_{MSY}$, indicating overfishing was not occurring. In the first analysis MSY was estimated to be 28,260 tons with a 95 percent confidence interval of 25,353-31,333, and for the second the estimates were 34,415 and 28,414-38,037. In both of these cases, catches during 1998 to 2001 were most likely in excess of MSY. However, catches during 2003-2007 have been around 26 thousand tons, which is about equal to or less than MSY, so overfishing of the stock is probably not occurring. The mean weight of albacore in the catches has been stable over the past 50 years, and the catch rate has been stable of the past 20 years.

Based on all of the above information it is considered that **albacore in the Indian Ocean are not in an overfished state nor is overfishing occurring.**

The Scientific Committee noted the preliminary nature of the albacore tuna assessment in 2008,

but on balance of the available stock status information and stable effort considers that the status of the stock of albacore is not likely to change markedly over the next 2-3 years and if the price of albacore remains low compared to other tuna species, no immediate action should be required on the part of the Commission. They also noted that greater emphasis should be placed on improving estimates of biological parameters such as growth, sexual maturity and natural mortality, as these are currently poorly estimated and lead to uncertainty in the results of the assessments.

4.4.2. Next scheduled stock assessment

The Scientific Committee recommended that the next albacore assessment be no later than 2010.

4.4.3. Conservation and management of albacore tuna

There has been only one measure taken by IOTC that directly addresses the management of albacore. A resolution was approved during the 2007 meeting of the Commission which places a limit on the number of longline vessels targeting albacore (and swordfish). Specifically, all CPCs are requested to limit the number of their vessels greater than 24 meters, and less than 24 meters if they fish outside their EEZ for albacore in the IOTC area of competence, to the number of their vessels recorded by IOTC for 2007. The number of vessels is to be commensurate with the corresponding overall Gross Tonnage, and for any replaced vessel the overall tonnage is not be exceeded. The measure also provides for any CPC with less than 10 vessels to submit a fleet development plan to the Compliance Committee of IOTC for review in 2008; the plans will be reviewed by the Commission and recommendations made regarding development, taking under consideration the advice of the Scientific Committee.

The status of yellowfin, bigeye, and skipjack in the Indian Ocean is summarized in Table B-6.

Species	$B_{\text{current}} < B_{\text{MSY}}$	$B_{\text{current}} \approx B_{\text{MSY}}$	$B_{\text{current}} > B_{\text{MSY}}$
Yellowfin	$B_c < B_{\text{MSY}}$		
Bigeye			$B_c > B_{\text{MSY}}, F_c < F_{\text{MSY}}$
Skipjack			$B_c > B_{\text{MSY}}, F_c < F_{\text{MSY}}$
Albacore			$B_c > B_{\text{MSY}}, F_c < F_{\text{MSY}}$

TABLE B-6. Status of yellowfin, bigeye and skipjack in the Indian Ocean, where $B_c = B_{\text{current}}$ the current biomass and $F_c = F_{\text{current}}$ the current fishing mortality rate, and F_{MSY} and B_{MSY} are the corresponding values for levels when the population is at a level corresponding to the MSY.