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STATUS OF YELLOWFIN TUNA IN THE EASTERN PACIFIC OCEAN IN 2011 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 (IATTC Stock Assessment Report 12). Yellowfin are distributed across the Pacific Ocean, but the bulk of the catch is made in the eastern and western regions. The purse-seine catches of yellowfin are relatively low in the vicinity of the western boundary of the EPO. The movements of tagged yellowfin are generally over hundreds, rather than thousands, of kilometers, and exchange between the eastern and western Pacific Ocean appears to be limited. This is consistent with the fact that longline catch-per-unit-of-effort (CPUE) trends differ among areas. It is likely that there is a continuous stock throughout the Pacific Ocean, with exchange of individuals at a local level, although there is some genetic evidence for local isolation. Movement rates between the EPO and the western Pacific 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, and stock structure. The assessment for 2011 is identical to that of 2010 except for updated and new data. The catch data for the surface fisheries have been updated and new data added for 2011. New or updated longline catch data are available for China (2010), Chinese Taipei (2008-2010), French Polynesia (2010), Japan (2007-2010), Korea (2009-2011) and the United States (2009-2010). Surface fishery CPUE data were updated, and new CPUE data added for 2011. New or updated CPUE data are available for the Japanese longline fleet (2007-2010). New surface-fishery size-composition data for 2011 were added. New or updated length-frequency data are not available for the Japanese longline fleet.

In general, the recruitment of yellowfin to the fisheries in the EPO is variable, with a seasonal component. This analysis and previous analyses have indicated that the yellowfin population has experienced two, or possibly three, different recruitment productivity regimes (1975-1982, 1983-2002, and 2003-2009) (Figure 1). Although the two most recent annual recruitments (2010 and 2011) were estimated at about average levels, 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.

Significant 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 slightly greater that that by unassociated fisheries. The impact of the longline and purse-seine discard fisheries is much less (Figure 3).

There has been a large retrospective pattern of overestimating recent recruitment. This pattern, in combination with the wide confidence intervals of the estimates of recent recruitment, indicate that these estimates and those of recent biomass are uncertain.

Historically, 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 2010-2011) (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 SBR levels. The SBR at the start of 2012 was estimated to be 0.26, above the level corresponding to the MSY (0.25). The recent SBR levels (2010-2011) predicted by the current assessment are more optimistic than those produced by the previous assessment, which indicated a sharp decline in the levels of spawning biomass since 2009 (IATTC Stock Assessment Report 12). This result is due to a decline in the fishing mortality levels for middle-age and older yellowfin tuna since 2009, which is estimated by the current assessment (Figure 2). The effort levels are estimated to be less than those that would support the MSY (based on the current distribution of effort among the different fisheries) (Figure 5), and recent catches are below MSY (Table 1). It is important to note that the curve relating the average sustainable yield to the long-term fishing mortality is very 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. Reducing fishing mortality below the level at MSY 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 SBR levels.

The MSY has been stable during the assessment period (1975-2011) (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 level corresponding to MSY.

If a stock-recruitment relationship is assumed, the outlook is more pessimistic, and current effort is estimated to be above the level corresponding to the MSY (Table 1). Previous assessments have also 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 larger values are assumed for this parameter. Under current levels of fishing mortality (2009-2011), the spawning biomass is predicted to slightly increase and remain above the level corresponding to MSY (Figure 4). However, the confidence intervals are wide, a retrospective pattern exists in recent recruitment, 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 level corresponding to MSY if a stock-recruitment relationship is assumed (Figure 5). Fishing at F_{msy} is predicted to reduce the spawning biomass slightly from that under current effort and produces slightly higher catches (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 levels of MSY and the biomasses corresponding to the MSY may differ among the regimes. The population may have recently switched from a high to an intermediate productivity regime.
2. The recent fishing mortality rates are lower than those corresponding to the MSY, and the recent levels of spawning biomass are estimated to be at about that level. As described in IATTC Stock Assessment Report 12 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 12). This result is due to a recent decline in the fishing mortality levels for middle-age and older yellowfin tuna since 2009 which is estimated by the current assessment.
4. Increasing the average weight of the yellowfin caught could increase the MSY.

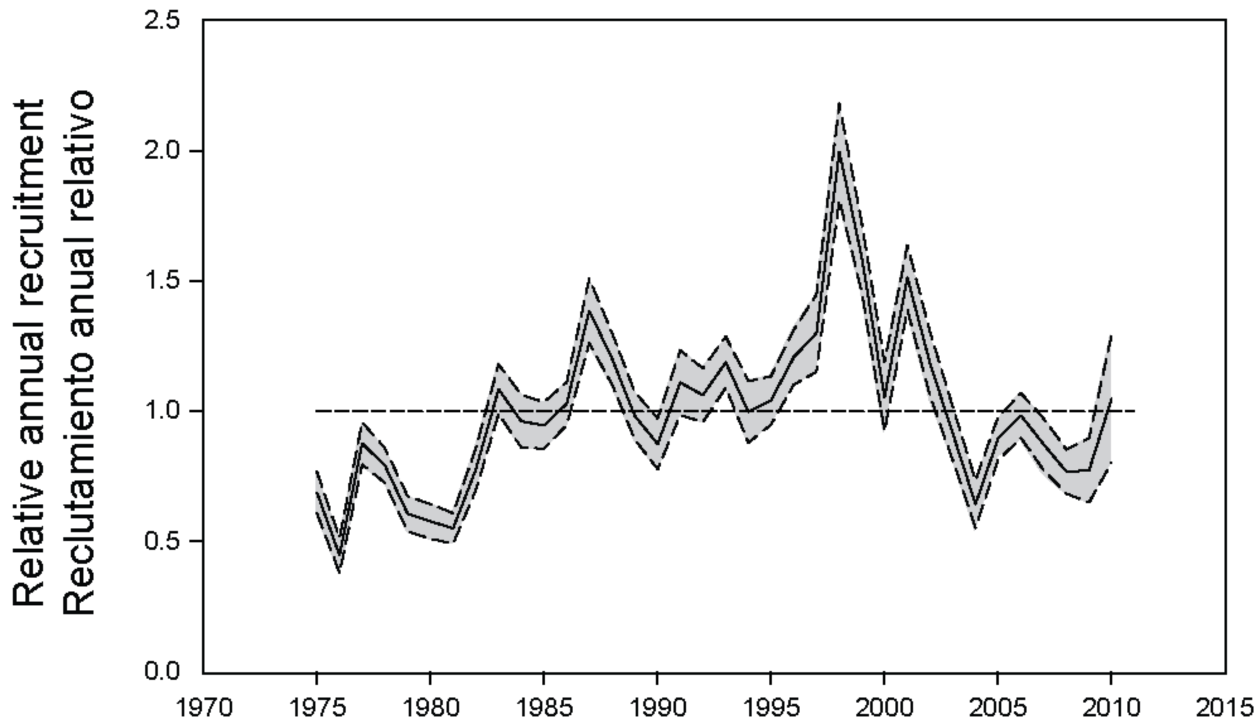

FIGURE 1. Estimated annual recruitment at age zero of yellowfin tuna to the fisheries of the EPO. The estimates are scaled so that the average recruitment is equal to 1.0 (dashed horizontal line). The solid line illustrates the maximum likelihood estimates of recruitment, and the shaded area indicates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

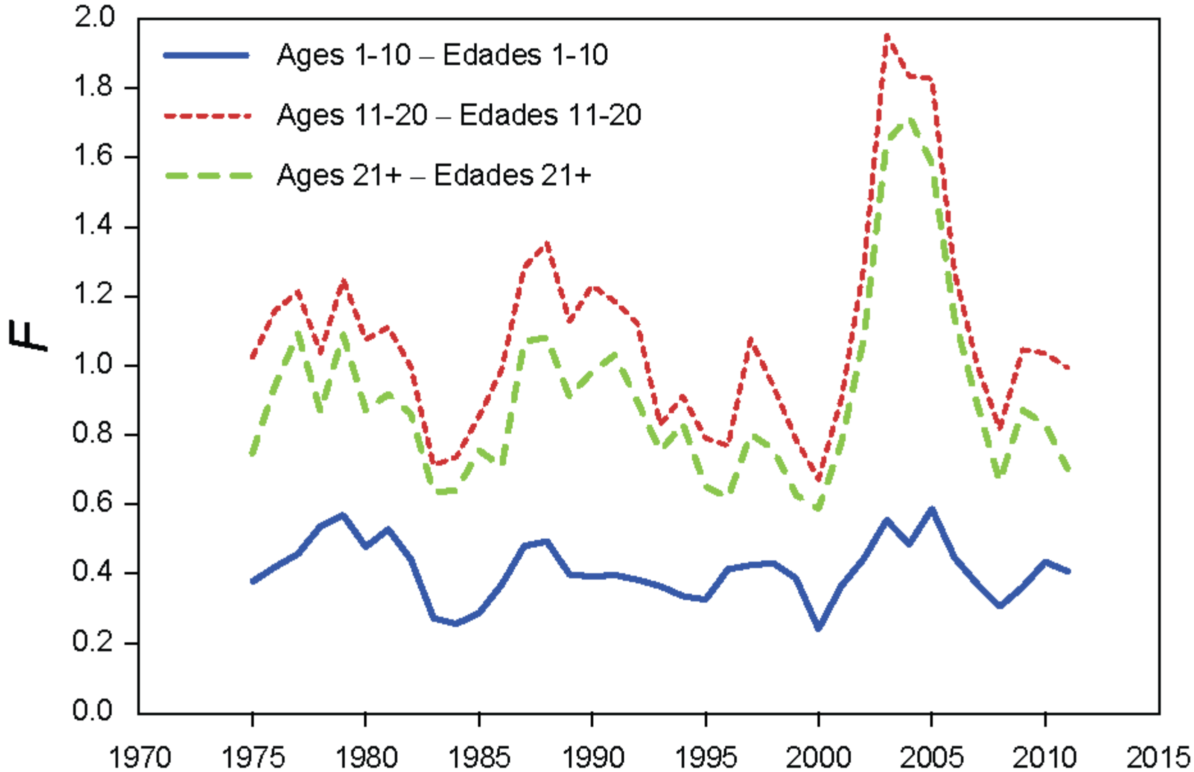

FIGURE 2. Average annual fishing mortality (*F*) by age groups, by all gears, of yellowfin tuna recruited to the fisheries of the EPO. The age groups are defined by age in quarters.
FIGURA 2. Mortalidad por pesca (*F*) anual media, por grupo de edad, por todas las artes, de atún aleta amarilla reclutado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

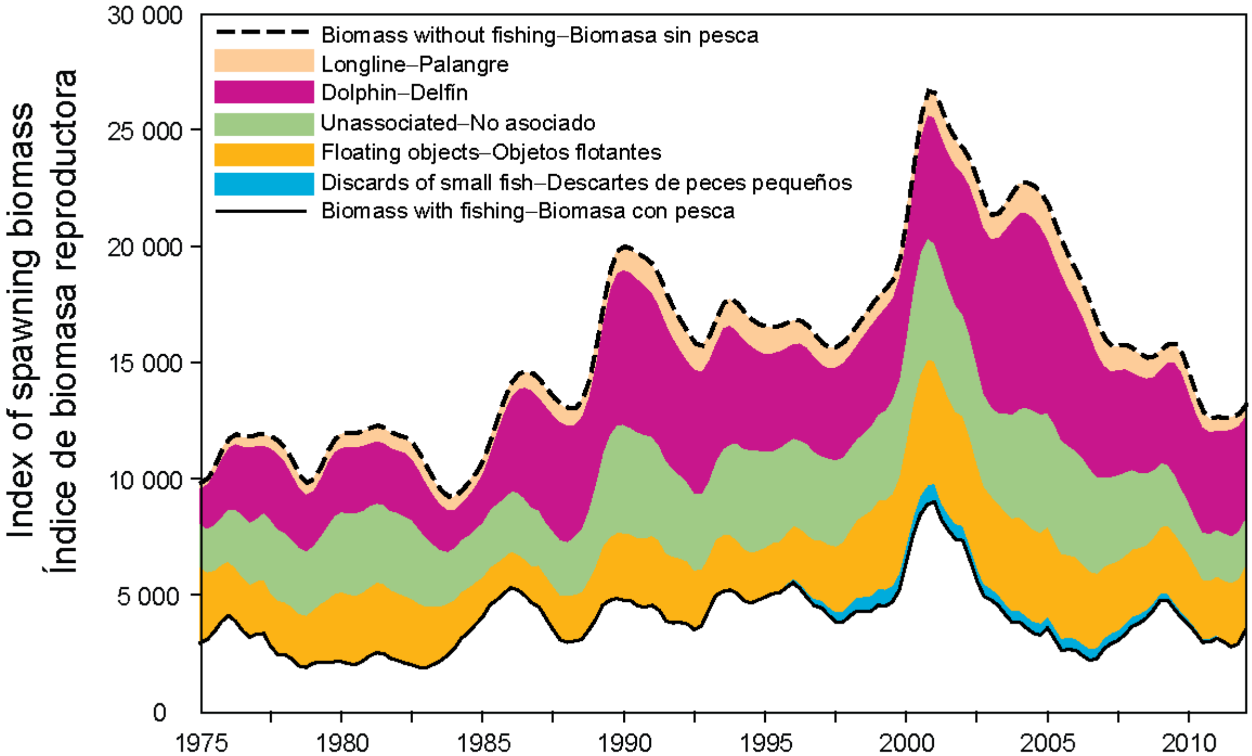

FIGURE 3. Biomass trajectory of a simulated population of yellowfin tuna that was never exploited (dashed line) and that predicted by the stock assessment model (solid line). The shaded areas between the two lines show the portions of the fishery impact attributed to each fishing method.

FIGURA 3. Trayectoria de la biomasa de una población simulada de atún aleta amarilla que nunca fue explotada (línea de trazos) y aquélla 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.

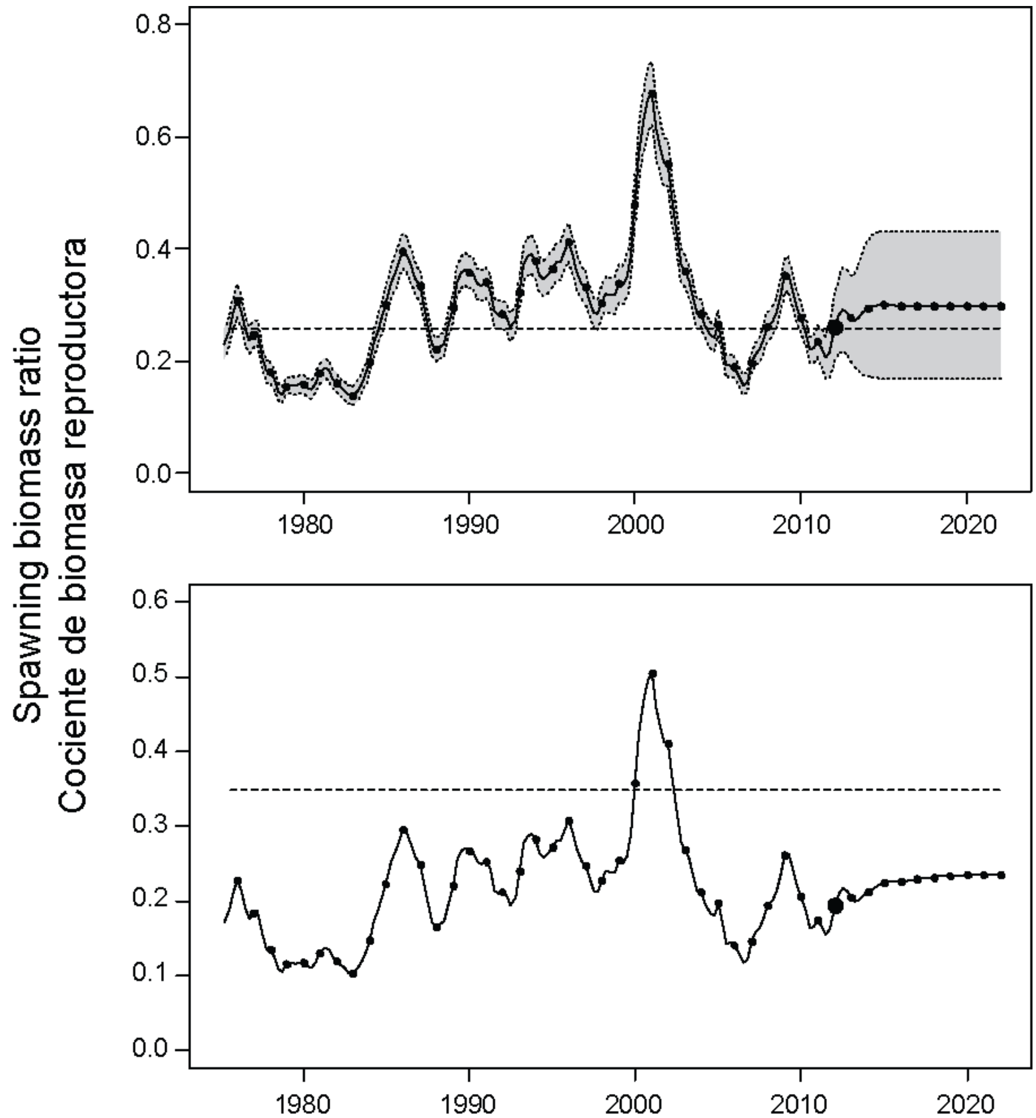

FIGURE 4. Spawning biomass ratios (SBRs) for yellowfin tuna in the EPO, including projections for 2012-2022 based on average fishing mortality rates during 2009-2011, from the base case (top) and the analysis of sensitivity to the steepness of the stock-recruitment relationship (bottom). The dashed horizontal line (at about 0.25 and 0.35, respectively) identifies the SBR at MSY. The solid line illustrates the maximum likelihood estimates, and the estimates after 2012 (the large dot) indicate the SBR predicted to occur if fishing mortality rates continue at the average of those observed during 2009-2011, 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) del atún aleta amarilla en el OPO, incluyendo proyecciones par 2012-2022 basadas en las tasas medias de mortalidad por pesca durante 2009-2011, del caso base (arriba) y el análisis de sensibilidad a la inclinación de la relación población-reclutamiento (abajo). La línea de trazos horizontal (en aproximadamente 0,25 y 0,35, respectivamente) identifica el SBR_{RMS}. La línea sólida ilustra las estimaciones de verosimilitud máxima, y las estimaciones a partir de 2012 (el punto grande) indican el SBR que se predice ocurrirá si las tasas de mortalidad por pesca continúan en el promedio de aquellas observadas durante 2009-2011, y ocurren condiciones ambientales medias durante la próxima década. La zona sombreada indica los límites de confianza de 95% aproximados de las estimaciones.

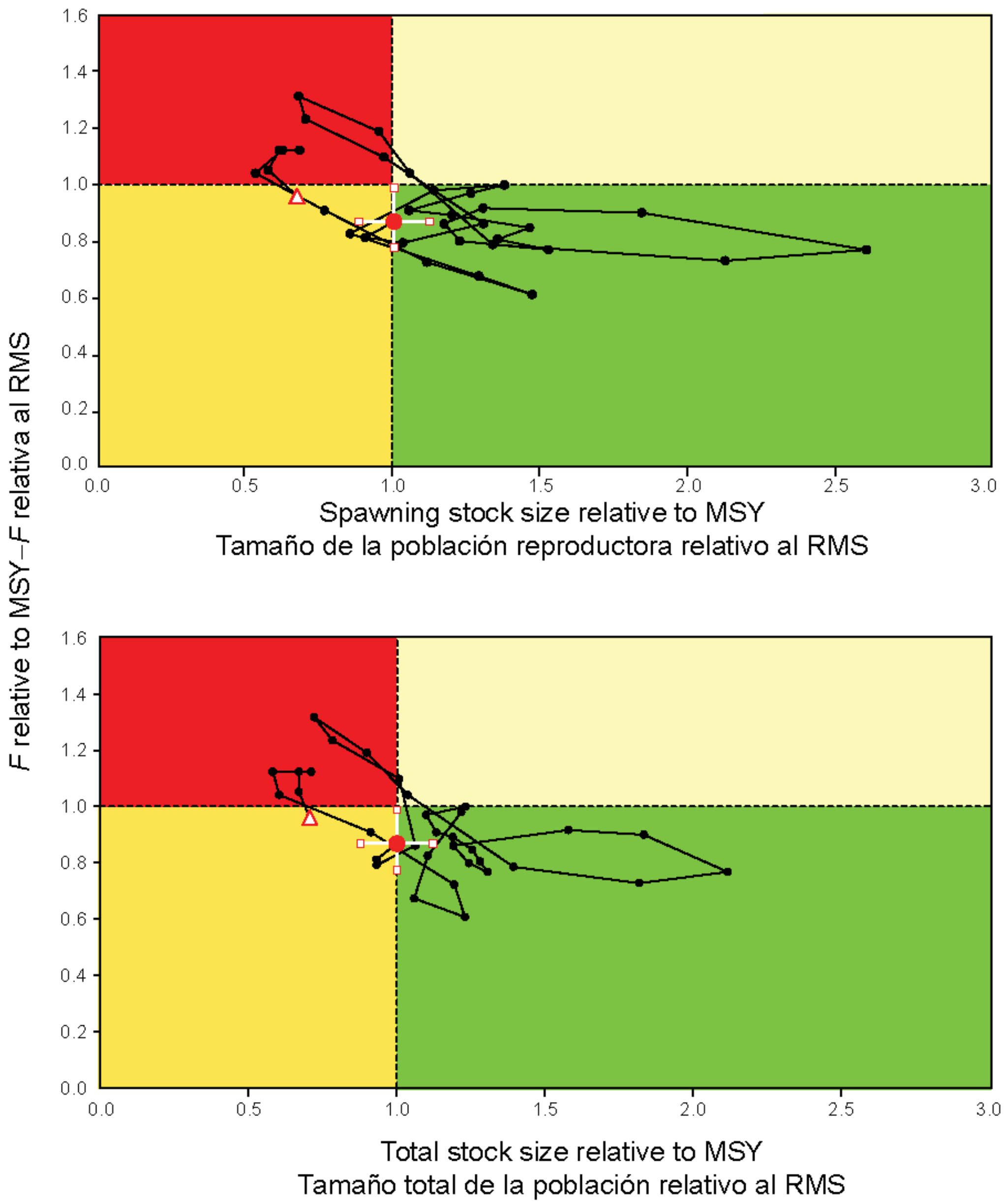

FIGURE 5. Kobe (phase) plot of the time series of estimates for stock size (top: spawning biomass; bottom: summary biomass) and fishing mortality relative to their MSY reference points. Each dot is based on the average exploitation rate over three years; the large red dot indicates the most recent estimate. The squares around the most recent estimate represent its approximate 95% confidence interval.

FIGURA 5. Gráfica de Kobe (fase) de la serie de tiempo de las estimaciones del tamaño de la población (arriba: biomasa reproductora; abajo: biomasa sumaria) y la mortalidad por pesca en relación con sus puntos de referencia de RMS. 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.

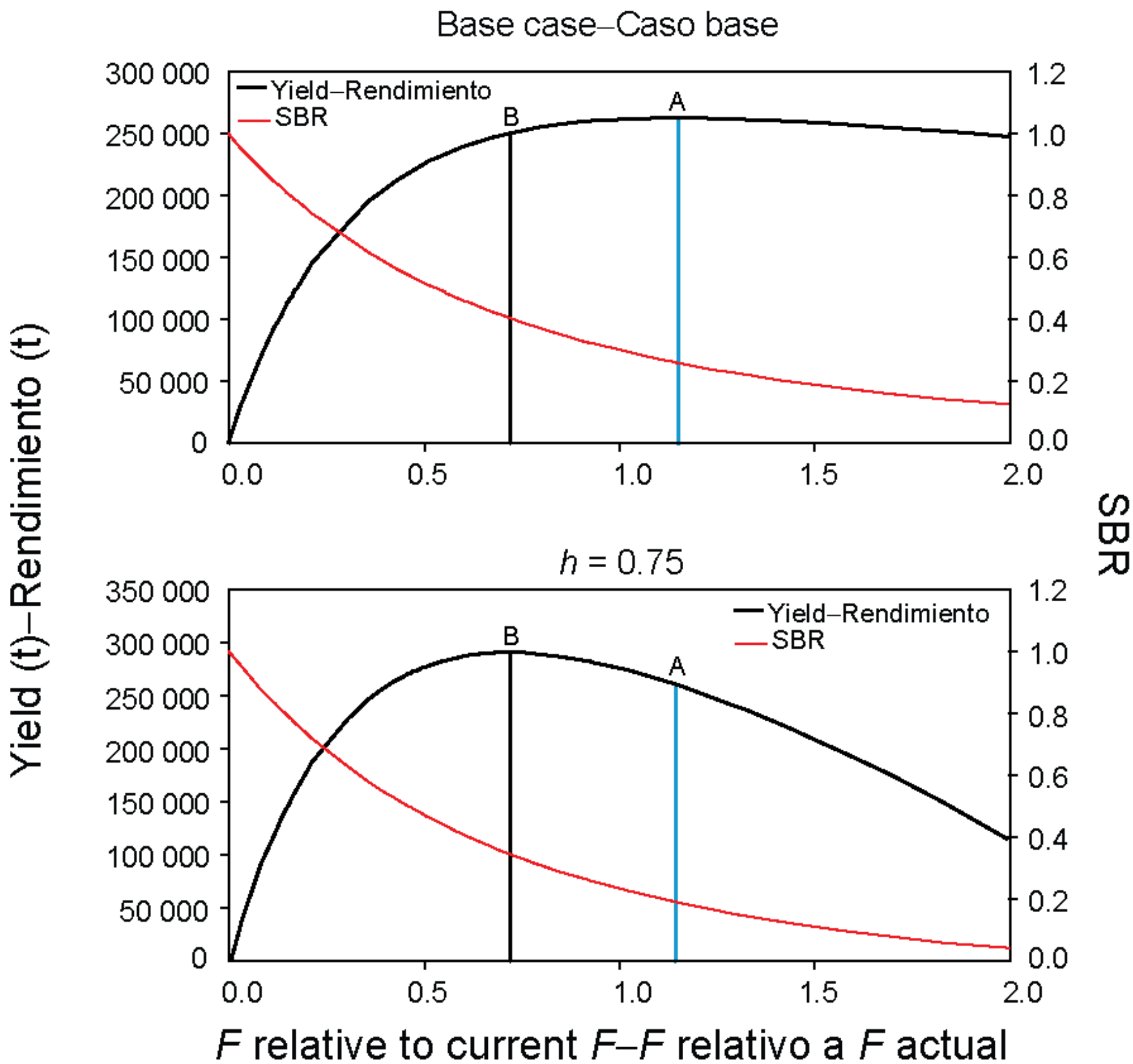

FIGURE 6. Yield and spawning biomass ratio (SBR) as a function of fishing mortality relative to the current fishing mortality. The vertical lines represent the fishing mortality corresponding to MSY for the base case and the sensitivity analysis that uses a stock-recruitment relationship (h = 0.75).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

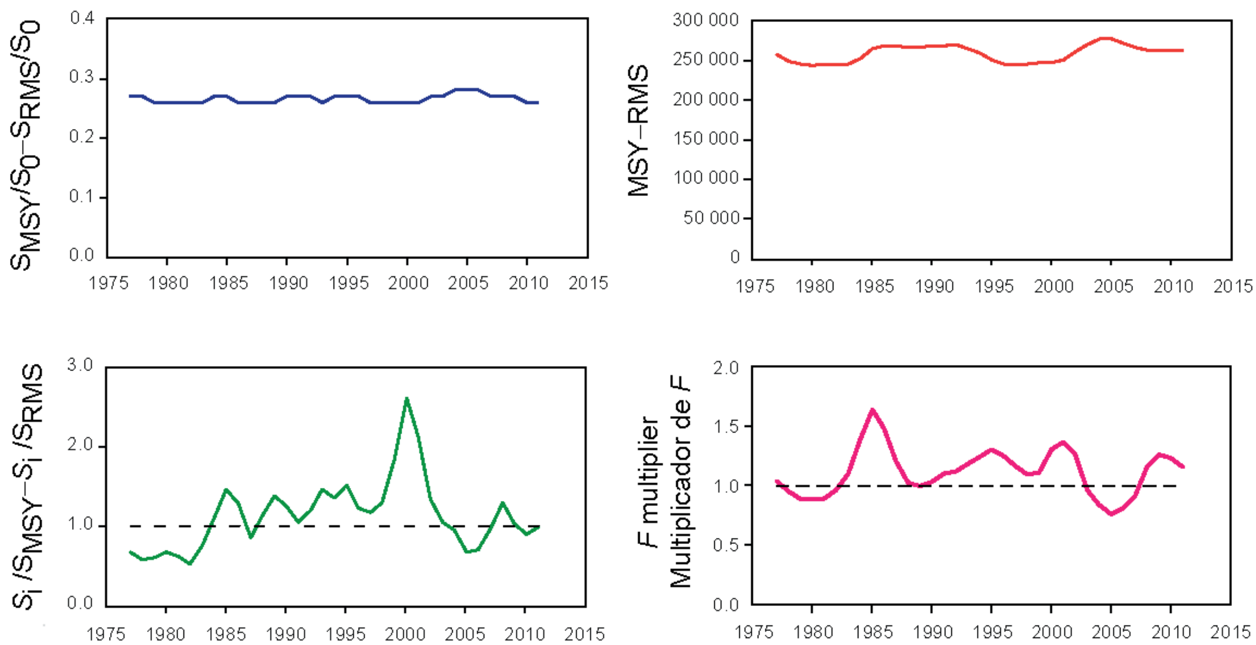

FIGURE 7. Estimates of MSY-related quantities calculated using the average age-specific fishing mortality for each year (S_{recent} is the index of spawning biomass at the end of the last year in the assessment).

FIGURA 7. Estimaciones de cantidades relacionadas con el RMS calculadas a partir de la mortalidad por pesca media por edad para cada año. (S_{recent} es el índice de la biomasa reproductora al fin del último año en la evaluación).

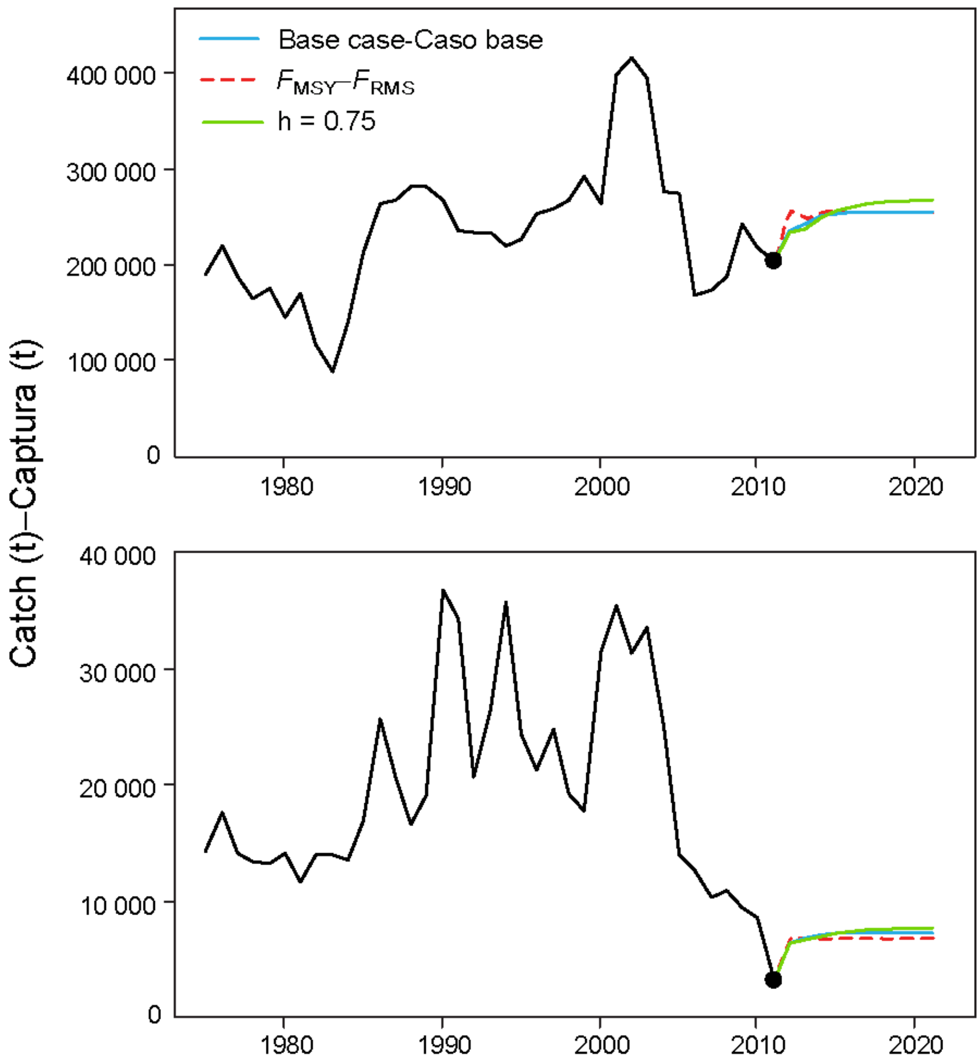

FIGURE 8. Historic and projected annual catches of yellowfin tuna by surface (top panel) and longline (bottom panel) fisheries from the base case while fishing with the current effort, the base case while fishing at the fishing mortality corresponding to MSY (F_{MSY}), and the analysis of sensitivity to steepness (labeled h = 0.75) of the stock-recruitment relationship while fishing with the current effort. The large dot indicates the most recent observed catch (2011).

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 observada más reciente (2011).

TABLE 1. MSY and related quantities for the base case and the stock-recruitment relationship sensitivity analysis, based on average fishing mortality (F) for 2009-2011. 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 2012 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 2011.

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 2009-2011. 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 2012 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 2011.

Data – Datos	**Base case Caso base**	***h* = 0.75**
MSY-RMS	262,642	290,680
B_{MSY}- B_{RMS}	356,682	560,354
S_{MSY}- S_{RMS}	3,334	6,013
B_{MSY}/B_0- B_{RMS}/B_0	0.31	0.37
S_{MSY}/S_0- S_{RMS}/S_0	0.26	0.35
C_{recent}/MSY- C_{recent}/RMS	0.79	0.71
B_{recent}/B_{MSY}- B_{recent}/B_{RMS}	1.00	0.63
S_{recent}/S_{MSY}-S_{recent}/S_{RMS}	1.00	0.56
F multiplier-Multiplicador de F	1.15	0.72