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STATUS OF YELLOWFIN TUNA IN THE EASTERN PACIFIC OCEAN IN 2009 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) 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. 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 2009 is identical to that of 2008 except for updated and new data. The catch data for the surface fisheries have been updated and new data added for 2009. New or updated longline catch data are available for China (2008), Chinese Taipei (2006-2009), French Polynesia (2008), Korea (2007-2008) and the United States (2007-2008). New surface fishery size composition data for 2009 were added. Surface fishery CPUE data were updated, and new CPUE data added for 2009. No new longline length composition or CPUE data were added.

In general, the recruitment of yellowfin to the fisheries in the EPO is variable, with a seasonal component (Figure 1). 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 2003-2008). The productivity regimes correspond to regimes in biomass, 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 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 do 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. All three purse-seine set types have had moderate impacts on the spawning biomass of yellowfin, while longline catches and discards of small yellowfin tuna in the purse-seine fishery on floating objects have had minor impacts (Figure 3).

There is a large retrospective pattern of overestimating recent recruitment, due to the size-composition data for the floating-object fishery. This retrospective pattern, in combination with the wide confidence intervals for estimates of recent recruitment, indicate that estimates of recent recruitment and recent biomass are uncertain. The results of the assessment are also particularly sensitive to the level of natural mortality assumed for adult yellowfin.

Historically, the spawning biomass ratio (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 1975-1983 corresponding to the low productivity regime, but above that level for most of the following years, except for the recent period (2004-2007) (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 two different productivity regimes may support two different MSY levels and associated SBR levels. The SBR at the start of 2010 is estimated to be above the level corresponding to the MSY. 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, 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 provide 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 (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 was 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 (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 biomass is estimated to be below the level corresponding to the MSY. The status of the stock is sensitive to the value of adult natural mortality and the assumed length of the oldest age modeled (29 quarters).

Under recent levels of fishing mortality (2007-2009), the spawning biomass is predicted to slightly decrease below the level corresponding to MSY, but then increase above it. Fishing at the level of fishing mortality corresponding to MSY (F_{MSY}) is predicted to produce slightly higher catches (Figure 8).

Key Results

1. There is uncertainty about recent and future recruitment and biomass levels, and there are retrospective patterns of overestimating recent recruitment.
2. The recent fishing mortality rates are lower than those corresponding to the MSY.
3. Increasing the average weight of the yellowfin caught could increase the MSY.
4. 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 the high to an intermediate productivity regime.

5. The results are more pessimistic if a stock-recruitment relationship is assumed.
6. The results are sensitive to the natural mortality assumed for adult yellowfin and the length assumed for the oldest fish.

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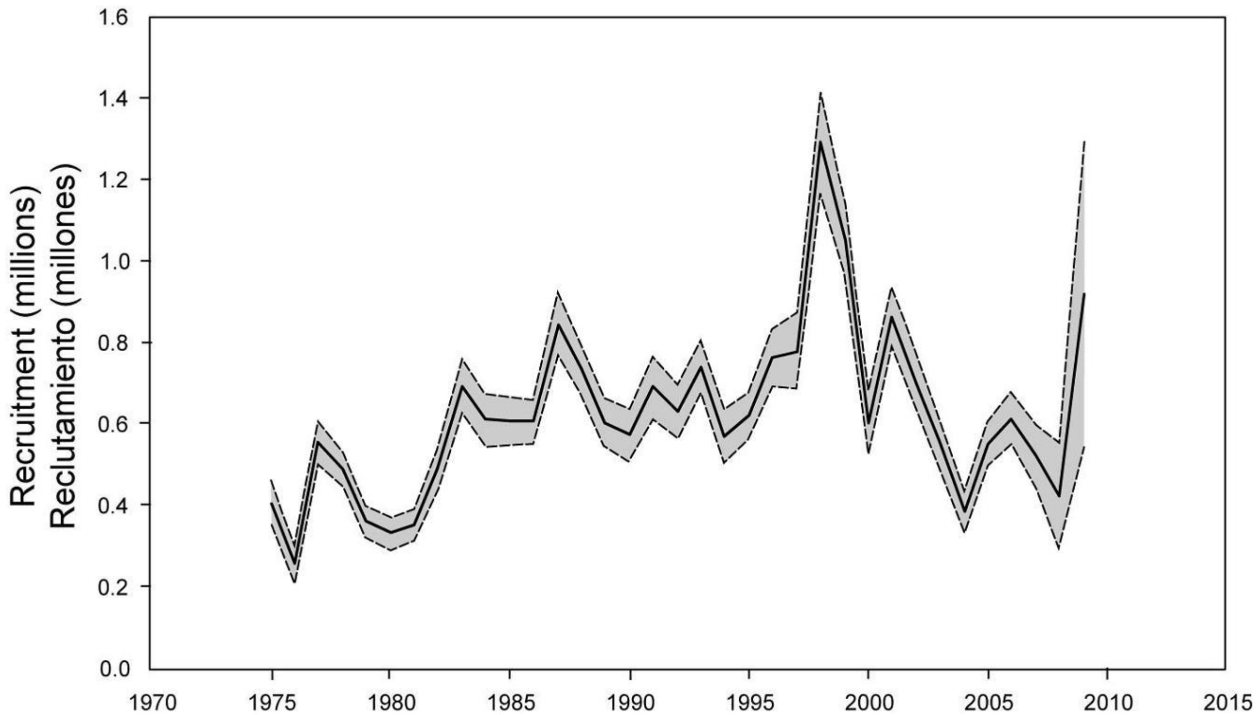

FIGURE 1. Estimated annual recruitment at age zero of yellowfin tuna to the fisheries of the EPO. The solid line illustrates the maximum likelihood estimates of recruitment, and the dashed lines indicate the approximate 95% confidence intervals around those estimates. The solid line illustrates the maximum likelihood estimates of recruitment, and the dashed lines 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. La línea sólida indica las estimaciones de verosimilitud máxima del reclutamiento, y las líneas de trazos los límites de confianza de 95% aproximados de las estimaciones. La línea sólida indica las estimaciones de verosimilitud máxima del reclutamiento, y las líneas de trazos los límites de confianza de 95% aproximados de las estimaciones.

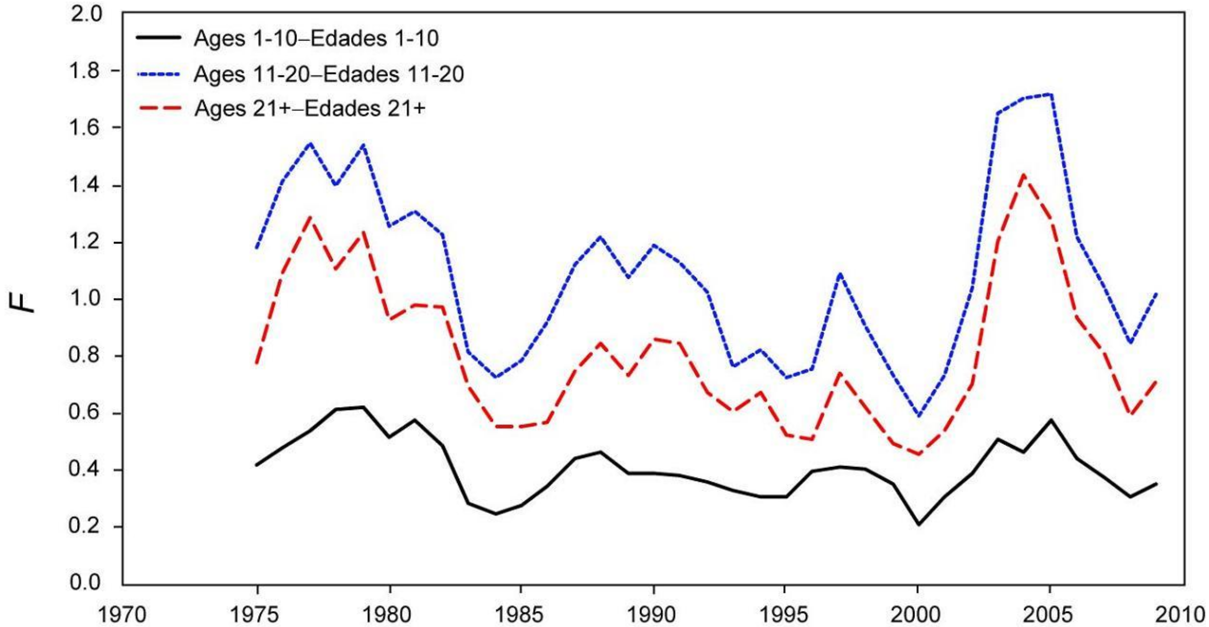

FIGURE 2. Average annual fishing mortality (*F*) by age groups, by all gears, of yellowfin tuna recruited to the fisheries of the EPO. The age groups are defined by age in quarters.
FIGURA 2. Mortalidad por pesca (*F*) anual media, por grupo de edad, por todas las artes, de atún aleta amarilla reclutado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

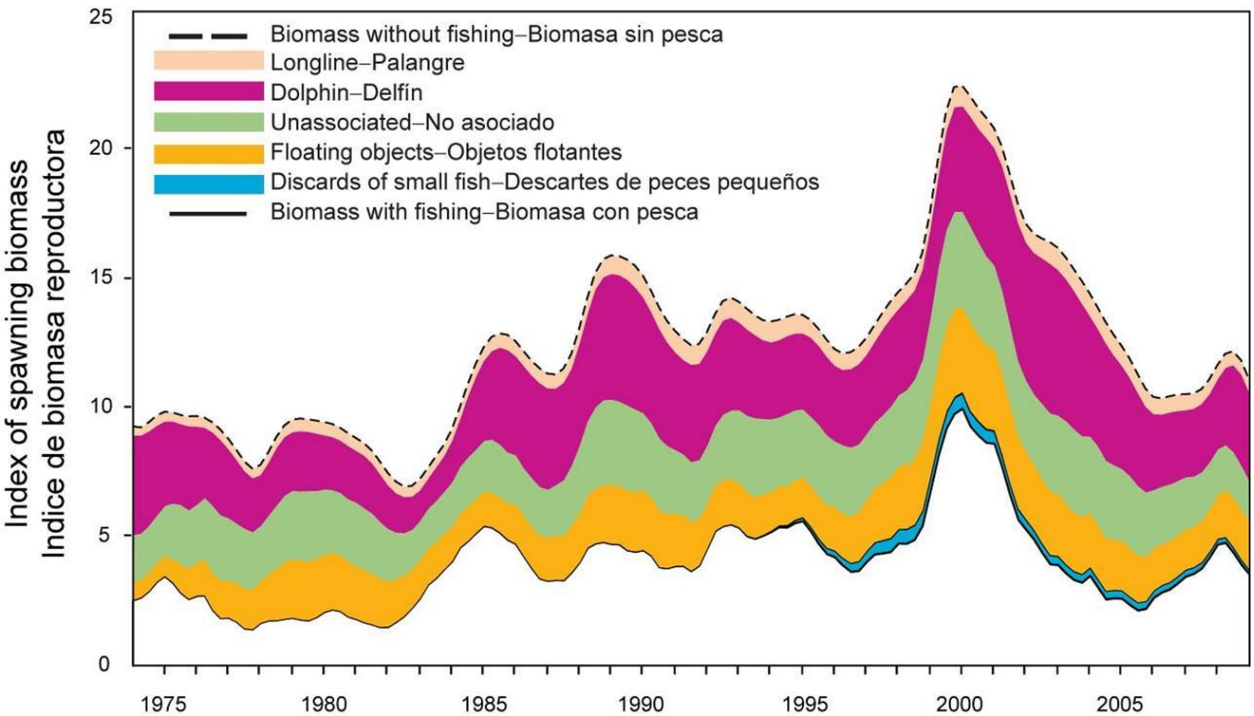

FIGURE 3. Biomass trajectory of a simulated population of yellowfin tuna that was never exploited (dashed line) and that predicted by the stock assessment model (solid line). The shaded areas between the two lines show the portions of the fishery impact attributed to each fishing method.

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.

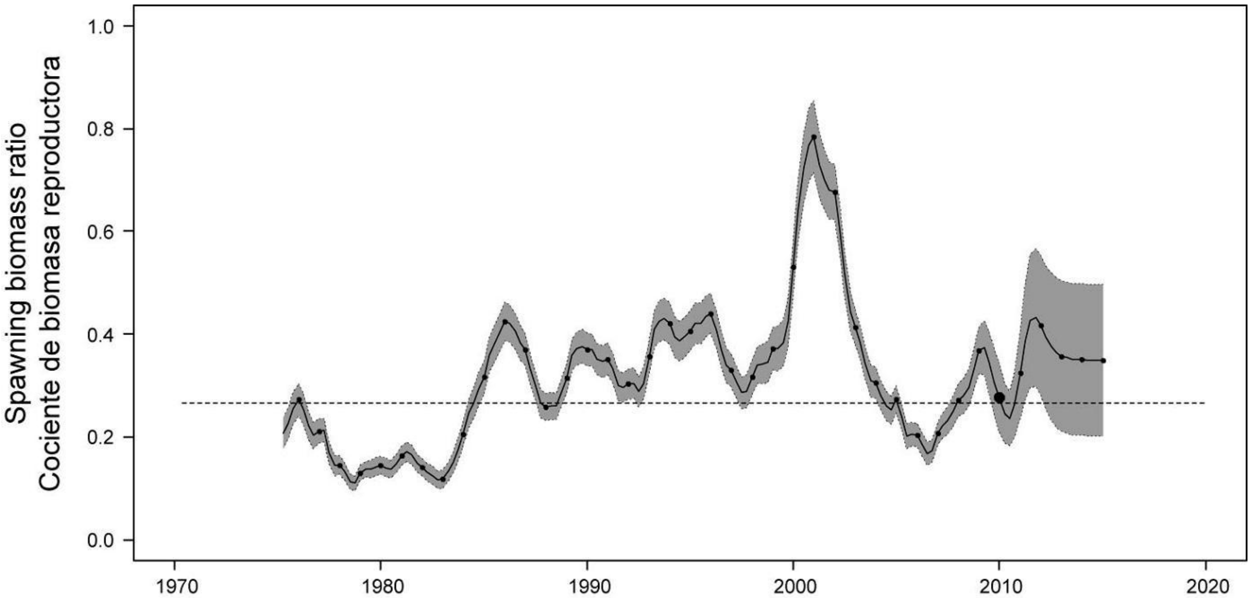

FIGURE 4. Spawning biomass ratios (SBRs) for 1975-2009 and SBRs projected during 2010-2013 for yellowfin tuna in the EPO. The dashed horizontal line identifies SBR_{MSY}, and the thin dashed lines represent the 95% confidence intervals of the estimates. The estimates after 2009 indicate the SBR predicted if the fishing mortality continues at the average of that observed during 2007-2009, and average environmental conditions occur during the next 5 years.

FIGURA 4. Cocientes de biomasa reproductora **(**SBR) de 1975-2009 y SBR proyectados durante 2010-2013 para el atún aleta amarilla en el OPO. La línea de trazos horizontal identifica el SBR_{RMS}, y las líneas delgadas de trazos representan los intervalos de confianza de 95% de las estimaciones. Las estimaciones a partir de 2009 señalan el SBR predicho si la mortalidad por pesca continúa en el nivel medio observado durante 2007-2009 y con condiciones ambientales promedio en los 5 años próximos.

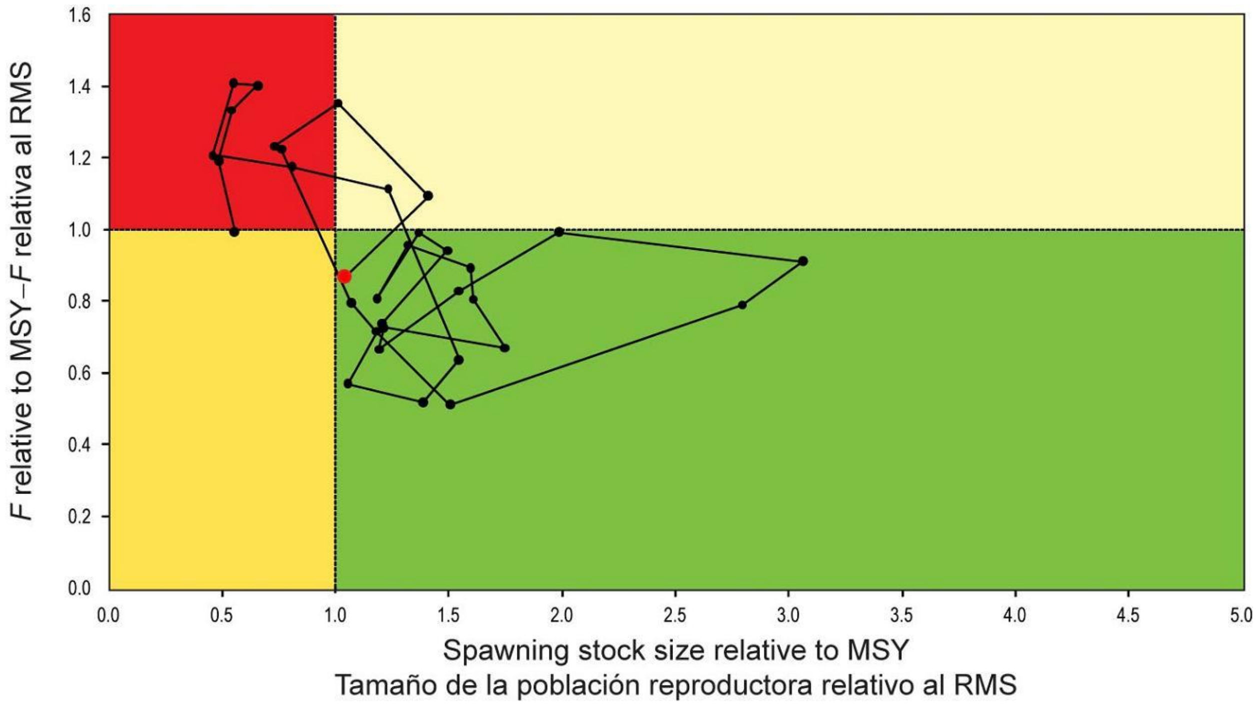

FIGURE 5. Phase plot of the time series of estimates for stock size and fishing mortality relative to their MSY reference points. Each dot is based on the average exploitation rate over three years; the large red dot indicates the most recent estimate.

FIGURA 5. Gráfica de fase de la serie de tiempo de las estimaciones del tamaño de la población 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 valor más reciente.

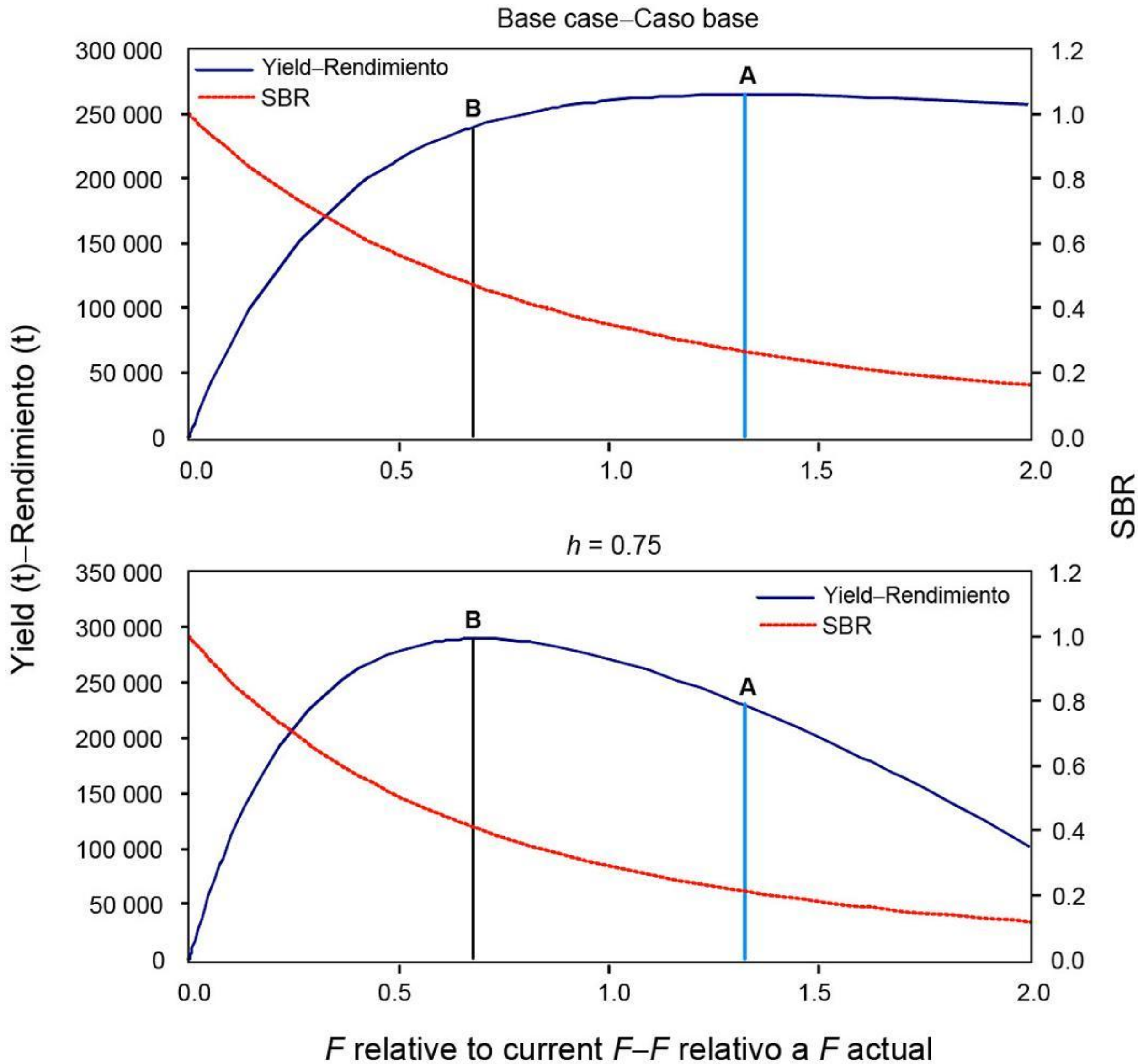

FIGURE 6. Yield and spawning biomass ratio (SBR) as a function of fishing mortality relative to the current fishing mortality. The vertical lines represent the fishing mortality corresponding to MSY for the base case and the sensitivity analysis that uses a stock-recruitment relationship (h = 0.75). 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 el 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 = 0.5, respectivamente.

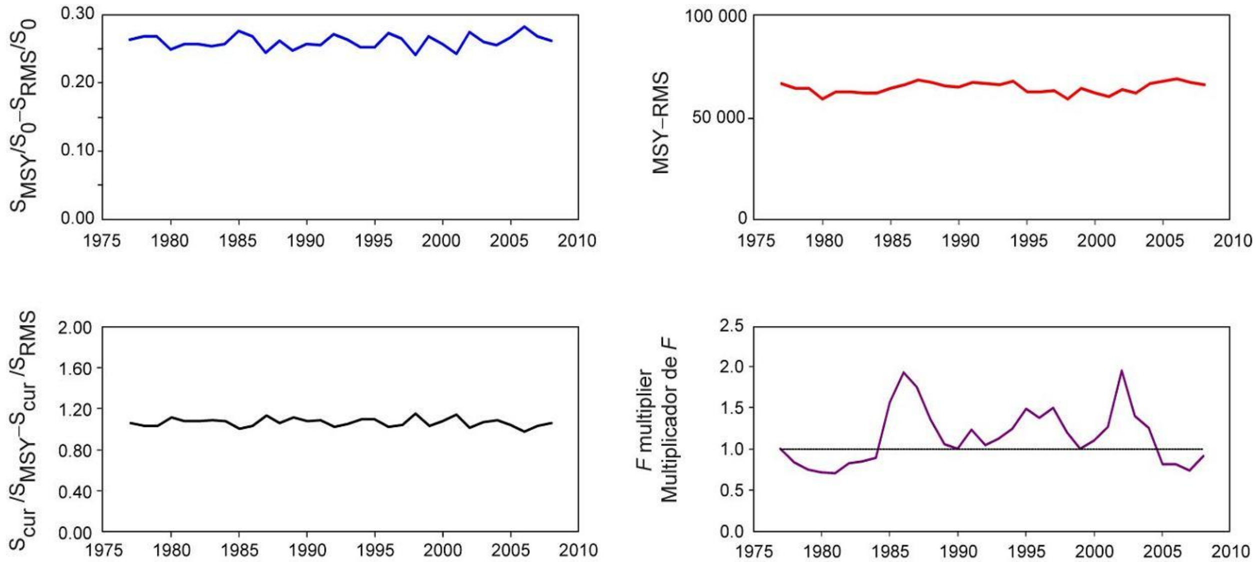

FIGURE 7. Estimates of MSY-related quantities calculated using the average age-specific fishing mortality for each year (*i.e.* the values for 2006 are calculated using the average age-specific fishing mortality in 2006 scaled by the quantity *F*scale, which maximizes the equilibrium yield). (S_{cur} is the index of spawning biomass at the end of the last year in the assessment). See the text for definitions.

FIGURA 7. Estimaciones de cantidades relacionadas con el RMS calculadas a partir de la mortalidad por pesca media por edad para cada año (o sea, se calculan los valores de 2006 usando la mortalidad por pesca media por edad escalada por la cantidad *F*scale, que maximiza el rendimiento de equilibrio). (S_{cur} es el índice de la biomasa reproductora al fin del último año en la evaluación). Ver definiciones en el texto.

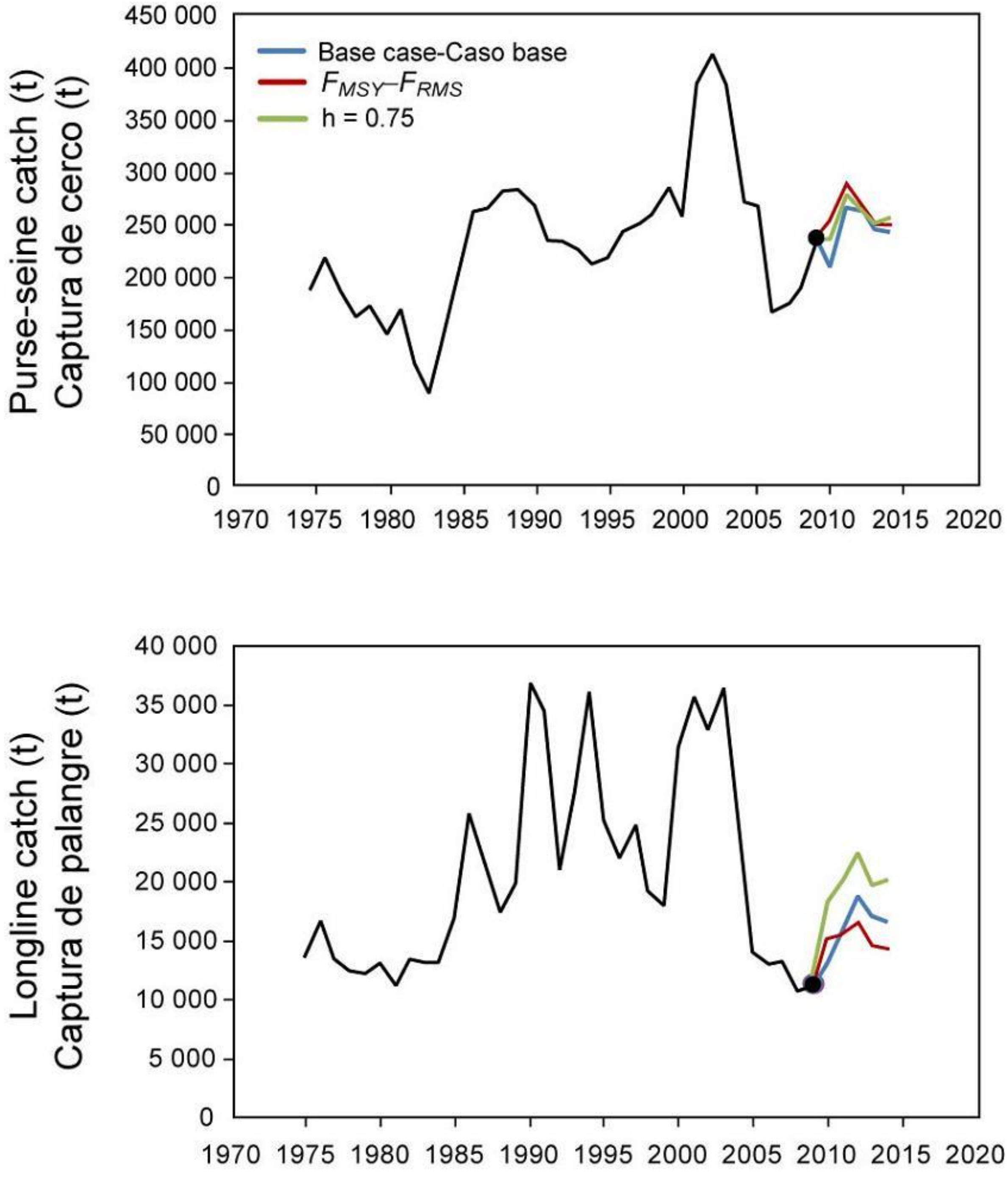

FIGURE 8. Historic and projected purse-seine and longline catch from the base case while fishing with the current effort, the base case while fishing at the fishing mortality corresponding to MSY (F_{MSY}), and the analysis of sensitivity to steepness (labeled h75) of the stock-recruitment relationship while fishing with the current effort.

FIGURA 8. Capturas de cerco y de palangre históricas y proyectadas 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 de la relación población-reclutamiento al pescar con el esfuerzo actual.

TABLE 1. MSY and related quantities for the base case and the stock-recruitment relationship sensitivity analysis, based on average fishing mortality (*F*) for 2007-2009. The quantities are also given based on average *F* for 2007-2009. 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 2010 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 2009.

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 2007-2009. Se presentan también las cantidades basadas en la *F* media de 2007-2009. Se definen $B_{reciente}$ y B_{RMS} como la biomasa, en toneladas, de peces de 3+ trimestres de edad al principio del primer trimestre de 2010 y en RMS, respectivamente, y $S_{reciente}$ y S_{RMS} como índices de biomasa reproductora (por lo tanto, no se expresan en toneladas). $C_{reciente}$ es la captura total estimada de 2009.

	Base case – Caso base	***h* = 0.75**
MSY–RMS	264,967	289,896
B_{MSY} –B_{RMS}	357,780	555,182
S_{MSY} —S_{RMS}	3,367	5,974
C_{recent}/MSY—$C_{reciente}$/RMS	0.94	0.86
B_{recent}/B_{MSY} –$B_{reciente}/B_{RMS}$	1.10	0.71
S_{recent}/S_{MSY} –$S_{reciente}/S_{RMS}$	1.05	0.59
$S_{MSY}/S_{F=0}$ –$S_{RMS}/S_{F=0}$	0.27	0.35
F multiplier—Multiplicador de *F*	1.33	0.69