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

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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 - YFT, bigeye - BET, and skipjack - SKJ). 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 negatively affected the fishery and port-sampling, so the SSIs in 2020 and 2021 should be used with caution when interpreting long-term trends. The general increasing trend in the number of sets in the floating-object fishery since 2005, up until the onset of the COVID-19 pandemic, is reflected in increased catches, reduced catch-per-set, and reduced 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 due to 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 in 2021 the catch-per-set for bigeye in floating-object sets is at the lowest level since 2000.

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, catch per unit of effort (CPUE), and 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 EPO 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 IATTC 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 conducted in a risk-based framework (SAC-11-08, SAC-11 INF-F), were considered sufficiently reliable to be used as the basis for providing management advice (IATTC-97-02). The new risk-based assessment framework is planned to be applied again before the start of the next multi-year management cycle. However, 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 during the management cycle, and to provide management advice as needed. 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)** and **average fish length** 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 2000-2021 period. The reference levels were changed from the 5% and 95% percentiles to the 10% and 90% percentiles because percentiles in the extremes of the distribution's tails 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), **CPUE** (catch-per-hook), and **average length** of fish estimated 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 2000-2021 period. Reference levels also are based on the 10% and 90% percentiles.

Further information about bigeye, yellowfin, and skipjack can be found in Documents SAC-11-06, SAC-11-07, and SAC-13-07, respectively, and information on the absolute catch and number of sets by set type, in SAC-13-03. The tables and R code we used to generate all figures in this report are available online at https://github.com/HaikunXu/Indicators/blob/main/2022.

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 21.5% 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. Both closure-adjusted fishing capacity and the number of sets in the floating-object fishery have recovered to a certain extent in 2021 but are still lower than their *status quo*[1] levels. 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 the number of floating objects sets and *F* for bigeye). Of particular concern is the general increasing trend in the number of floating-object sets observed since 2005 up until the onset of the COVID-19 pandemic in 2020 (Figure 1). There are also increases in catch for yellowfin and skipjack, particularly in numbers, along with an increase in catch in numbers for bigeye in floating-object sets (Figure 2) and 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. In 2021, the catch-per-set for bigeye in floating-object sets is at the lowest level since 2000 (Figure 3) and the catch for bigeye in that fishery is below the *status quo* level (Figure 2). The catches in weight and numbers for skipjack in floating-object sets are slightly above and below the *status quo* levels, respectively. The interpretation of increased fishing mortality is supported by trends in average length of bigeye and skipjack caught in the other set types.

On the other hand, trends in some of the other SSIs do not necessarily support the interpretation that increased fishing mortality is occurring due to 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 that 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).

[1] Defined as the average conditions in 2017-2019.

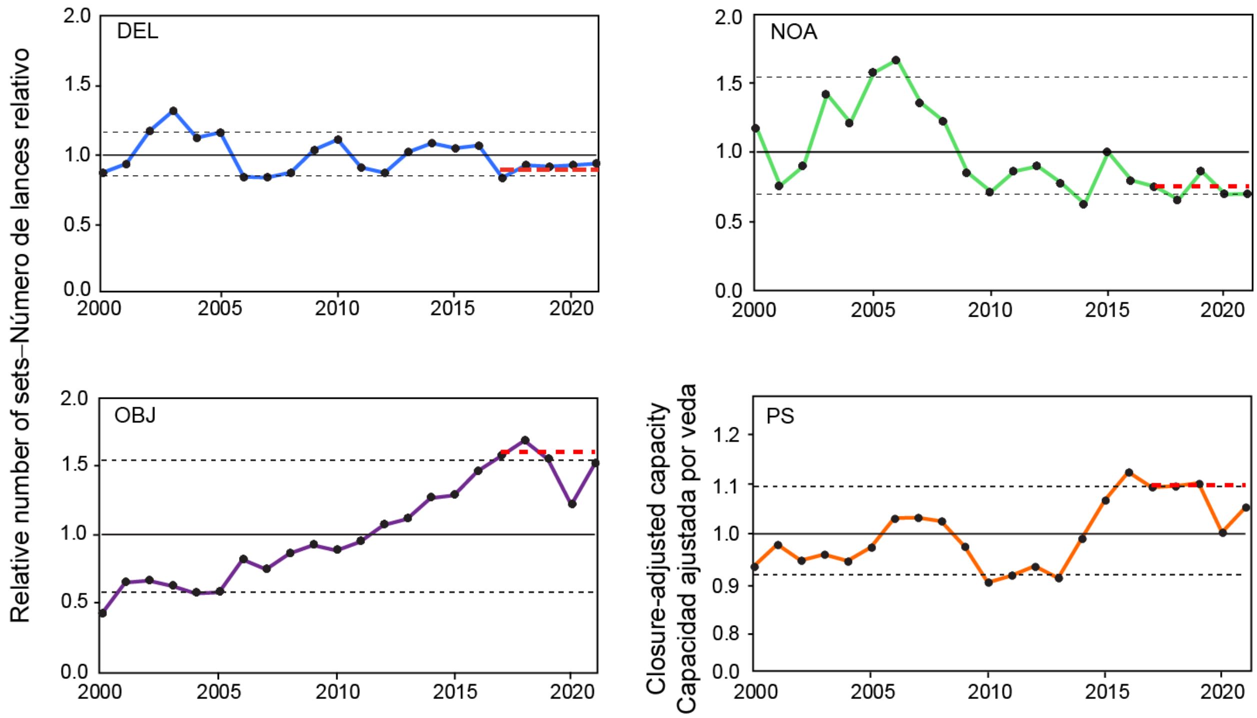

FIGURE 1. Indicators based on purse-seine fishing effort, 2000-2021. The red dashed lines mark the *status quo* levels (average conditions in 2017-2019).
FIGURA 1. Indicadores basados en el esfuerzo de pesca de cerco, 2000-2021. Las líneas discontinuas rojas marcan los niveles de *statu quo* (condiciones promedio en 2017-2019).

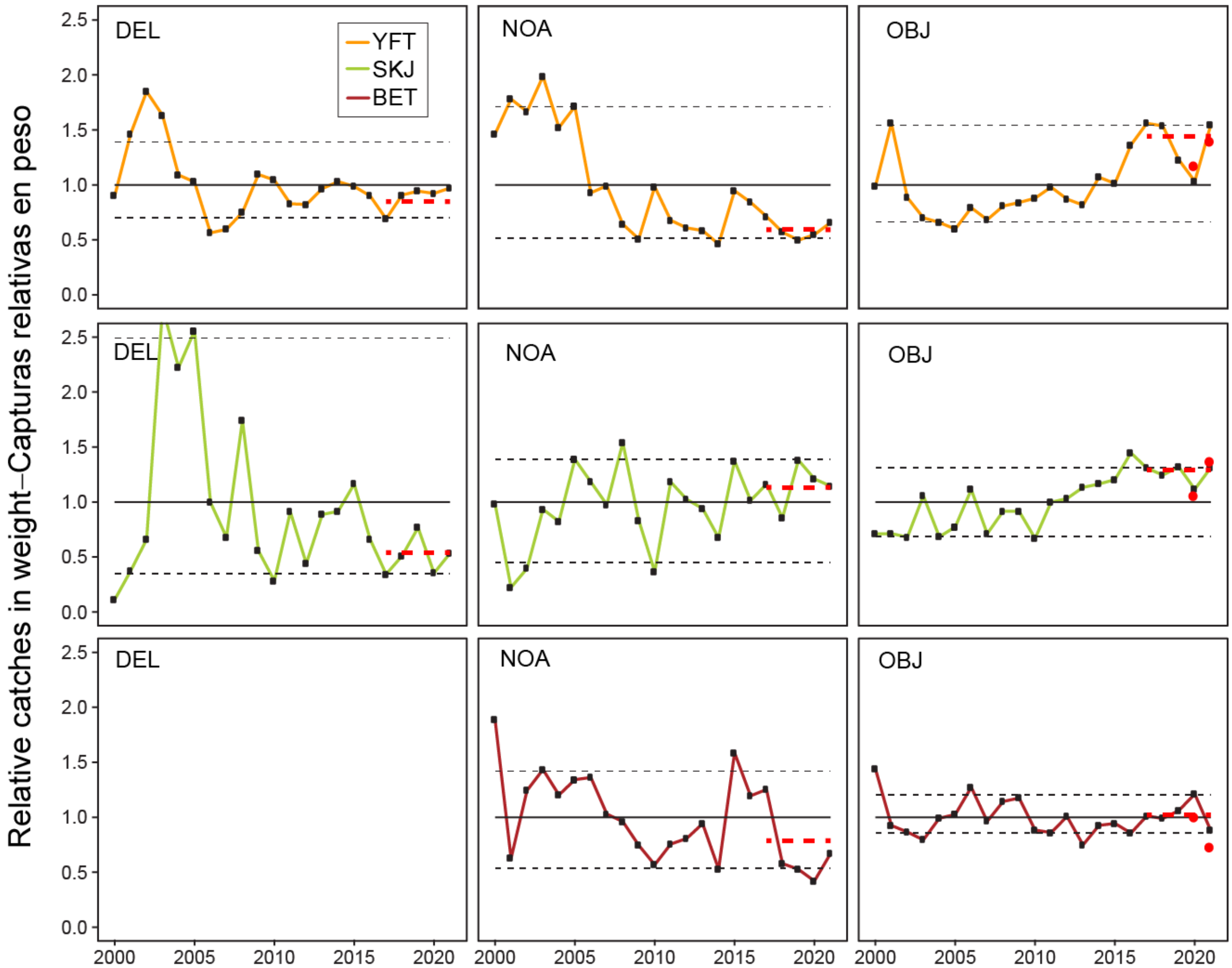

FIGURE 2a. Indicators based on purse-seine catch in weight, 2000-2021. The red dots are the bias-adjusted values for OBJ catches in the two COVID-19 years[2] of 2020 and 2021 (see SAC-13-05). The red dashed lines mark the *status quo* levels (average conditions in 2017-2019).

FIGURA 2a. Indicadores basados en la captura cerquera en peso, 2000-2021. Los puntos rojos son los valores ajustados al sesgo para las capturas OBJ en los dos años de COVID-19 de 2020 y 2021 (ver SAC-13-05). Las líneas discontinuas rojas marcan los niveles de *statu quo* (condiciones promedio en 2017-2019).

[2] The 2021 catch and bias estimates are considered preliminary and further research is need to investigate their reliability (see SAC-13-05).

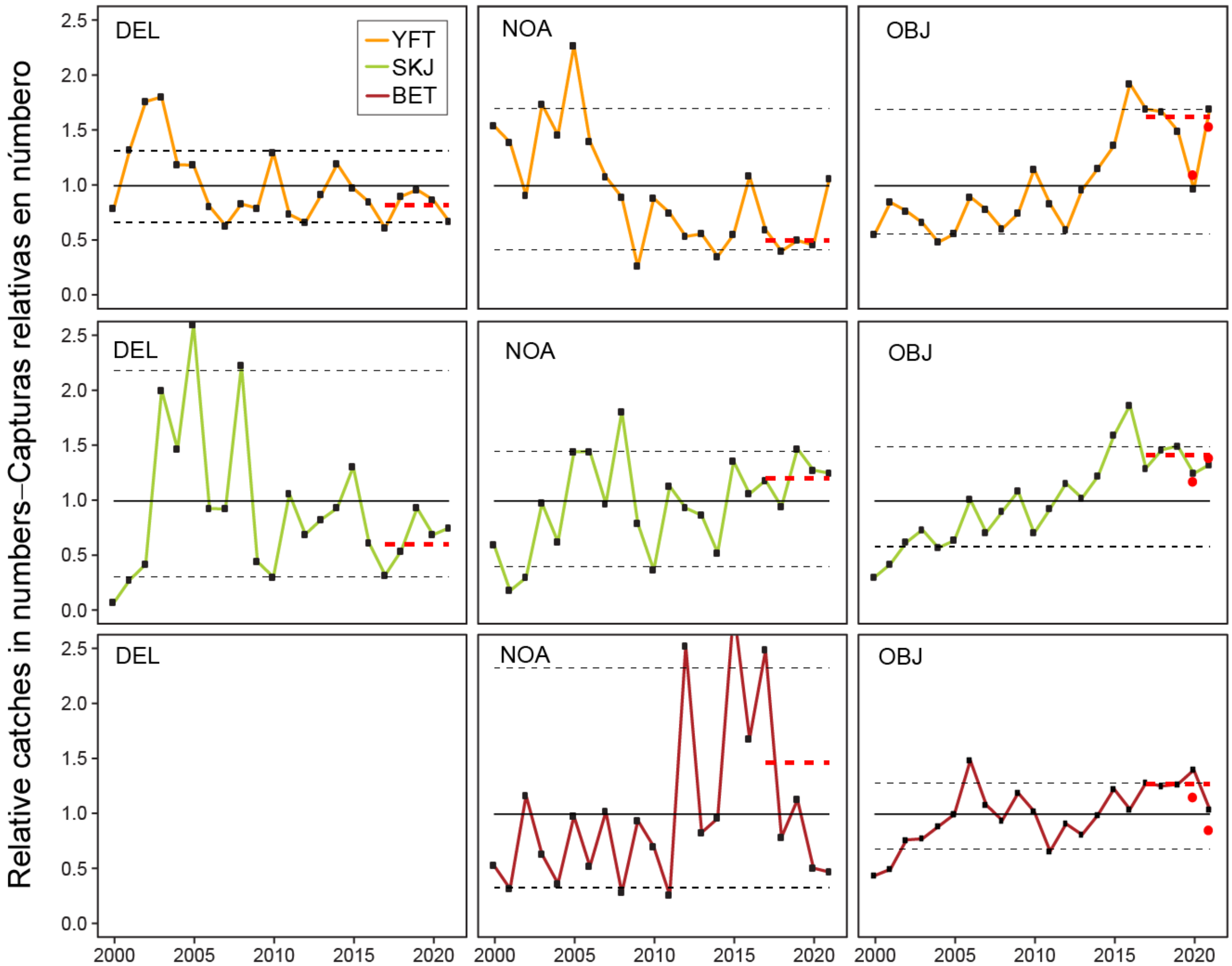

FIGURE 2b. Indicators based on purse-seine catch in number, 2000-2021. The red dots are the bias-adjusted values for OBJ catches in the two COVID-19 years (see SAC-13-05). Here we assume that the impact of COVID-19 on the port sampling did not influence the size composition of the catch. The red dashed lines mark the *status quo* levels (average conditions in 2017-2019).

FIGURA 2b. Indicadores basados en la captura cerquera en número, 2000-2021. Los puntos rojos son los valores ajustados al sesgo para las capturas OBJ en los dos años de COVID-19 (ver SAC-13-05). Aquí se supone que el impacto del COVID-19 en el muestreo en puerto no influyó en la composición por talla de la captura. Las líneas discontinuas rojas marcan los niveles de *statu quo* (condiciones promedio en 2017-2019).

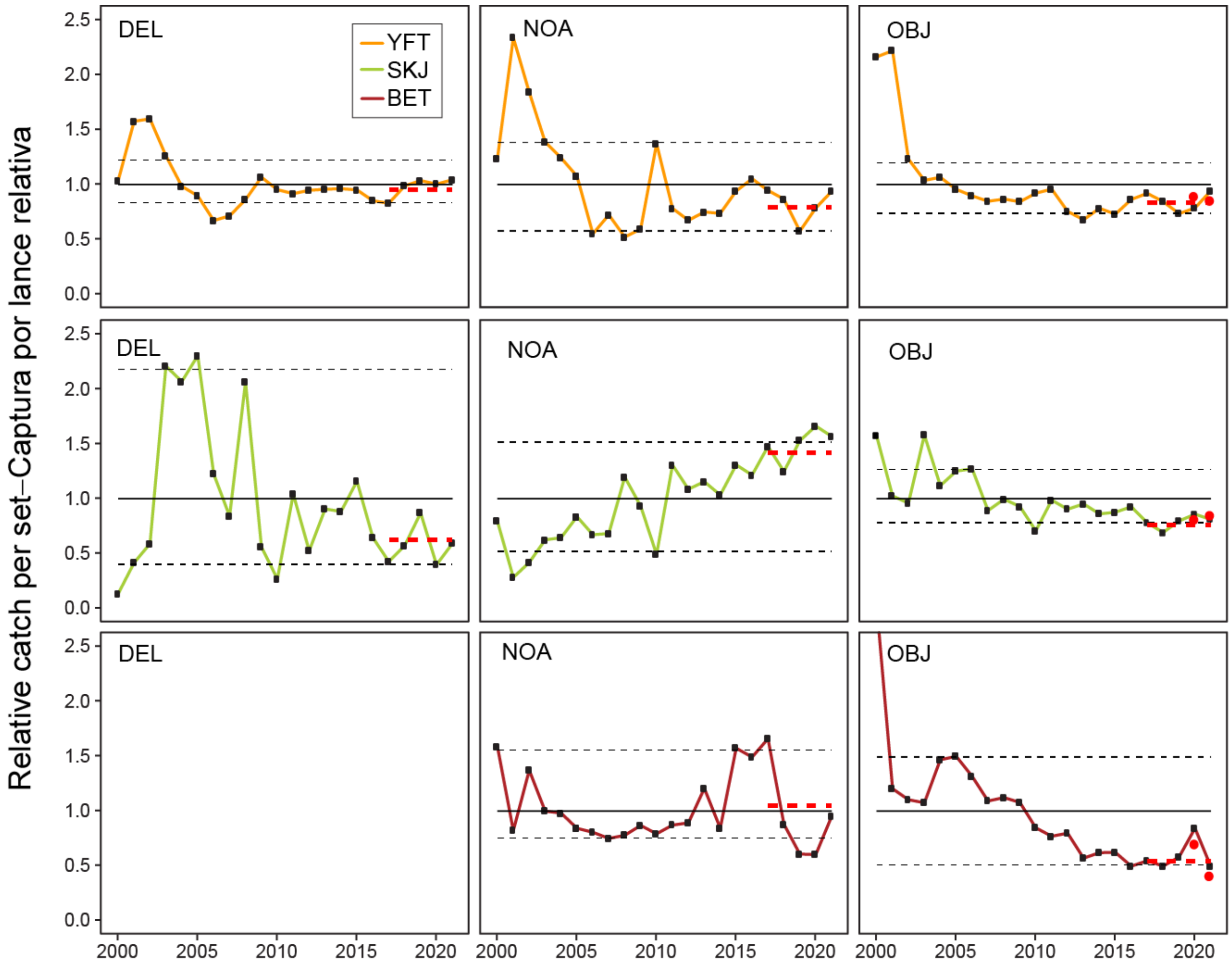

FIGURE 3. Indicators based on purse-seine catch-per-set, 2000-2021. The red dots are the bias-adjusted values for OBJ catches in the two COVID-19 years (see SAC-13-05). The red dashed lines mark the *status quo* reference levels (average conditions in 2017-2019).

FIGURA 3. Indicadores basados en captura por lance cerquero, 2000-2021. Los puntos rojos son los valores ajustados al sesgo para las capturas OBJ en los dos años de COVID-19 (ver SAC-13-05). Las líneas discontinuas rojas marcan los niveles de referencia de *statu quo* (condiciones promedio en 2017-2019).

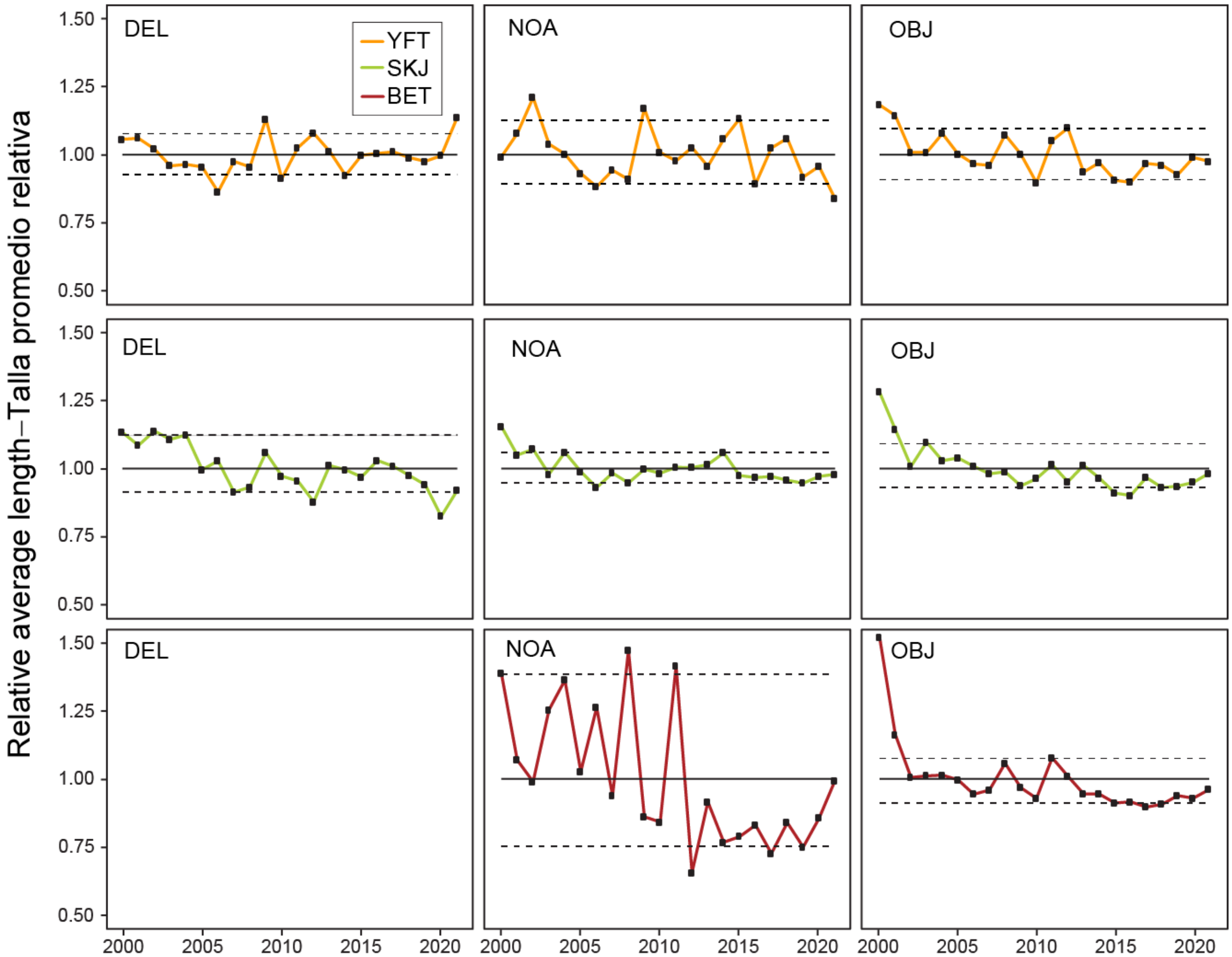

FIGURE 4. Indicators based on average length of fish in the purse-seine catch, 2000-2021. The y-axis limits differ from the figures for the other indicators to accentuate the changes because average length is less sensitive to fishing mortality.

FIGURA 4. Indicadores basados en la talla promedio de los peces en la captura cerquera, 2000-2021. 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.

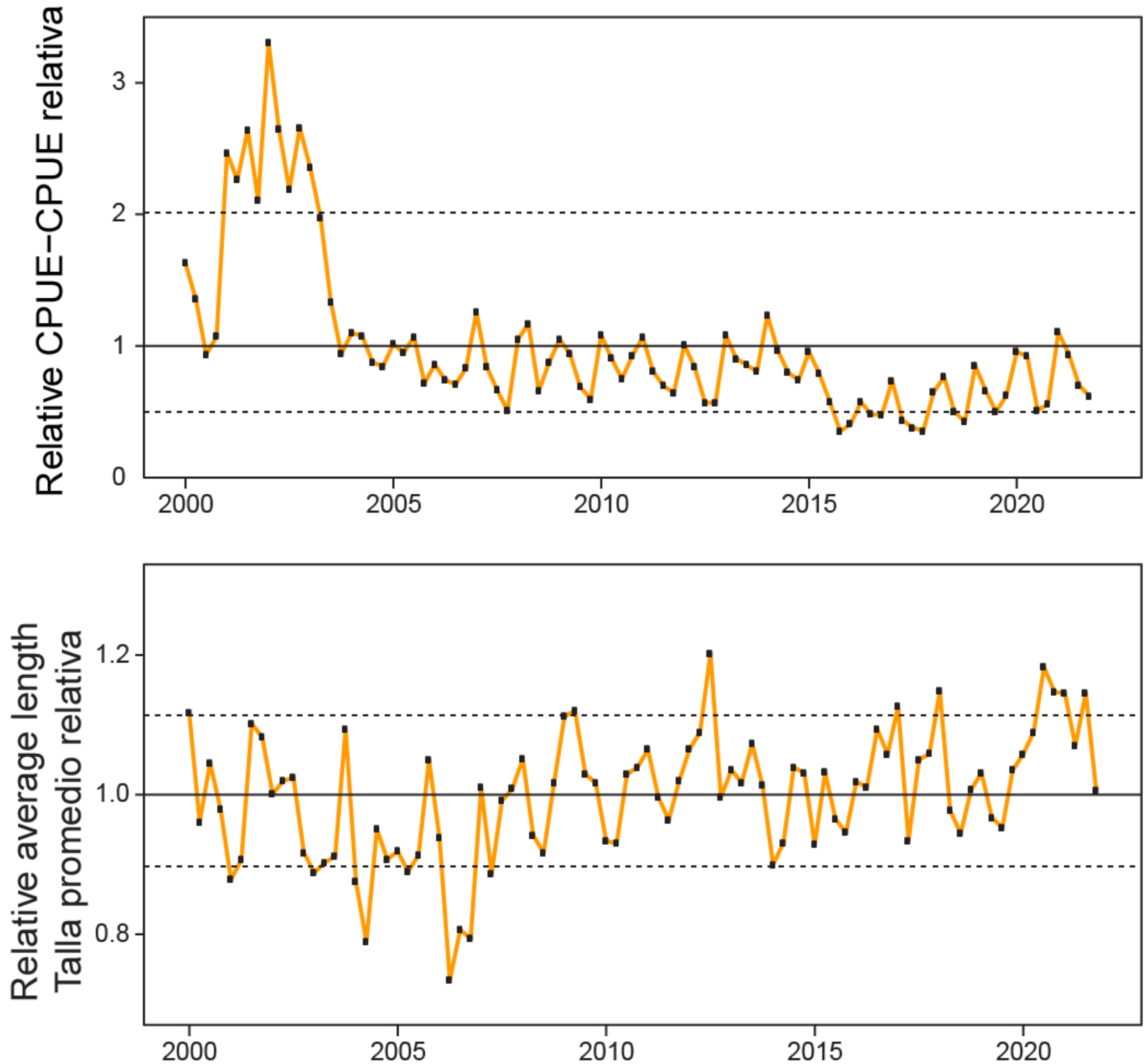

FIGURE 5. Indicators based on spatio-temporal modelling of catch-per-day-fished and length compositions for the purse-seine fishery on yellowfin associated with dolphins, 2000-2021.

FIGURA 5. Indicadores basados en el modelado espaciotemporal de la captura por día de pesca y composiciones por talla para la pesquería cerquera de aleta amarilla asociada a delfines, 2000-2021.

FIGURE 6. Indicators based on longline catch and effort data, 2000-2021 (data for 2021 only included for bigeye tuna from the montly reports).

FIGURA 6. Indicadores basados en datos de captura y esfuerzo de palangre, 2000-2021 (los datos de 2021 solo se incluyen para atún patudo, obtenidos de los informes mensuales).

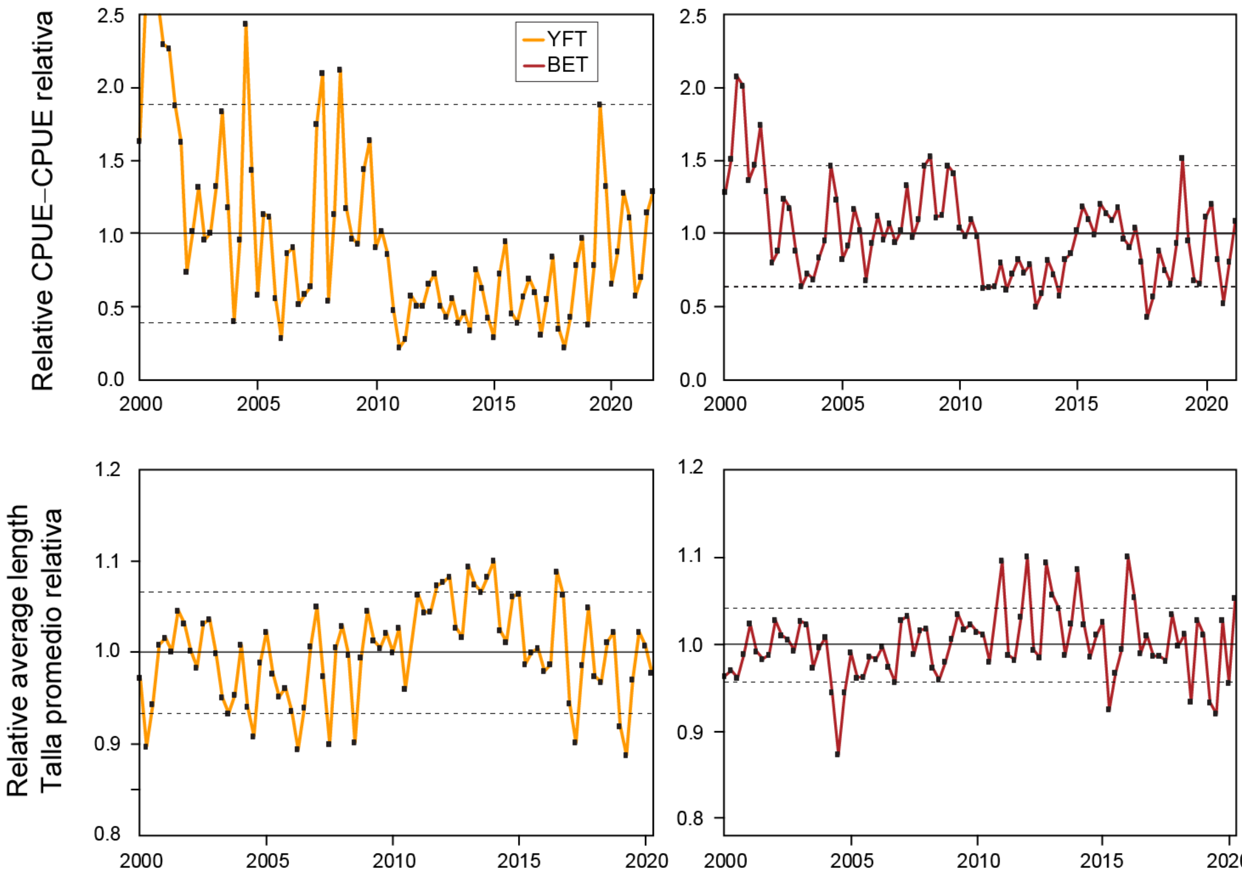

FIGURE 7. Indicators based on spatio-temporal modelling of longline data, 2000-2021. The y-axis limits for average length differ from the figures for the other indicators to accentuate the changes because average length is less sensitive to fishing mortality.

FIGURA 7. Indicadores basados en el modelado espaciotemporal de datos de palangre, 2000-2021. 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.