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STOCK STATUS INDICATORS (SSIs) FOR TROPICAL TUNAS IN THE EASTERN PACIFIC OCEAN

CONTENTS

SUMMARY

Stock status indicators (SSIs; time series of data used as supplements to, or in the absence of, stock assessments), based on both purse-seine and longline data, are presented for the three tropical tuna species (yellowfin, bigeye, and skipjack). The methods used in previous IATTC reports to compute the SSIs, based on purse-seine data only, have been revised to mitigate possible bias introduced in the allocation of fishing effort among purse-seine set types. The new SSIs: (a) include measures of catch, effort, CPUE, and average length of the fish in the retained catch; (b) begin in 2000, the first year of species composition sampling for the purse-seine fishery and shortly after the major offshore expansion of the floating-object fishery around the early- to mid 1990s; and (c) have reference levels set at the 10% and 90% percentiles. Most SSIs based on the floating-object fishery suggest that the fishing mortality of all three species has increased, mainly due to the increase in the number of floating-object sets. The COVID-19 pandemic has affected the fishery, and hence the SSIs in 2020, due to the reduced number of sets in the floating-object fishery, and therefore, this year should be used with caution when interpreting long term trends. The constantly increasing trend in the number of sets in the floating-object fishery since 2005 is reflected in increased catches, reduced catch-per-set, and average length for all three species in the floating object fishery. However, trends in some other SSIs do not support the interpretation that fishing mortality has increased as a result of an increase in the number of floating-object sets. Identifying the causes of differences among the SSIs is difficult, even when SSIs are considered in aggregate. Nonetheless, most SSIs based on the floating-object fishery are consistent with an increase in fishing mortality in that fishery and the average length for bigeye and skipjack are at historically low levels in 2020, which means that precautionary management measures should be considered to prevent further increases in fishing mortality. This is further supported by a positive relationship between number of sets and fishing mortality estimated in the bigeye tuna stock assessment (FAD-05 INF-D).

1. BACKGROUND

One of the management objectives for tropical tunas in the eastern Pacific Ocean (EPO) established in the Antigua Convention is to maintain populations at levels of abundance which can produce the maximum sustainable yield (MSY). Management objectives based on MSY or related reference points (*e.g.* fishing mortality that produces MSY (F_{MSY}); spawner-per-recruit proxies) are in use for many species and stocks worldwide. However, these objectives require the estimation of both reference points and quantities to which they can be compared. Various model-based reference points require different amounts and types of information, from biological information (*e.g*. natural mortality, growth, stock-recruitment relationship) and fisheries characteristics (*e.g.* age-specific selectivity) to estimates of absolute biomass and exploitation rates, which in turn generally require a formal stock assessment. For many species and stocks, the information required to conduct such an assessment is not available, the assessments are unreliable, or cannot be conducted at the frequency that management may require, and thus, alternative approaches are needed.

One alternative is to compute stock status indicators (SSIs), which are simply time series of raw or lightly-processed data for a stock, that may reflect trends in abundance or exploitation of that stock. SSIs include quantities such as fishing effort, catch, CPUE, or the size of fish in the catch. SSIs cannot be used directly for management that depends on model-based quantities (*e.g*. MSY, F_{MSY}), but they can be used for historical comparisons and to identify trends, and can provide information that may be useful for managing a stock. They can also be used in management strategies that do not rely on model-based harvest control rules (HCRs), such as strategies that use empirical (data-based) harvest control rules (HCRs) whose performance can be formally evaluated using management strategy evaluation (MSE).

SSIs were initially developed for skipjack because traditional stock assessments of that species were considered unreliable (*e.g*. Maunder and Deriso 2007), but they have also been used recently as a complementary component of the staff's management advice for yellowfin and bigeye in the EPO. Since 2018, SSIs have become particularly important as supplemental information to, or temporary replacement of, formal stock assessments for both bigeye (SAC-09-16) and yellowfin (SAC-10-08), because the staff considered that the results of the assessments at that time were not sufficiently reliable to be used as the basis for its management advice.

The staff has completed the workplan to improve the tropical tuna stock assessments, and the bigeye (SAC-11-06) and yellowfin (SAC-11-07) assessments, which are now included in a risk-based framework (SAC-11 INF-F), were considered sufficiently reliable to be used as the basis for providing management advice (IATTC-95-01). The new risk-based assessment framework will be applied before the start of a multi-year management cycle. Two sets of SSIs, one based on data from the purse-seine fishery and the other on data from the longline fishery, will continue to be reported as supplemental information to monitor the stocks between assessments within the management cycle, and to provide management advice. We computed the same SSIs for all three species, where possible, and collated them into this report to facilitate comparisons among species.

The **purse-seine-based SSIs** reported by set type (NOA: unassociated; DEL: dolphin-associated: OBJ: floating-object associated) whenever possible are the following: **number of sets, by set type** (Figure 1), **closure-adjusted capacity** (Figure 1), **catch by set type** (Figure 2), **catch-per-set by set type** (Figure 3), and **average length of the fish in the retained catch, by set type** (Figure 4). For yellowfin, an additional SSI was developed based on spatio-temporal modelling of **catch-per-day-fished (CPDF)** for the fishery associated with dolphins (Figure 5), which is superior to the CPDF SSIs used previously. Catch-per-set by set type replaces the CPDF SSIs used previously, which are considered unreliable due to possible biases in the method used to assign days fished to set types; also, the model-based indicators used for skipjack are no longer reported because they were based on the same CPDF data. The current SSIs begin in 2000 because the IATTC port-sampling program began the species composition sampling in that year, and it is after the major offshore expansion of the floating-object fishery which started in the early- to mid-1990s. All SSIs are scaled (relative indicators) so that their average equals 1 during the 2000-2020 period. The reference levels were changed from the 5% and 95% percentiles to the 10% and 90% percentiles because extreme percentiles are less reliable with fewer years of data.

Several indicators that use data from the **longline fishery** have also been developed. These include **catch and effort** (Figure 6), and **CPUE** (catch-per-hook) and **average length** of fish from a spatio-temporal model (Figure 7). To be consistent with the purse-seine SSIs, the longline SSIs begin in 2000 and have been scaled so that their average equals 1 during the 2000-2020 period. Reference levels also are based on the 10% and 90% percentiles.

Further information about bigeye and yellowfin can be found in Documents SAC-11-06 and SAC-11-07, respectively, and information on the absolute catch and number of sets, by set type, in SAC-12-03.

2. RESULTS AND DISCUSSION

Many of the SSIs for recent years are near their 10% and 90% reference levels, with 2020 being an exception in that the number of sets in the floating-object fishery was substantially reduced (Figure 1). This 25% decline in the total number of floating-object sets from 2019 to 2020 is most likely attributable to the effect of the COVID-19 pandemic on fishery operations. Exceeding a reference level can have multiple interpretations, and these will depend on the SSI being considered and whether the upper or the lower reference level has been exceeded. To interpret trends in SSIs, it may be helpful to take multiple SSIs into consideration simultaneously.

Most floating-object fishery SSIs suggest that the stocks for all three species have potentially been subject to increased fishing mortality, mainly due to the increase in the number of sets in the floating-object fishery (see FAD-05 INF-D for details on the relationship between number of floating objects sets and *F* for bigeye). Of particular concern is the constantly increasing trend in the number of floating-object sets observed since 2005, with the exception of 2020 (Figure 1). This is reflected as an increase in catch in yellowfin and skipjack, particularly in numbers, along with an increase in catch in numbers for bigeye in floating-object sets (Figure 2). It is also reflected as a decline in catch-per-set (Figure 3) and in average length of the fish in the catch (Figure 4) in all three species for the floating-object fishery. The interpretation of increased fishing mortality is supported by trends in average length of bigeye and skipjack caught in the other set types, and by the trend in the yellowfin longline CPUE index based on spatio-temporal modelling (Figure 7). The different patterns seen in 2020 are likely due to the COVID-19 pandemic, and therefore cannot be interpreted in the context of long-term trends. For example, the catch per set for bigeye and skipjack increased in 2020, but this may be due to the larger reduction in the number of sets made by IATTC Class 1-5 vessels, which have lower catch per set, as compared to the number of sets made by IATTC Class-6 vessels (see Table 7 of SAC-12-03). The average length of fish in the retained catch may be less influenced by the unprecedented changes in fishing operations due to COVID-19, and in 2020 is at historically low levels for bigeye and skipjack in the floating-object fishery (Figure 4).

On the other hand, trends in some of the other SSIs do not necessarily support the interpretation that increased fishing mortality is occurring as a result of an increase in the number of floating-object sets. In particular, trends in catch-per-set for other set types (Figure 3), mean length of yellowfin in the other set types (Figure 4), and the longline SSIs (Figures 6-7), except yellowfin CPUE, are not consistent with this interpretation. The indicator for yellowfin based on spatio-temporal modelling of CPDF for the purse-seine fishery on yellowfin associated with dolphins shows a recent period of low CPUE starting in 2015 (Figure 5), which coincides with a period of increased yellowfin catches in floating-objects sets (Figure 2).

Identifying the causes of differences in the SSIs is difficult, even when SSIs are considered in aggregate. The inconsistencies among SSIs for yellowfin may be due to an interaction between potential stock structure and differences in the spatial distribution of effort in the different set types and gears (see IATTC-95-05 Fig. B-4). In addition, catch-per-set may not be a reliable indicator of relative abundance, particularly for the target species (*i.e.* skipjack in the floating-object fishery and yellowfin in the dolphin-associated fishery). Nonetheless, the fact that most SSIs based on the floating-object fishery are consistent with an increase in fishing mortality in that fishery, and that the average length for bigeye and skipjack in the catch of that fishery are at historically low levels in 2020 and at or very near the lower reference levels, means that precautionary management measures should be considered to prevent further increases.

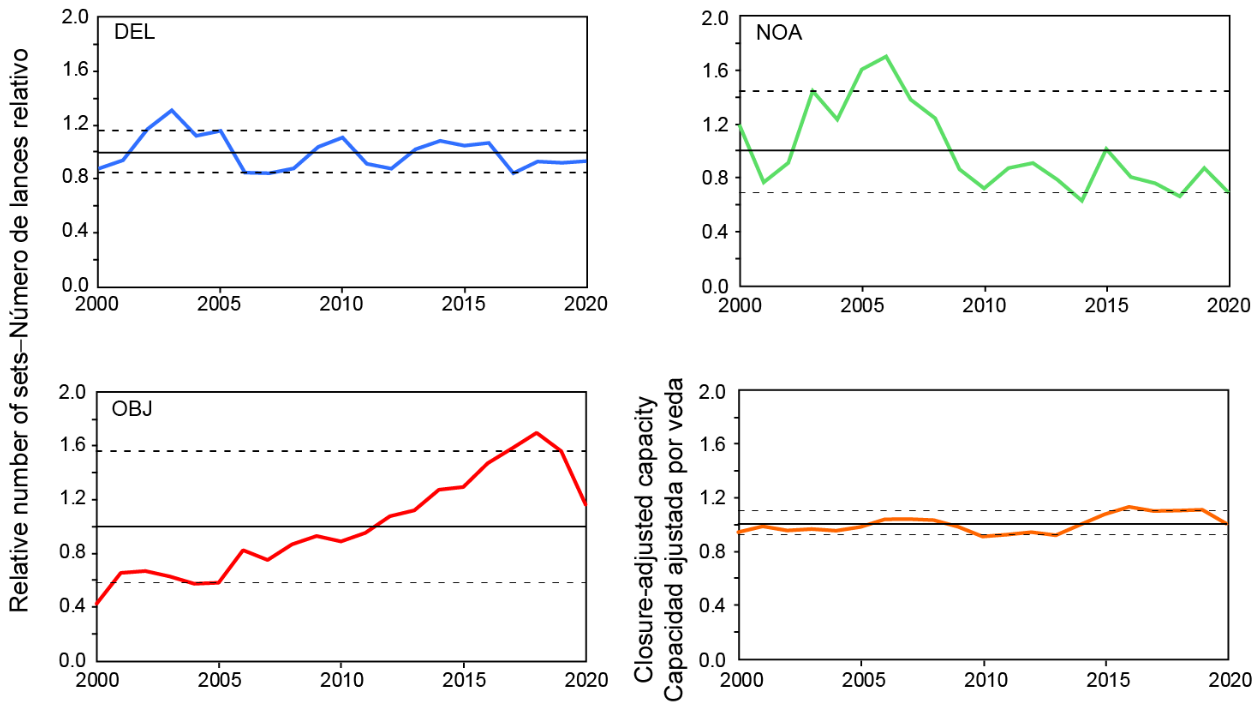

FIGURE 1. Indicators based on purse-seine fishing effort, 2000-2020.
FIGURA 1. Indicadores basados en el esfuerzo de pesca de cerco, 2000-2020.

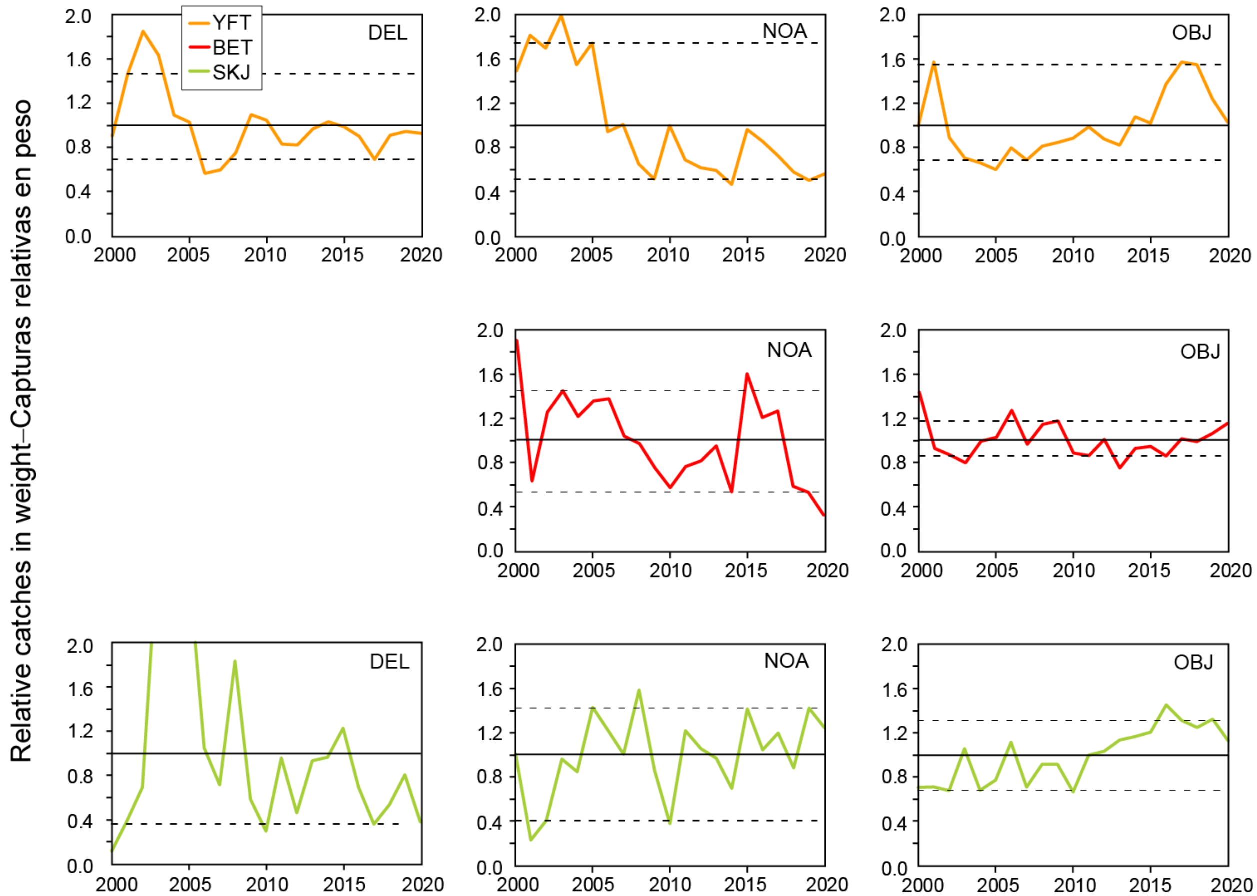

FIGURE 2a. Indicators based on purse-seine catch in weight, 2000-2020.
FIGURA 2a. Indicadores basados en la captura cerquera en peso, 2000-2020.

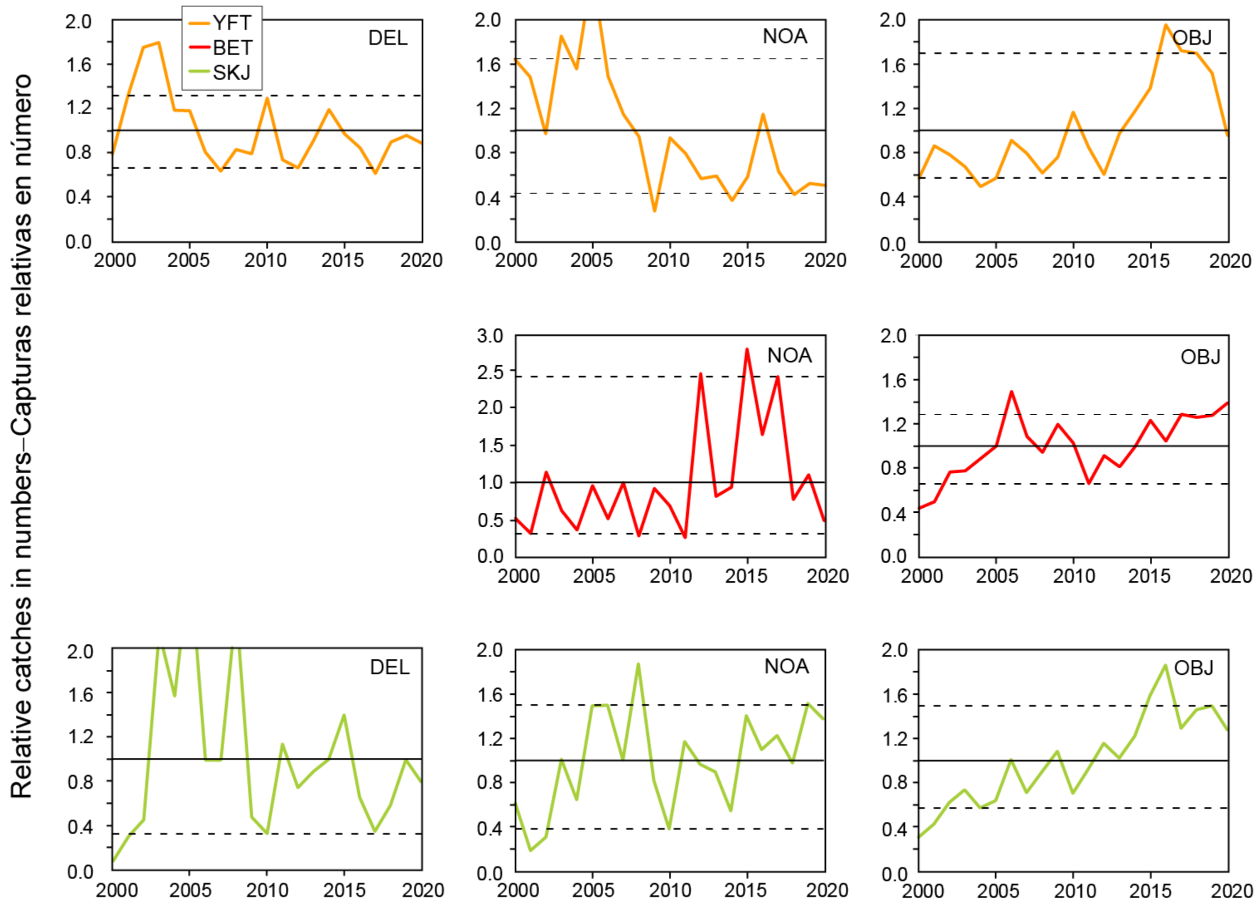

FIGURE 2b. Indicators based on purse-seine catch in number, 2000-2020.
FIGURA 2b. Indicadores basados en la captura cerquera en número, 2000-2020.

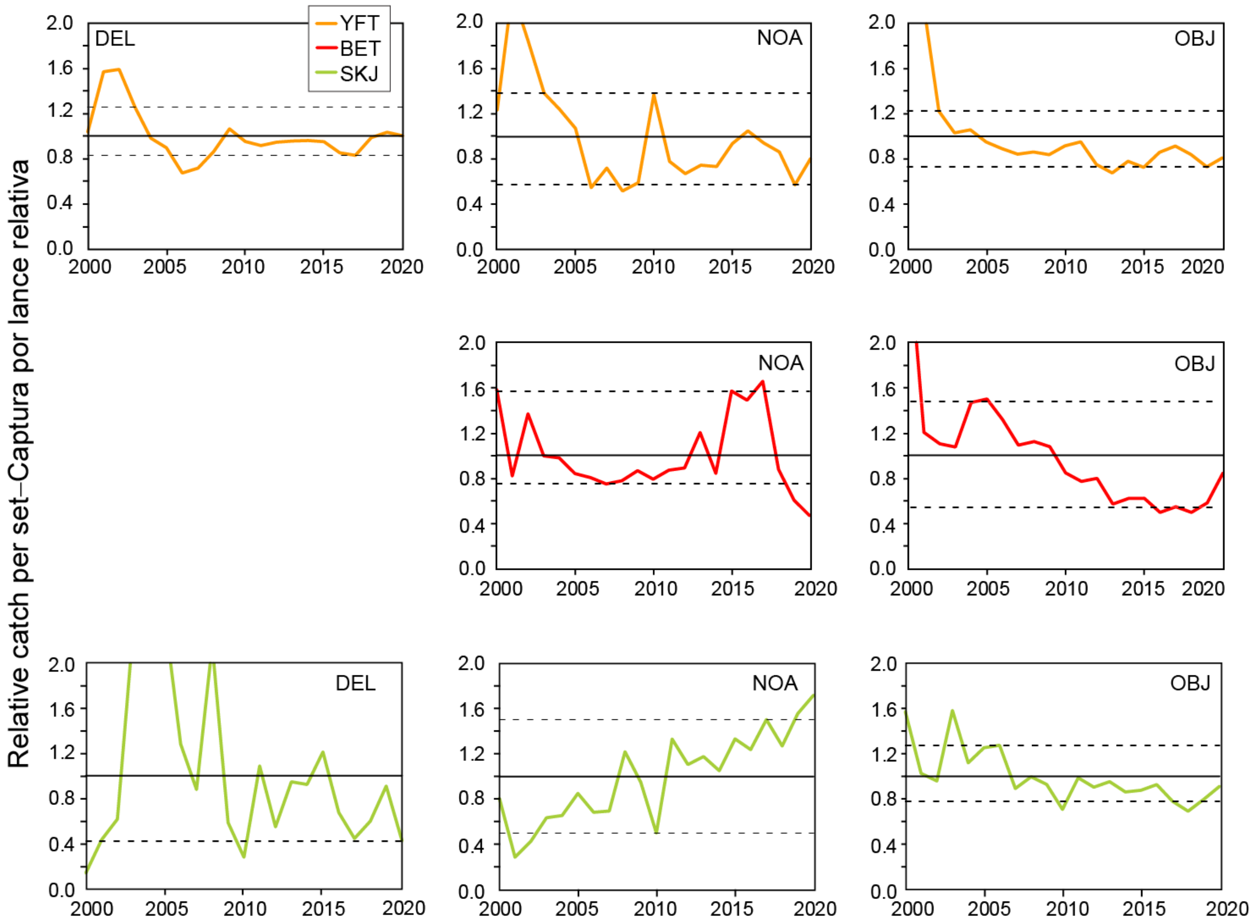

FIGURE 3. Indicators based on purse-seine catch-per-set, 2000-2020.
FIGURA 3. Indicadores basados en captura por lance cerquero, 2000-2020.

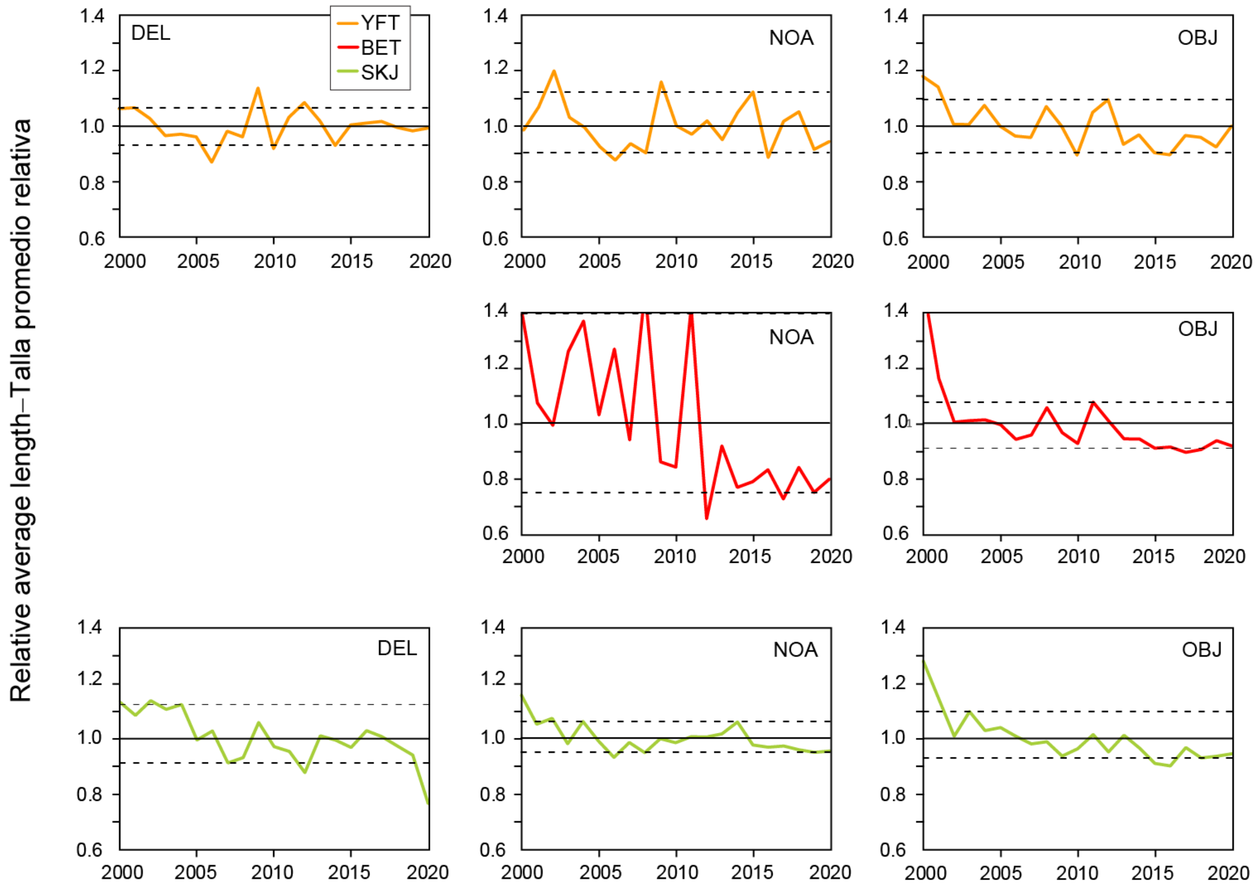

FIGURE 4. Indicators based on average length of fish in the purse-seine catch, 2000-2020. The y-axis limits differ from the figures for the other indicators to accentuate the changes because average length is less sensitive to fishing mortality.

FIGURA 4. Indicadores basados en la talla promedio del pescado en la captura cerquera, 2000-2020. Los límites del eje y difieren de las figuras de los otros indicadores para acentuar los cambios ya que la talla promedio es menos sensible a la mortalidad por pesca.

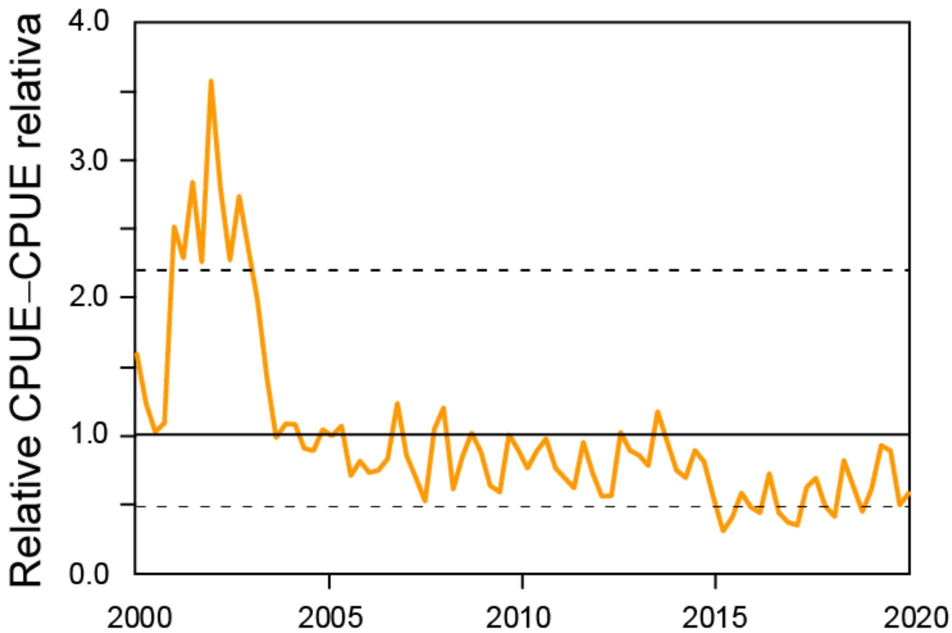

FIGURE 5. Indicator based on spatio-temporal modelling of catch-per-day-fished for the purse-seine fishery on yellowfin associated with dolphins, 2000-2020.
FIGURA 5. Indicador basado en el modelado espaciotemporal de la captura por día de pesca para la pesquería cerquera de aleta amarilla asociado a delfines, 2000-2020.

FIGURE 6. Indicators based on longline catch and effort data, 2001-2020 (data for 2000 only included for BET, from the montly reports, and the values for 2006 are uncertain due to possible unreported catch and effort for those years).

FIGURA 6. Indicadores basados en datos de captura y esfuerzo de palangre, 2001-2020 (los datos de 2000 solo se incluyen para BET, de los informes mensuales, y los valores de 2006 son inciertos debido a posible captura y esfuerzo no reportados para esos años).

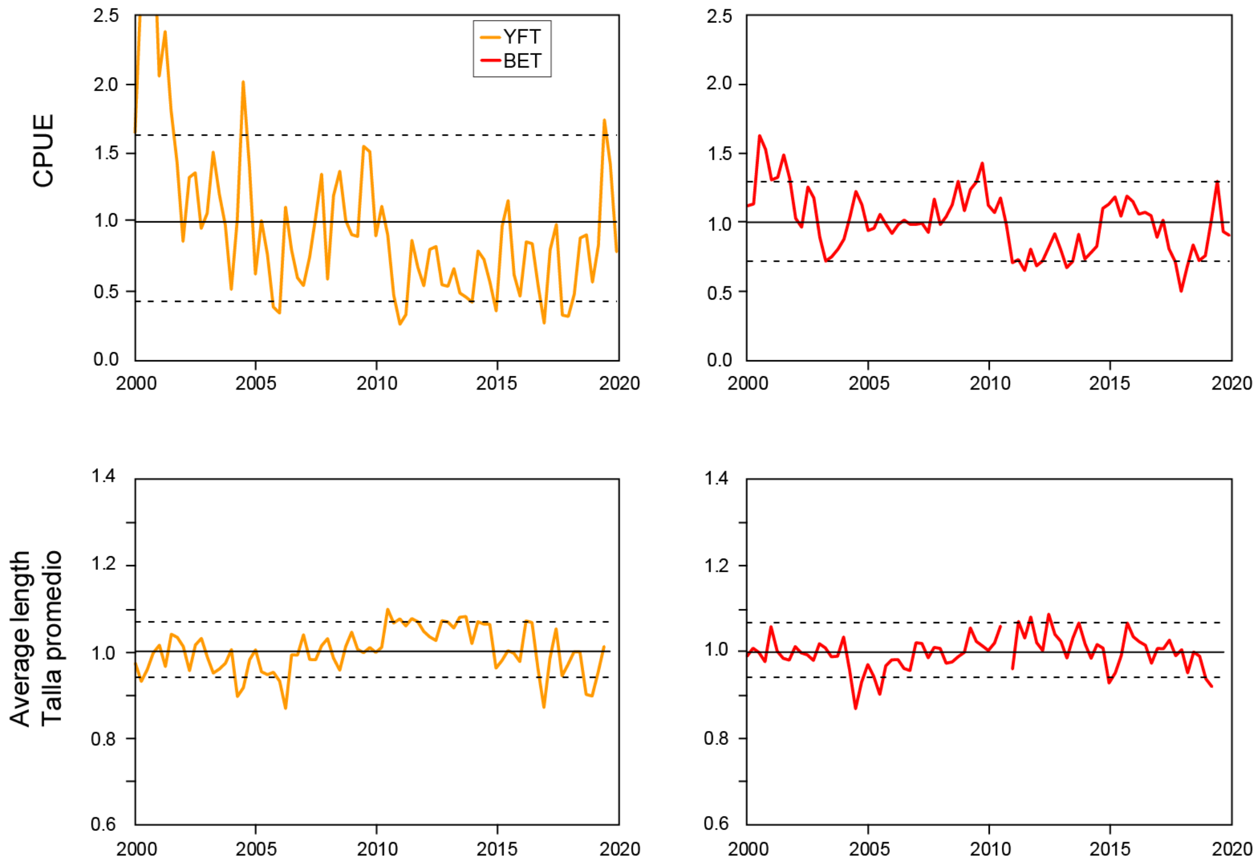

FIGURE 7. Indicators based on spatio-temporal modelling of longline data, 2000-2020. The y-axis limits for average length differ from the figures for the other indicators to accentuate the changes because average length is less sensitive to fishing mortality.

FIGURA 7. Indicadores basados en el modelado espaciotemporal de datos de palangre, 2000-2020. Los límites del eje y para la talla promedio difieren de las figuras de los otros indicadores para acentuar los cambios ya que la talla promedio es menos sensible a la mortalidad por pesca.