INTER-AMERICAN TROPICAL TUNA COMMISSION

SCIENTIFIC ADVISORY COMMITTEE

14TH MEETING

La Jolla, California (USA)
15-19 May 2023

DOCUMENT SAC-14-04

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

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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 - 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, except in the first COVID-19 pandemic year of 2020, is reflected in increased catches, reduced catch-per-set, and reduced average length for all three species in the floating object fishery, although there has been a flattening off of the trends in some indicators over the most recent decade. As the impact of the pandemic on the fishery operation began to diminish in 2021, the number of sets on floating objects resumed its general increasing trend. In 2022, the number of sets on floating objects reached its maximum historic level and exceeded the *status quo*[1] by 10.6%. 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. In 2022, both the catch in weight and catch-per-set for bigeye in floating-object sets reached their lowest levels since 2000, which may partly be a result of the introduction of a catch threshold scheme per vessel for bigeye tuna under Resolution C-21-04.

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

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

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 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, such as strategies that use empirical (data-based) harvest control rules whose performance can be formally evaluated using management strategy evaluation.

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). In addition, during 2022 an *interim* stock assessment was developed for skipjack in the EPO (SAC-13-07). This is the first conventional stock assessment for skipjack that the staff considers reliable for management advice. The new risk-based assessment framework is planned to be applied for all three species in 2024, before the start of the next multi-year management cycle in 2025. 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 spatiotemporal 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. 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 2000-2022 period. The 10% and 90% percentiles are used as reference levels 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 spatiotemporal 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 2000-2022 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 can be found in SAC-14-03. 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/2023.

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). The 21.5% decline in the total number of floating-object sets from 2019 to 2020 is most likely attributed to the negative impact of the COVID-19 pandemic on fishery operations. Although closure-adjusted fishing capacity and the number of sets in the floating-object fishery recovered to a certain extent in 2021, they remain below their *status quo* levels. In 2022, the closure-adjusted fishing capacity changed slightly from 2021 but the number of sets in the floating-object fishery increased to the highest level since 2000, exceeding the *status quo* level by 10.6%. In contrast, the number of sets in the unassociated fishery in 2022 decreased to the lowest level since 2000. 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 the fishing mortality for juvenile bigeye). Of particular concern is the general increasing trend in the number of floating-object sets observed since 2005. Although this increasing trend had been interrupted with the onset of the COVID-19 pandemic in 2020, this trend has resumed in 2021 and 2022 when the effects of the pandemic on fishery operations gradually diminished (Figure 1). Particularly, the number of sets on floating objects in 2022 reached the highest value since 2000. In 2022, both catch in weight (Figure 2a) and catch-per-set (Figure 3) for bigeye on floating-object sets are at the lowest level since 2000, which may partly be a result of the introduction of the catch threshold scheme per vessel for bigeye tuna under Resolution C-21-04. Overall, there are increasing trends in catch, particularly in numbers, for skipjack and yellowfin on floating-object sets since 2000 (Figure 2). Since 2015, however, the catches for all three tropical tunas on floating-object sets have had high variability without notable positive trends. The catch-per-set (Figure 3) and average length (Figure 4) for the three tropical tunas on floating-object sets showed similar temporal trends: decreased between 2000 and 2015 and have remained relatively stable thereafter. The recent increase in the catch of yellowfin on floating-object sets in 2022 is particularly strong, which was at the highest level since 2000 (increase of 38.9% and 67.5% from 2021 to 2022, in bias-adjusted weight and numbers, respectively).

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 (Figures 4 and 5), and the dolphin-associated purse-seine (Figure 5) and longline (Figure 7) indices of abundance are not consistent with that interpretation.

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).

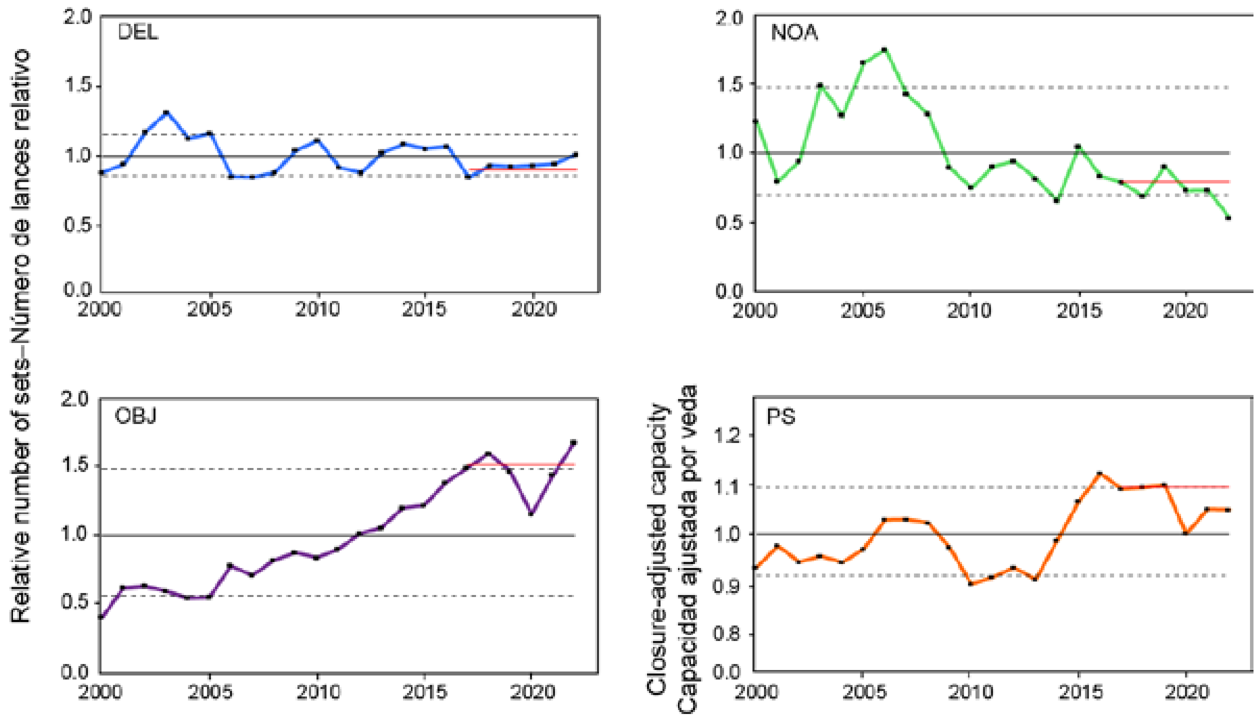

FIGURE 1. Indicators based on purse-seine fishing effort, 2000-2022. The red dashed lines mark the *status quo* levels (average conditions in 2017-2019).

FIGURA 1. Indicadores basados en el esfuerzo de pesca de cerco, 2000-2022. Las líneas discontinuas rojas marcan los niveles de *statu quo* (condiciones promedio en 2017-2019).

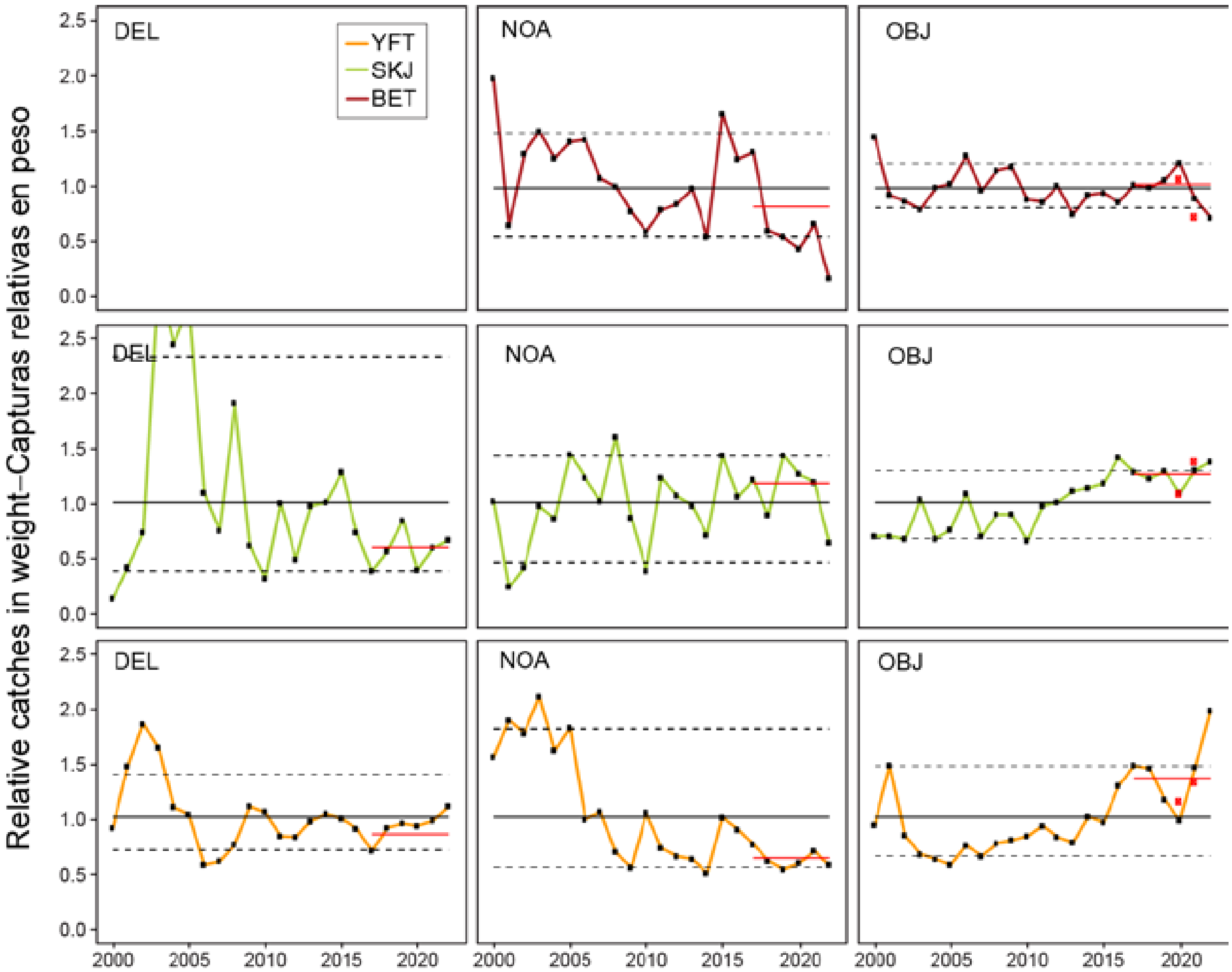

FIGURE 2a. Indicators based on purse-seine catch in weight, 2000-2022. The red dots are the bias-adjusted values for OBJ catches in the two COVID-19 years of 2020 and 2021 (see SAC-14-INF-D). The red dashed lines mark the *status quo* levels (average conditions in 2017-2019).

FIGURA 2a. Indicadores basados en la captura cerquera en peso, 2000-2022. 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-14-INF-D). Las líneas discontinuas rojas marcan los niveles de *statu quo* (condiciones promedio en 2017-2019).

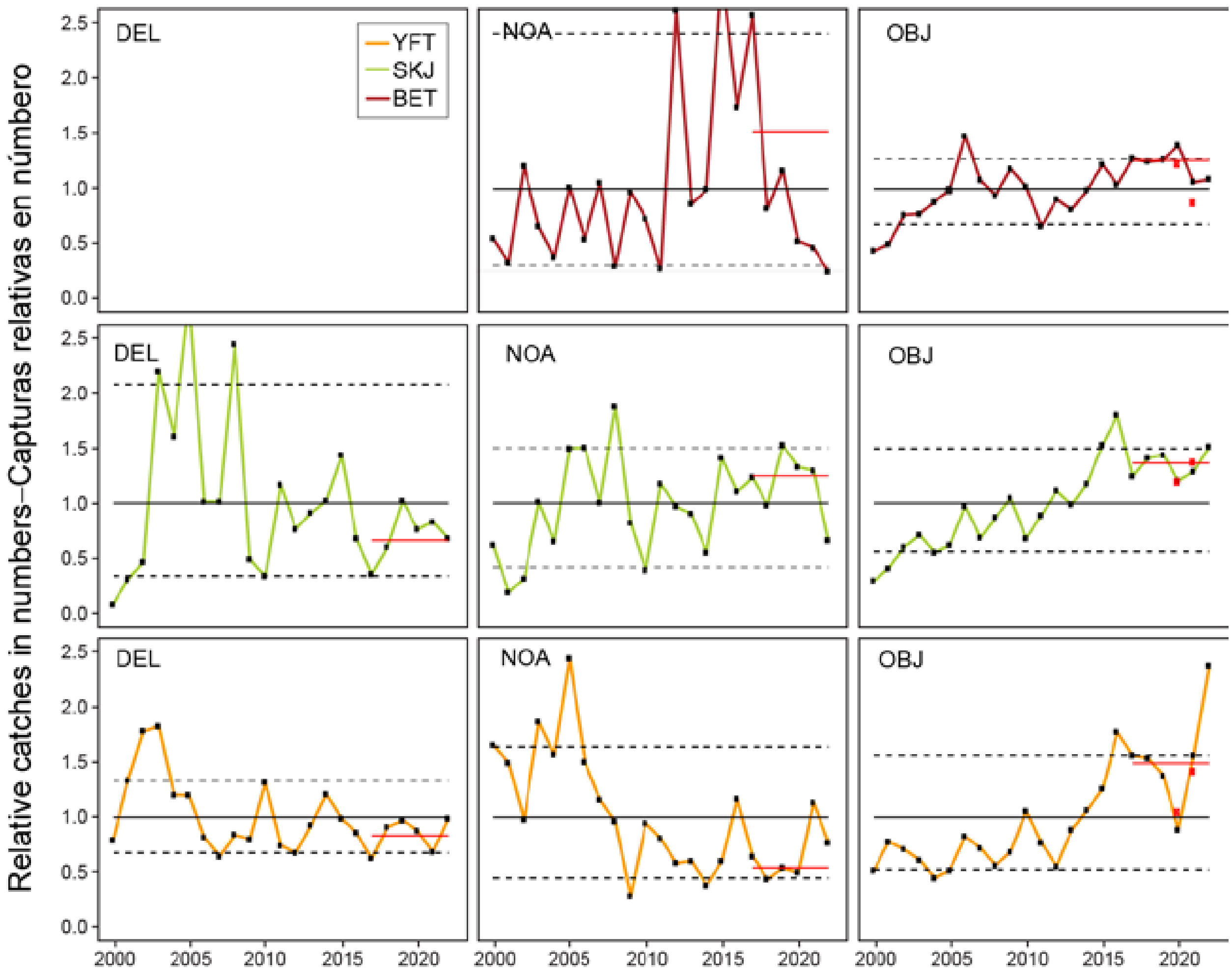

FIGURE 2b. Indicators based on purse-seine catch in number, 2000-2022. The red dots are the bias-adjusted values for OBJ catches in the two COVID-19 years (see SAC-14-INF-D). Here we assume that the impact of COVID-19 on the port sampling did not influence the size composition of the catch. The red dashed lines mark the *status quo* levels (average conditions in 2017-2019).

FIGURA 2b. Indicadores basados en la captura cerquera en número, 2000-2022. Los puntos rojos son los valores ajustados al sesgo para las capturas OBJ en los dos años de COVID-19 (ver SAC-14-INF-D). 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).

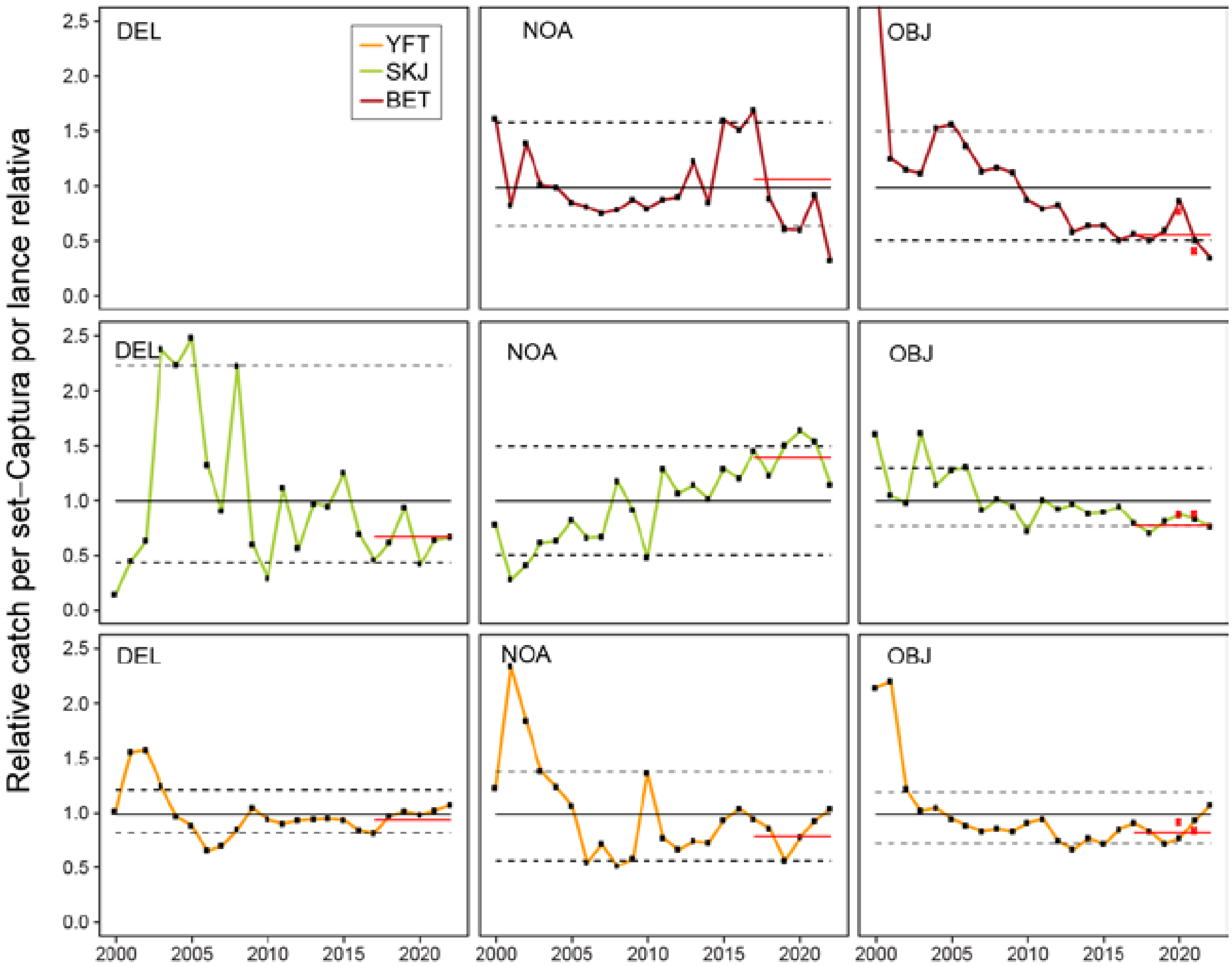

FIGURE 3. Indicators based on purse-seine catch-per-set, 2000-2022. The red dots are the bias-adjusted values for OBJ catches in the two COVID-19 years (see SAC-14-INF-D). The red dashed lines mark the *status quo* reference levels (average conditions in 2017-2019).

FIGURA 3. Indicadores basados en captura por lance cerquero, 2000-2022. Los puntos rojos son los valores ajustados al sesgo para las capturas OBJ en los dos años de COVID-19 (ver SAC-14-INF-D). Las líneas discontinuas rojas marcan los niveles de referencia de *statu quo* (condiciones promedio en 2017-2019).

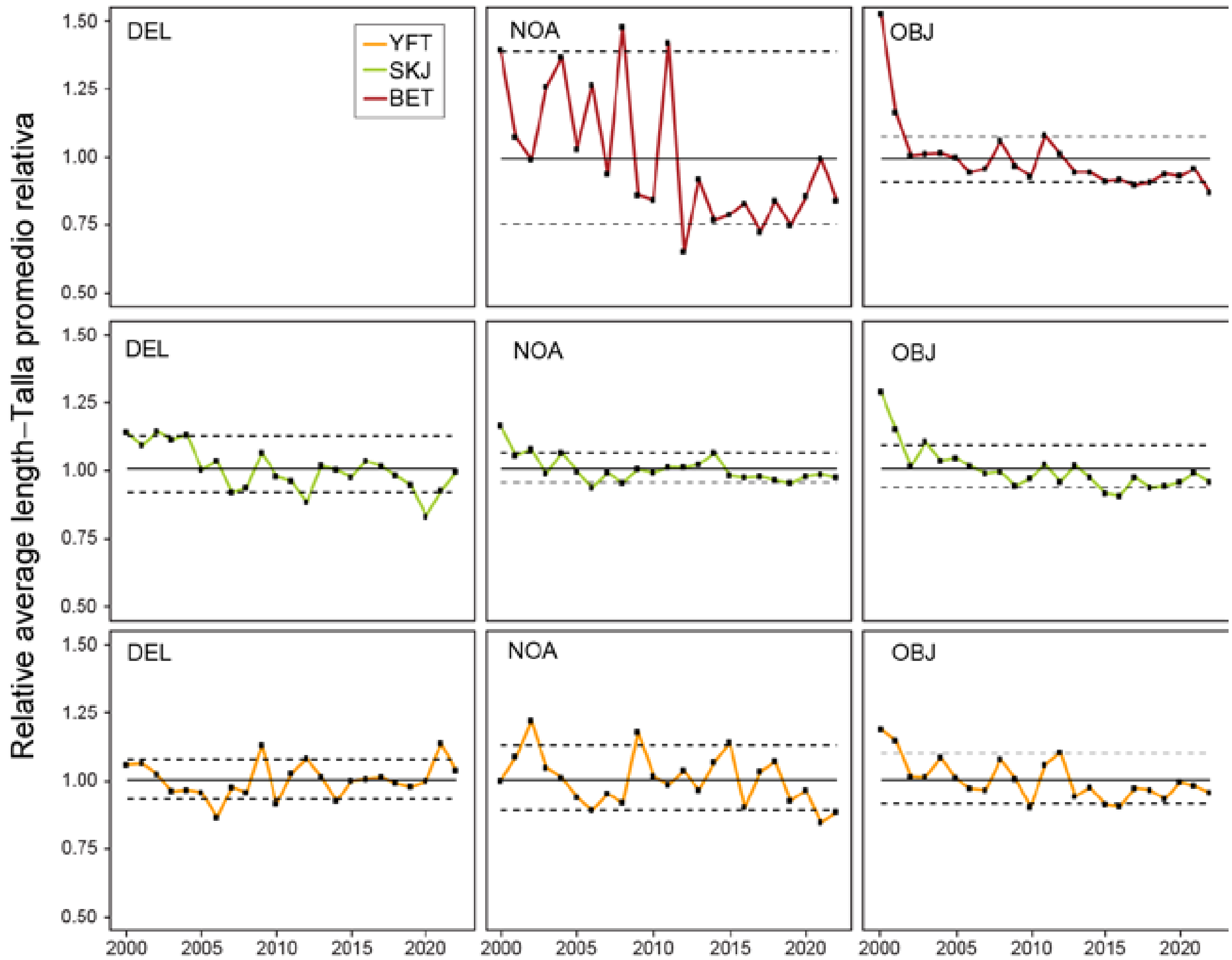

FIGURE 4. Indicators based on average length of fish in the purse-seine catch, 2000-2022. The y-axis limits differ from the figures for the other indicators to accentuate the changes because average length is less sensitive to fishing mortality.

FIGURA 4. Indicadores basados en la talla promedio de los peces en la captura cerquera, 2000-2022. 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.

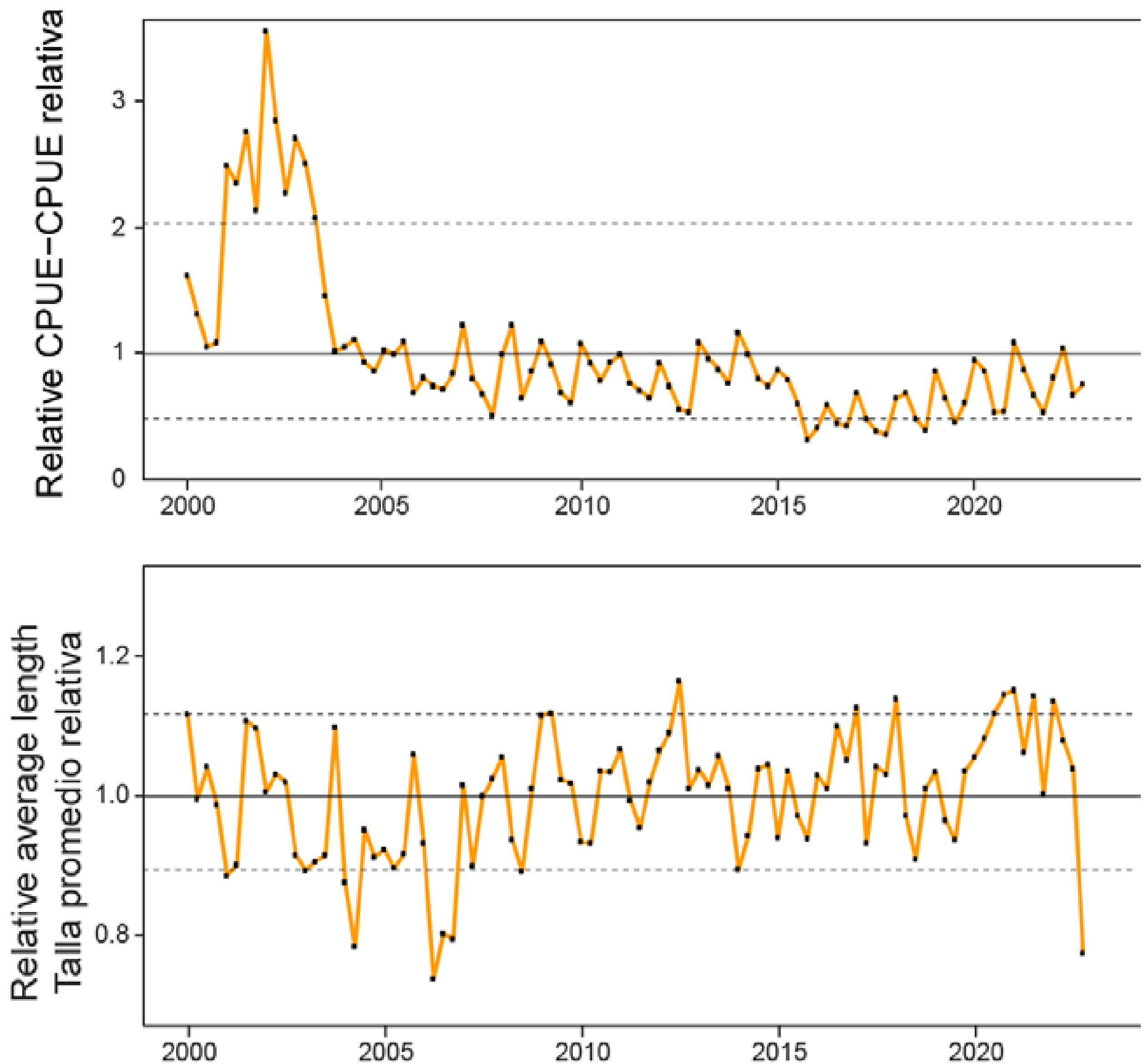

FIGURE 5. Indicators based on spatio-temporal modelling of catch-per-day-fished and length compositions for the purse-seine fishery on yellowfin associated with dolphins, 2000-2022.
FIGURA 5. Indicadores basados en el modelado espaciotemporal de la captura por día de pesca y composiciones por talla para la pesquería cerquera de aleta amarilla asociada a delfines, 2000-2022.

FIGURE 6. Indicators based on longline catch and effort data, 2000-2022 (data for 2022 only included for bigeye tuna from the montly reports).
FIGURA 6. Indicadores basados en datos de captura y esfuerzo de palangre, 2000-2022 (los datos de 2022 solo se incluyen para atún patudo, obtenidos de los informes mensuales).

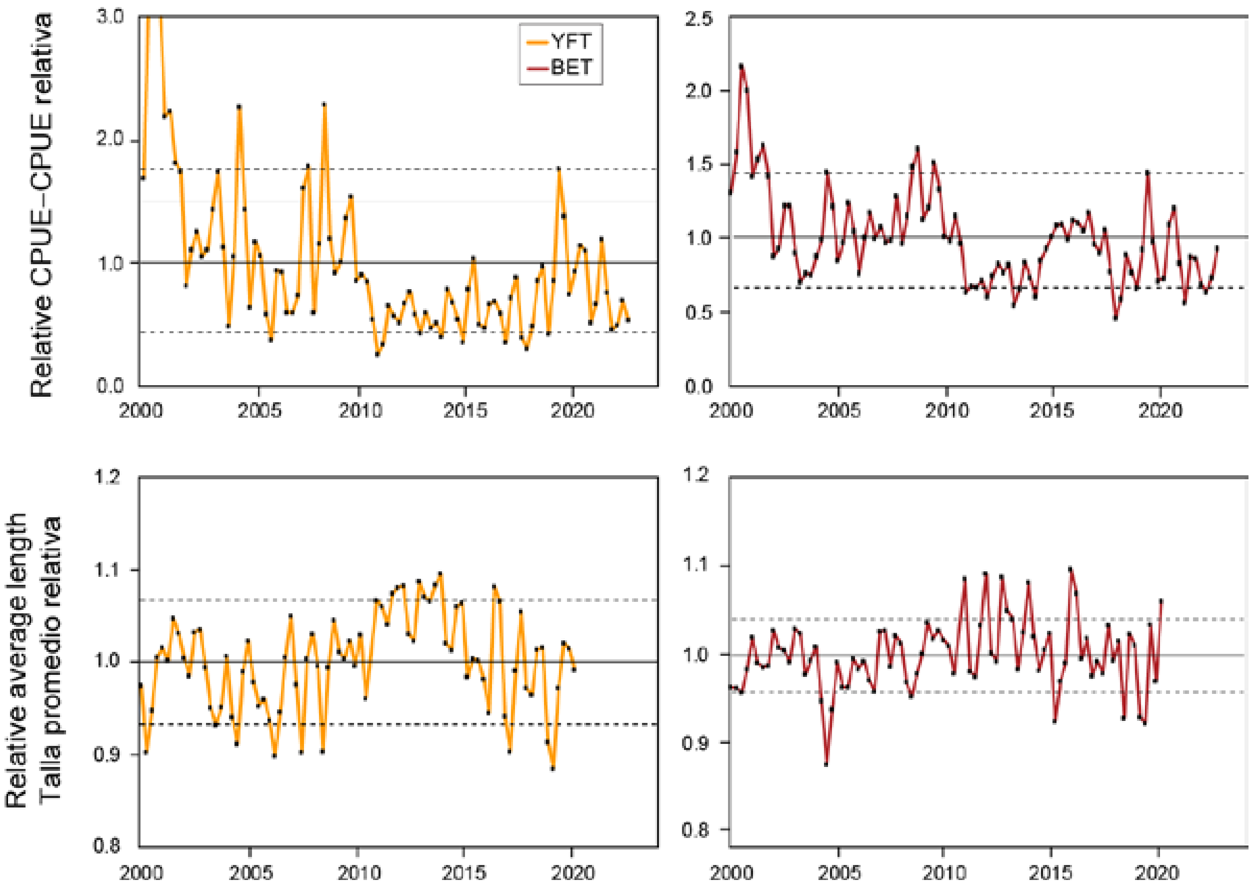

FIGURE 7. Indicators based on spatio-temporal modelling of longline data, 2000-2022. The y-axis limits for average length differ from the figures for the other indicators to accentuate the changes because average length is less sensitive to fishing mortality.

FIGURA 7. Indicadores basados en el modelado espaciotemporal de datos de palangre, 2000-2022. 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.