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STATUS OF YELLOWFIN TUNA IN THE EASTERN PACIFIC OCEAN IN 2014 AND OUTLOOK FOR THE FUTURE

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This report presents the most current stock assessment of yellowfin tuna (*Thunnus albacares*) in the eastern Pacific Ocean (EPO). An integrated statistical age-structured stock assessment model (Stock Synthesis Version 3.23b) was used in the assessment, which is based on the assumption that there is a single stock of yellowfin in the EPO. This model is the same as that used in the previous assessment in 2014 (IATTC Stock Assessment Report 15).

Yellowfin are distributed across the Pacific Ocean, but the bulk of the catch is made in the eastern and western regions. Purse-seine catches of yellowfin are relatively low in the vicinity of the western boundary of the EPO at 150ºW. The majority of the catch in the EPO is taken in purse-seine sets on yellowfin associated with dolphins and in unassociated schools. Tagging studies of yellowfin throughout the Pacific indicate that the fish tend to stay within 1800 km of their release positions. This regional fidelity, along with the geographic variation in phenotypic and genotypic characteristics of yellowfin shown in some studies, suggests that there might be multiple stocks of yellowfin in the EPO and throughout the Pacific Ocean. This is consistent with the fact that longline catch-per-unit-of-effort (CPUE) trends differ among areas in the EPO. However, movement rates between these putative stocks, as well as across the 150°W meridian, cannot be estimated with currently-available tagging data.

The stock assessment requires substantial amounts of information, including data on retained catches, discards, indices of abundance, and the size compositions of the catches of the various fisheries. Assumptions have been made about processes such as growth, recruitment, movement, natural mortality, fishing mortality (F), and stock structure. The assessment for 2014 is nearly identical1 to that of 2013, and includes new and updated data. The staff performed substantial investigative analyses in preparation for the external review of its assessment of yellowfin tuna, held in October 2012. The review resulted in a series of recommendations (Document SAC-04-INF A), which are being explored to be incorporated in the upcoming full stock assessment.

The catch data for the surface fisheries have been updated and new data added for 2014. New or updated longline catch data are available for China (2013), Japan (2008-2013), Korea (2013), Chinese Taipei (2011-2013), the United States (2012-2013), French Polynesia (2013), Vanuatu (2013-2014), and other nations (2013). Japanese longline catch data for 2014 are available from the monthly report statistics. For longline fisheries with no new catch data for 2014, catches were assumed to be the same as in 2013. Surface fishery CPUE data were updated, and new CPUE data added for 2014. New or updated CPUE data are available for the Japanese longline fleet (2008-2013). New surface-fishery size-composition data for 2014 were added and data for 2013 were updated. New or updated length-frequency data are available for the Japanese longline fleet (2008-2013).

[1] The CV for the LL-S index was assumed to be 0.2. See Appendix A of IATTC Stock Assessment Report 14

In general, the recruitment of yellowfin to the fisheries in the EPO is variable, with a seasonal component. This analysis and previous analyses indicate that the yellowfin population has experienced two, or possibly three, different recruitment productivity regimes (1975-1982, 1983-2002, and 2003-2012) (Figure 1). The recruitments for 2011 and 2012 were estimated to be below average. The most recent recruitments (2013 and 2014) were estimated to be above average, but these estimates are highly uncertain. The productivity regimes correspond to regimes in biomass, with higher-productivity regimes producing greater biomass levels. A stock-recruitment relationship is also supported by the data from these regimes, but the evidence is weak, and this is probably an artifact of the apparent regime shifts.

The average weights of yellowfin taken from the fishery have been fairly consistent over time, but vary substantially among the different fisheries. In general, the floating-object, northern unassociated, and pole-and-line fisheries capture younger, smaller yellowfin than do the southern unassociated, dolphin-associated, and longline fisheries. The longline fisheries and the dolphin-associated fishery in the southern region capture older, larger yellowfin than the northern and coastal dolphin-associated fisheries.

Substantial levels of fishing mortality have been estimated for the yellowfin fishery in the EPO (Figure 2). These levels are highest for middle-aged yellowfin. Historically, the dolphin-associated and unassociated purse-seine fisheries have the greatest impact on the spawning biomass of yellowfin, followed by the floating-object fisheries. In more recent years, the impact of the floating-object fisheries has been greater than that of the unassociated fisheries. The impacts of the longline and purse-seine discard fisheries are much less, and have decreased in recent years (Figure 3).

The spawning biomass ratio (the ratio of the spawning biomass to that of the unfished population; SBR) of yellowfin in the EPO was below the level corresponding to the maximum sustainable yield (MSY) during 1977-1983, coinciding with the low productivity regime, but above that level during most of the following years, except for the recent period (2005-2007 and 2010-2014) (Figure 4). The 1984 increase in the SBR is attributed to the regime change, and the recent decrease may be a reversion to an intermediate productivity regime. The different productivity regimes may support different MSY levels and associated SBRs. The SBR at the start of 2015 was estimated to be 0.26, slightly below the MSY level (0.27). The recent (2011-2014) SBRs estimated by the current assessment are less optimistic than those produced by the previous assessment, which indicated a sharp decline in spawning biomass after 2009, followed by an increase in 2012 to above the level corresponding to the MSY (IATTC Stock Assessment Report 15). In the current assessment, the SBRs for 2012, and for 2013 and 2014 as well, are slightly below the MSY level . This result is probably due to the higher fishing mortality of middle-aged yellowfin since 2009 estimated by the current assessment (Figure 2). The effort is estimated to be below the level that would support the MSY (based on the current distribution of effort among the different fisheries) (Figure 5, and recent catches are below that level (Table 1). It is important to note that the curve relating the average sustainable yield to the long-term fishing mortality is flat around the MSY level (Figure 6). Therefore, moderate changes in the long-term levels of effort will change the long-term catches only marginally, while changing the biomass considerably. Maintaining the fishing mortality below the MSY level would result in only a marginal decrease in the long-term average yield, with the benefit of a relatively large increase in the spawning biomass. In addition, if management is based on the base case assessment (which assumes that there is no stock-recruitment relationship), when in fact there is such a relationship, there would be a greater loss in yield than if management is based on assuming a stock-recruitment relationship when in fact there is no relationship (Figure 6).

The MSY calculations indicate that, theoretically at least, catches could be increased if the fishing effort were directed toward longlining and purse-seine sets on yellowfin associated with dolphins. This would also increase the SBRs.

The MSY has been stable during the assessment period (1975-2014) (Figure 7), which suggests that the overall pattern of selectivity has not varied a great deal through time. However, the overall level of fishing effort has varied with respect to the MSY level.

If a stock-recruitment relationship is assumed, the outlook is more pessimistic, and current effort is estimated to be above the MSY level (Table 1). Previous assessments have indicated that the status of the stock is also sensitive to the value assumed for the average size of the oldest fish, and more pessimistic results are obtained when higher values are assumed for this parameter. At current (2012-2014) levels of fishing mortality and average levels of recruitment, the spawning biomass is predicted to increase above the MSY level (Figure 4). However, the confidence intervals are wide, and there is a moderate probability that the SBR will be substantially above or below this level. In addition, the spawning biomass is predicted to remain below the MSY level if a stock-recruitment relationship is assumed (Figure 5). If fishing effort continues at recent levels, both the spawning biomass (Figure 4) and the catches of surface fisheries (Figure 8) are predicted to increase, assuming average recruitment and no stock-recruitment relationship (base case). Slightly higher catches are predicted if in fact such a relationship exists (Figure 8).

Key Results

1. There is uncertainty about recent and future levels of recruitment and biomass. There have been two, and possibly three, different productivity regimes, and the MSY levels and the biomasses corresponding to the MSY may differ among the regimes. The population may have switched in the last ten years from a high to an intermediate productivity regime.
2. The recent fishing mortality rates are below the MSY level, and the recent levels of spawning biomass are estimated to be at that level. As noted in IATTC Stock Assessment Report 15 and previous assessments, these interpretations are uncertain, and highly sensitive to the assumptions made about the steepness parameter of the stock-recruitment relationship, the average size of the older fish, and the assumed levels of natural mortality. The results are more pessimistic if a stock-recruitment relationship is assumed, if a higher value is assumed for the average size of the older fish, and if lower rates of natural mortality are assumed for adult yellowfin.
3. The recent levels of spawning biomass predicted by the current assessment are more optimistic than those from the previous assessment (IATTC Stock Assessment Report 15). This result is due to moderate fishing mortality levels for middle-age yellowfin tuna since 2008, which are estimated by the current assessment.
4. Increasing the average weight of the yellowfin caught could increase the MSY.

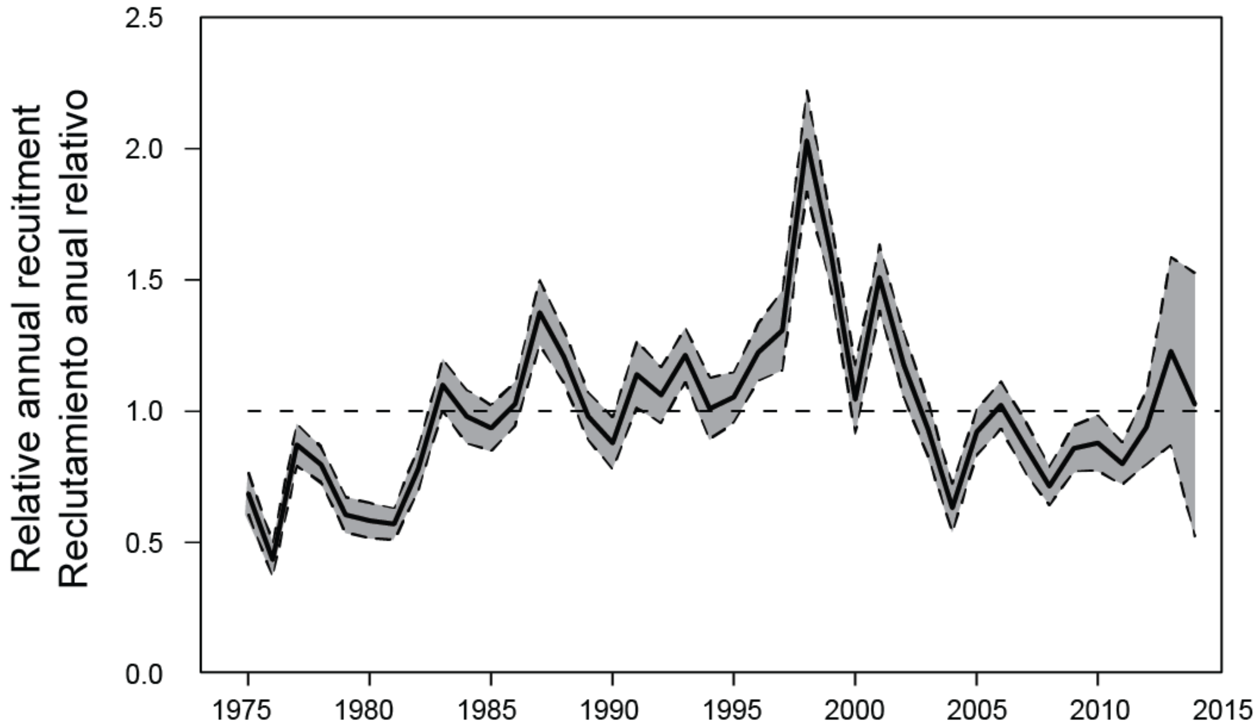

FIGURE 1. Estimated annual recruitment at age zero of yellowfin tuna to the fisheries of the EPO. The estimates are scaled so that the average recruitment is equal to 1.0 (dashed horizontal line). The solid line illustrates the maximum likelihood estimates of recruitment, and the shaded area indicates the approximate 95% confidence intervals around those estimates.

FIGURA 1. Reclutamiento anual estimado a edad cero del atún aleta amarilla a las pesquerías del OPO. Se escalan las estimaciones para que el reclutamiento medio equivalga a 1.0 (línea de trazos horizontal). La línea sólida ilustra las estimaciones de verosimilitud máxima del reclutamiento, y la zona sombreada los límites de confianza de 95% aproximados de las estimaciones.

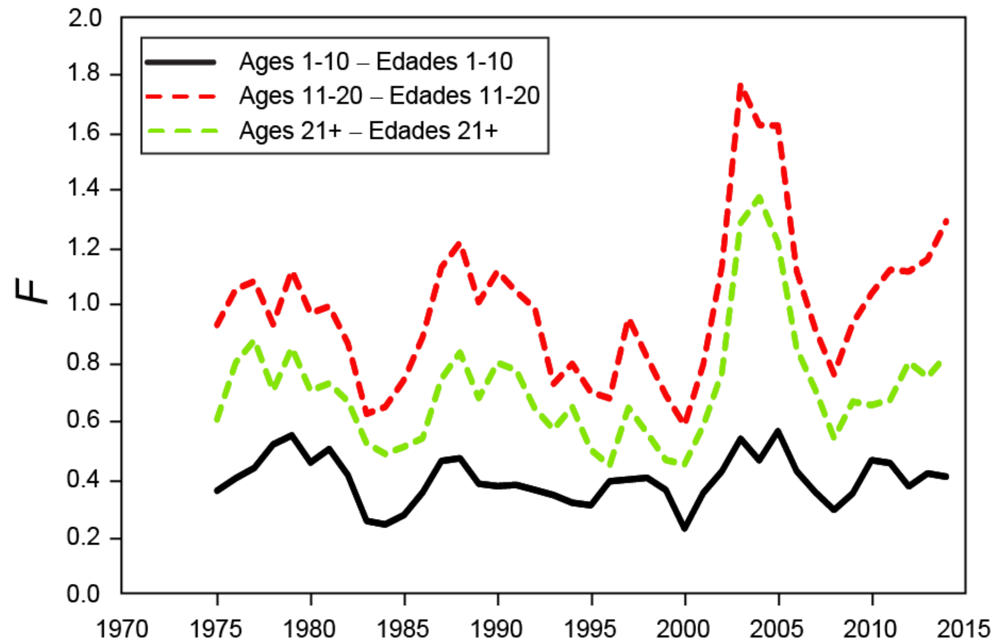

FIGURE 2. Average annual fishing mortality (*F*) by age groups, by all gears, of yellowfin tuna recruited to the fisheries of the EPO. The age groups are defined by age in quarters.
FIGURA 2. Mortalidad por pesca (*F*) anual media, por grupo de edad, por todas las artes, de atún aleta amarilla reclutado a las pesquerías del OPO. Se definen los grupos de edad por edad en trimestres.

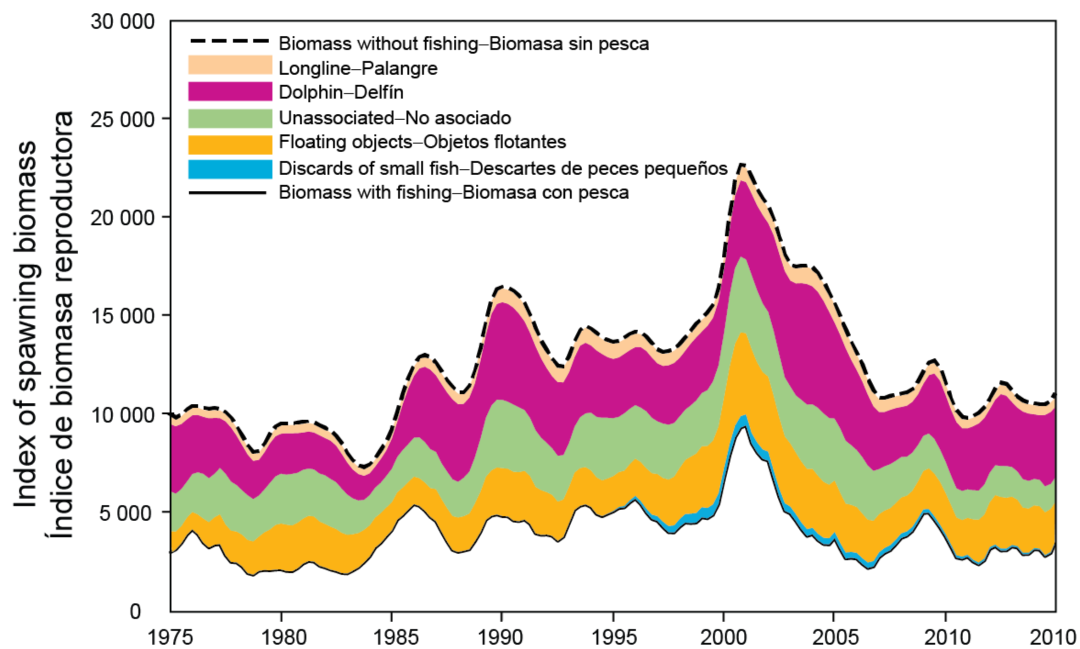

FIGURE 3. Biomass trajectory of a simulated population of yellowfin tuna that was never exploited (dashed line) and that predicted by the stock assessment model (solid line). The shaded areas between the two lines show the portions of the fishery impact attributed to each fishing method.
FIGURA 3. Trayectoria de la biomasa de una población simulada de atún aleta amarilla que nunca fue explotada (línea de trazos) y aquella predicha por el modelo de evaluación de la población (línea sólida). Las áreas sombreadas entre las dos líneas representan la porción del impacto de la pesca atribuida a cada método de pesca.

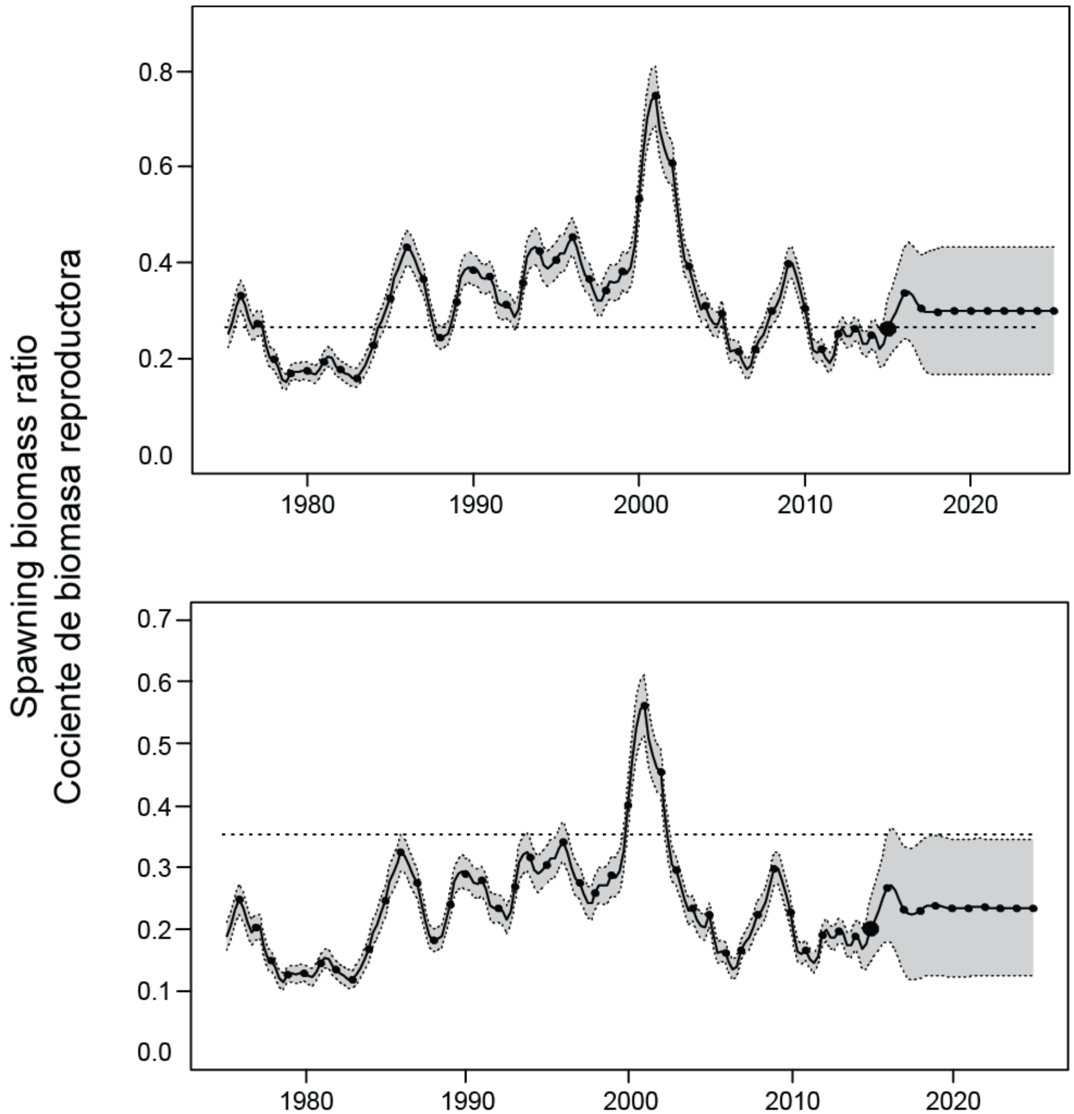

FIGURE 4. Spawning biomass ratios (SBRs) for yellowfin tuna in the EPO, including projections for 2015-2025 based on average fishing mortality rates during 2012-2014, from the base case (top) and the sensitivity analysis that assumes a stock-recruitment relationship (h = 0.75, bottom). The dashed horizontal line (at 0.27 and 0.35, respectively) identifies the SBR at MSY. The solid curve illustrates the maximum likelihood estimates, and the estimates after 2015 (the large dot) indicate the SBR predicted to occur if fishing mortality rates continue at the average of that observed during 2012-2014, and average environmental conditions occur during the next 10 years. The shaded area indicates the approximate 95% confidence intervals around those estimates.

FIGURA 4. Cocientes de biomasa reproductora (SBR) de atún aleta amarilla en el OPO, con proyecciones para 2015-2025 basadas en las tasas de mortalidad por pesca medias durante 2012-2014, del caso base (arriba) y el análisis de sensibilidad que supone una relación población-reclutamiento (h = 0.75, abajo). La línea de trazos horizontal (en 0.27 y 0.35, respectivamente) identifica el SBR correspondiente al RMS. La curva sólida ilustra las estimaciones de verosimilitud máxima, y las estimaciones a partir de 2015 (punto grande) indican el SBR que se predice ocurrirá con tasas de mortalidad por pesca en el promedio de aquellas observadas durante 2012-2014, y con condiciones ambientales medias durante los 10 años próximos. El área sombreada indica los intervalos de confianza de 95% aproximados alrededor de esas estimaciones.

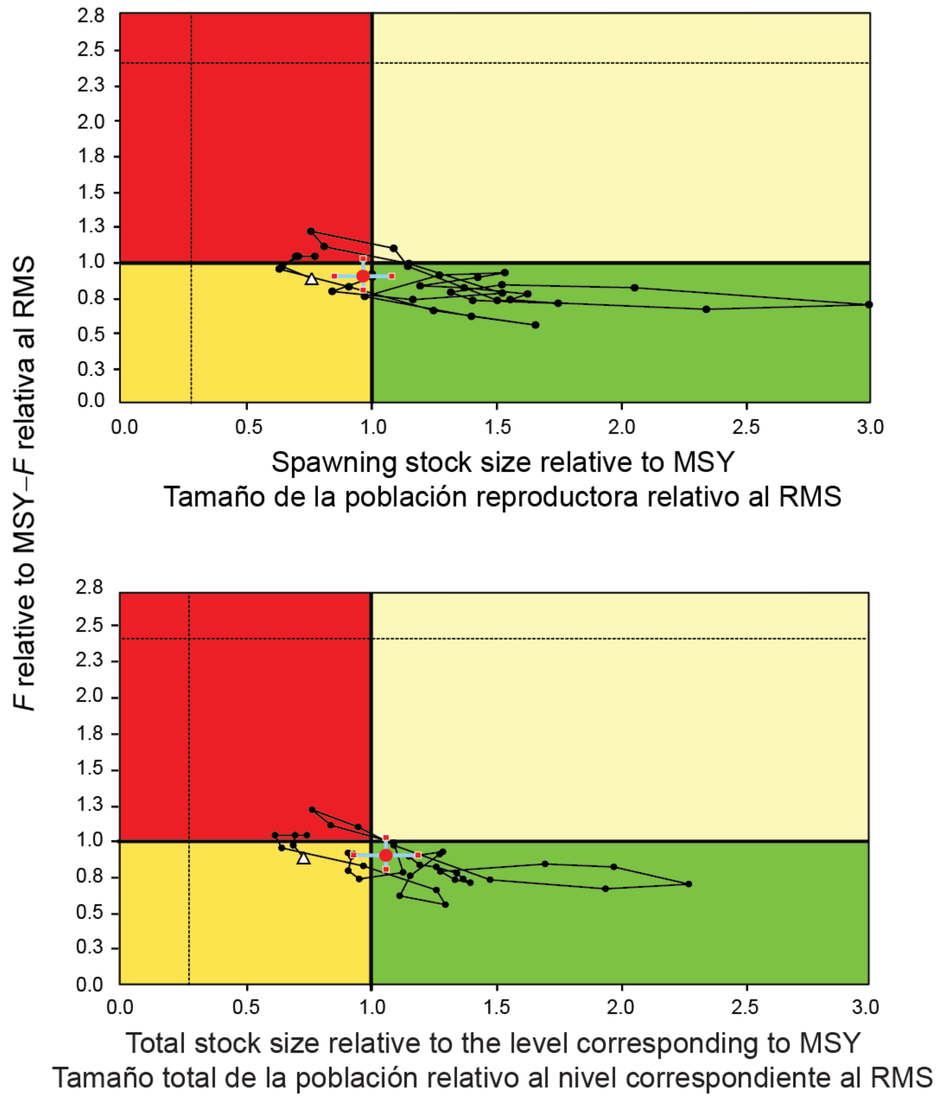

FIGURE 5. Kobe (phase) plot of the time series of estimates of stock size (top: spawning biomass; bottom: total biomass of fish aged 3 quarters and older) and fishing mortality relative to their MSY reference points. The panels represent interim target reference points (S_{MSY} and F_{MSY}). The solid lines represent the interim limit reference points of 0.28 *S_{MSY} and 2.42*F_{MSY}, which correspond to a 50% reduction in recruitment from its average unexploited level based on a conservative steepness value (h = 0.75) for the Beverton-Holt stock-recruitment relationship. Each dot is based on the average exploitation rate over three years; the large red dot indicates the most recent estimate. The squares around the most recent estimate represent its approximate 95% confidence interval. The triangle is the first estimate (1975).

FIGURA 5. Gráfica de Kobe (fase) de la serie de tiempo de las estimaciones del tamaño de la población (arriba: biomasa reproductora; abajo: biomasa total de peces de 3 o más trimestres de edad) y la mortalidad por pesca en relación con sus puntos de referencia de RMS. Las líneas contínuas representan los puntos de referencia límite provisionales de 0.28*S_{RMS} y 2.42*F_{RMS}, que corresponden a una reducción de 50% del reclutamiento de su nivel medio no explotado basada en un valor cauteloso de la inclinación de la relación población-reclutamiento de Beverton-Holt (h = 0.75). Cada punto se basa en la tasa de explotación media de tres años; el punto rojo grande indica la estimación más reciente. Los cuadrados alrededor de la estimación más reciente representan su intervalo de confianza de 95% aproximado. El triángulo es la primera estimación (1975).

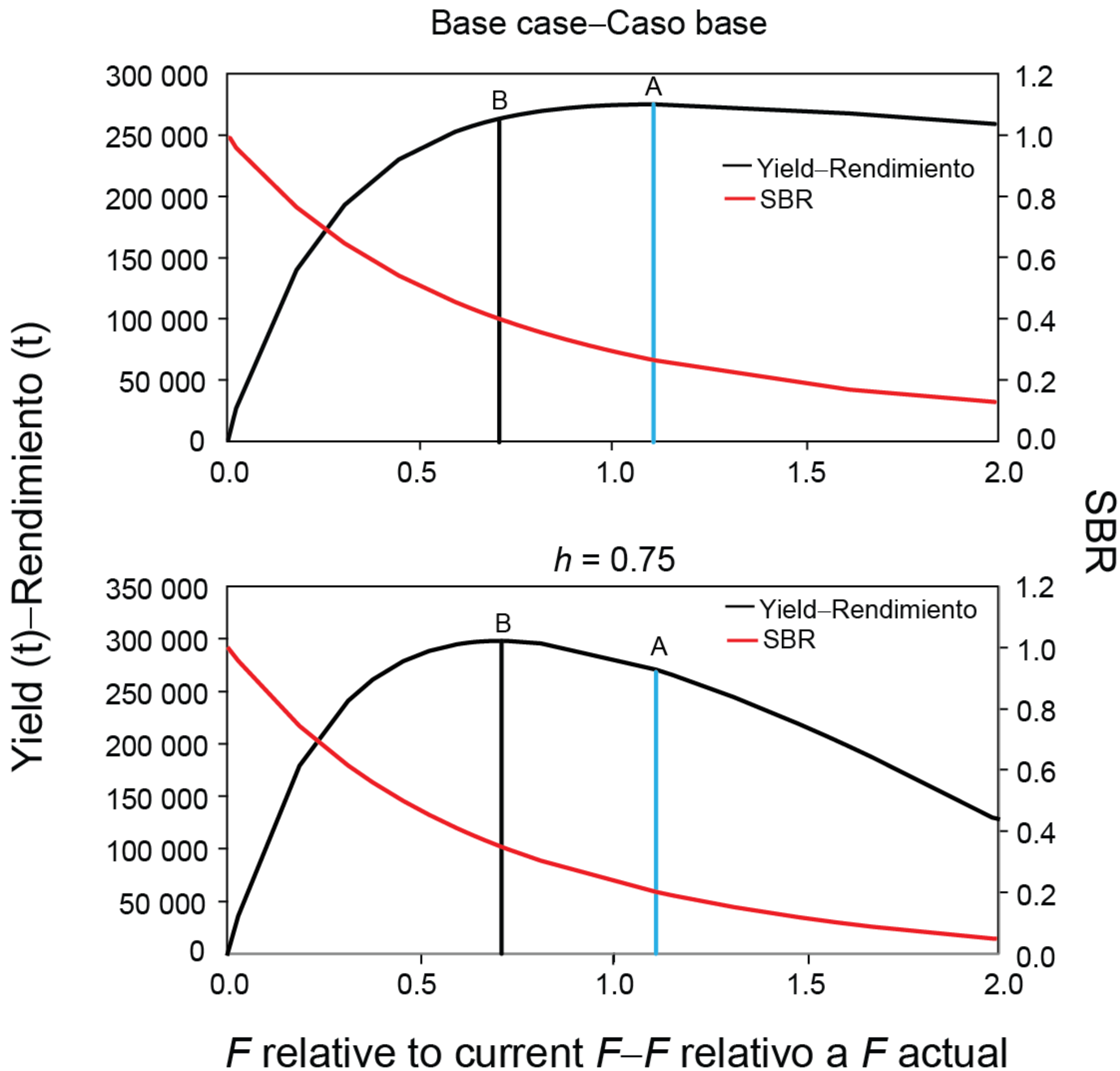

FIGURE 6. Yield and spawning biomass ratio (SBR) as a function of fishing mortality relative to the current fishing mortality. The vertical lines represent the fishing mortality corresponding to MSY for the base case and the sensitivity analysis that assumes a stock-recruitment relationship (h = 0.75). The vertical lines A and B represent the fishing mortality corresponding to MSY for the base case and h = 0.75, respectively.

FIGURA 6. Rendimiento y cociente de biomasa reproductora (SBR) como función de la mortalidad por pesca relativa a la mortalidad por pesca actual. Las líneas verticales representan la mortalidad por pesca correspondiente al RMS del caso base y del análisis de sensibilidad que supone una relación población-reclutamiento (h = 0.75). Las líneas verticales A y B representan la mortalidad por pesca correspondiente al RMS del caso base y de h = 0.75, respectivamente.

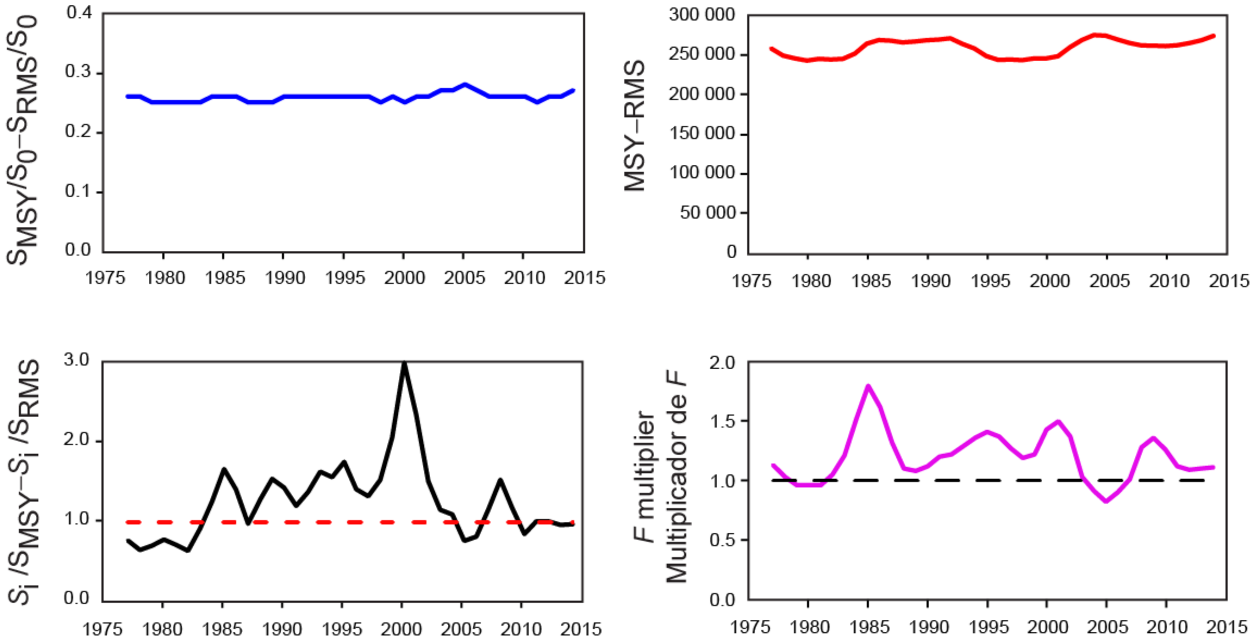

FIGURE 7. Estimates of MSY-related quantities calculated using the average age-specific fishing mortality for each year (S_i is the index of spawning biomass at the end of the last year in the assessment).
FIGURA 7. Estimaciones de cantidades relacionadas con el RMS calculadas a partir de la mortalidad por pesca media por edad para cada año. (S_i es el índice de la biomasa reproductora al fin del último año en la evaluación).

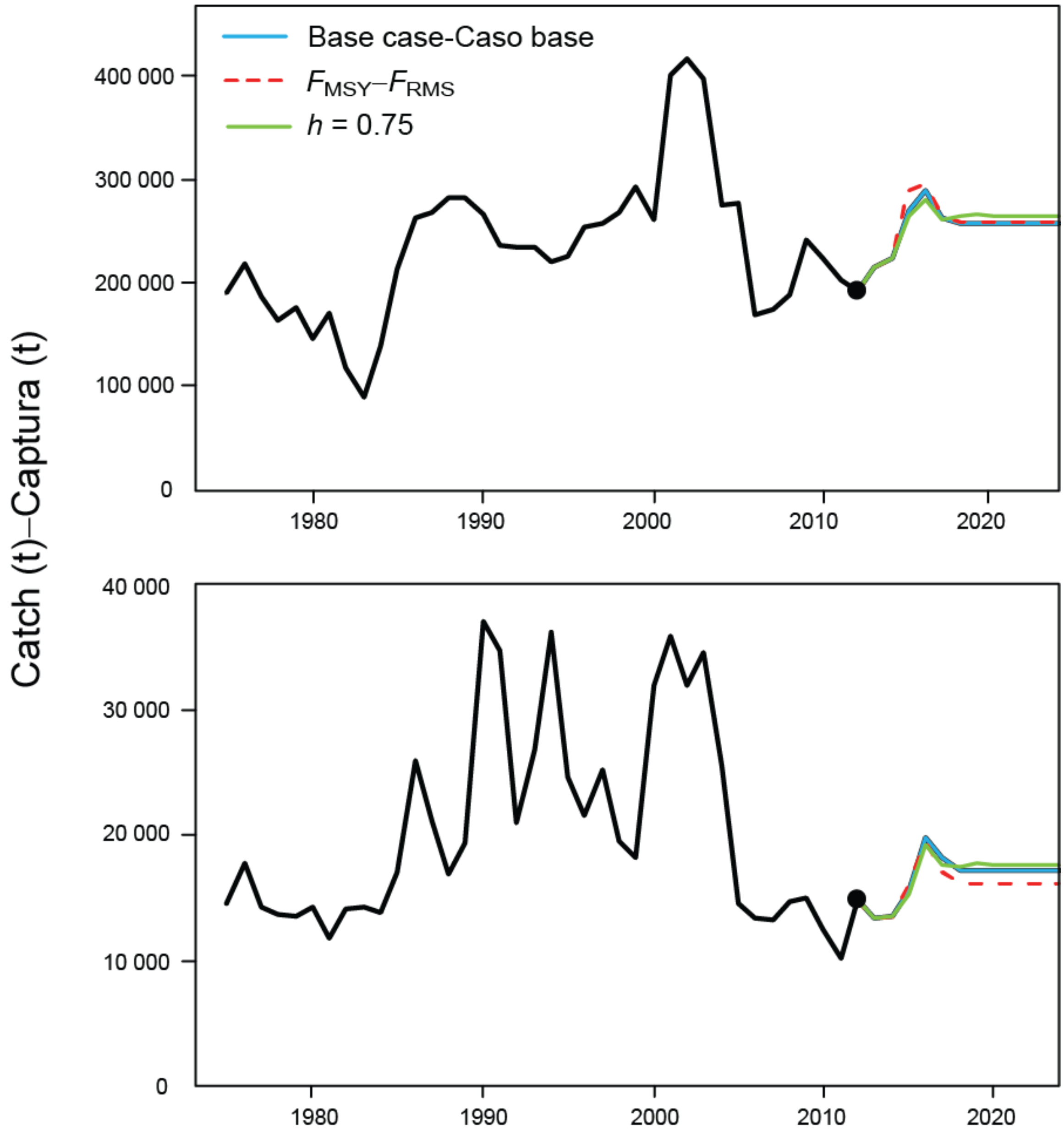

FIGURE 8. Historic and projected annual catches of yellowfin tuna by surface (top panel) and longline (bottom panel) fisheries from the base case while fishing with the current effort, the base case while fishing at the fishing mortality corresponding to MSY (F_{MSY}), and the analysis of sensitivity to steepness (labeled h = 0.75) of the stock-recruitment relationship while fishing with the current effort. The large dot indicates the most recent catch (2014).

FIGURA 8. Capturas históricas y proyectadas de atún aleta amarilla por las pesquerías de superficie (panel superior) y palangre (panel inferior) del caso base con la pesca en el nivel actual de esfuerzo, del caso base con la pesca en la mortalidad por pesca correspondiente al RMS (F_{RMS}), y el análisis de sensibilidad a la inclinación (identificado como h = 0.75) de la relación población-reclutamiento al pescar con el esfuerzo actual. El punto grande indica la captura más reciente (2014).

TABLE 1. MSY and related quantities for the base case and the stock-recruitment relationship sensitivity analysis, based on average fishing mortality (*F*) for 2012-2014. B_{recent} and B_{MSY} are defined as the biomass, in metric tons, of fish 3+ quarters old at the start of the first quarter of 2015 and at MSY, respectively, and S_{recent} and S_{MSY} are defined as indices of spawning biomass (therefore, they are not in metric tons). C_{recent} is the estimated total catch for 2014.

TABLA 1. RMS y cantidades relacionadas para el caso base y el análisis de sensibilidad a la relación población-reclutamiento, basados en la mortalidad por pesca (*F*) media de 2012-2014. Se definen B_{recent} y B_{RMS} como la biomasa, en toneladas, de peces de 3+ trimestres de edad al principio del primer trimestre de 2015 y en RMS, respectivamente, y S_{recent} y S_{RMS} como índices de biomasa reproductora (por lo tanto, no se expresan en toneladas). C_{recent} es la captura total estimada de 2014.

YFT	**Base case** **Caso base**	***h* = 0.75**
MSY-RMS	275,258	297,677
B_{MSY}- B_{RMS}	368,336	556,279
S_{MSY}- S_{RMS}	3,469	5,990
B_{MSY}/B_0- B_{RMS}/B_0	0.32	0.37
S_{MSY}/S_0- S_{RMS}/S_0	0.27	0.35
C_{recent}/MSY- C_{recent}/RMS	0.86	0.80
B_{recent}/B_{MSY}- B_{recent}/B_{RMS}	1.12	0.73
S_{recent}/S_{MSY}-S_{recent}/S_{RMS}	0.99	0.57
F multiplier-Multiplicador de *F*	1.11	0.71