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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). Some 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 general increasing trend in the number of sets in the floating-object fishery, except in the first COVID-19 pandemic year of 2020, is reflected in increased catches for yellowfin and skipjack, reduced catch-per-set for bigeye, and reduced average length initially for all three species in the floating-object fishery, but the trends in average length have flattened off 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 and reached its maximum historical level in 2022. The increasing trend did not continue since 2023, and the number of floating-object sets for 2024 dropped to 9% below the benchmark reference[1] level. In 2024, the catch for skipjack in both floating-object sets and unassociated sets reached its highest level since 2000. Trends in some other SSIs do not support the interpretation that fishing mortality has increased due to an overall increase in the number of floating-object sets. Identifying the reasons for the differences among the SSIs is difficult, even when SSIs are considered in aggregate.

Of all three tropical tuna species, the SSIs are particularly concerning for bigeye. Bigeye is caught mainly in the floating-object fishery for which the catch per set and the average length have shown a consistent decline over time. The catch for bigeye in the floating-object fishery has been somewhat stable, except in 2022-2024 where catches reached low historical levels. These all indicate that, for bigeye, the fishing mortality has been increasing and the abundance has been decreasing. During 2022-2024, both the catch in weight and catch-per-set for bigeye caught in floating-object sets were at the lowest levels since 2000,

[1] Defined as the average condition in 2021-2023, which is the terminal period used to calculate management quantities in the most recent benchmark assessments for yellowfin, bigeye, and skipjack.

which may partly be a result of the introduction of the individual vessel threshold (IVT) scheme to provide incentives to reduce bigeye catches under Resolution C-21-04. An evaluation of the impact of the IVT scheme confirmed that it likely had a positive effect on reducing bigeye catches in 2022 and 2023 (SAC-15 INF-K). In addition, updated analyses including the 2024 data indicated that the IVT program had a similar effect on bigeye catches in 2024 as it did in 2022 and 2023 (SAC-16 INF-S).

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 that 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 estimating 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 approaches that depend 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 for which performance can be formally evaluated using management strategy evaluation.

SSIs were initially developed for EPO skipjack because traditional stock assessments of that species were initially 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.

In 2024 and 2025, the staff completed bigeye (SAC-15-02), yellowfin (SAC-16-03), and skipjack (SAC-15-04; SAC-16-04) benchmark assessments, which are now conducted in a model ensemble risk-based framework. 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 during the management cycle between assessments, and to provide management advice as needed. The same SSIs are computed annually for all three species and compiled in this report to facilitate comparisons among them.

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, additional SSIs were developed based on spatiotemporal modeling of **catch-per-day-fished (CPDF)** and **average fish length** for the fishery associated with dolphins (Figure 5). The current SSIs start 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 2000-2024 period (the horizontal solid line in each plot). The 10% and 90% percentiles (the two horizontal dashed lines in each plot) are used as reference levels.

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 spatiotemporal models (Figure 7). To be consistent with the purse-seine SSIs, the longline SSIs start in 2000 and have been scaled so that their average equals 1 during the 2000-2024 period. Reference levels are also based on the 10% and 90% percentiles.

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 consider multiple SSIs simultaneously.

Further information about bigeye, yellowfin, and skipjack can be found in Documents SAC-15-02, SAC-16-03, and SAC-16-04, respectively, and information on the absolute catch and number of sets by set type can be found in SAC-16-01. 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/2025.

2. RESULTS AND DISCUSSION

Care needs to be taken when interpreting the information content of indicators about increased fishing mortality. In general, increased effort implies increased fishing mortality, but changes in fishing strategy could cause fishing mortality to remain stable or even decrease when effort is increased. Similarly, increased fishing mortality typically reduces the population size and will be reflected in reduced CPUE. However, changes in fishing strategy could influence the relationship between CPUE and abundance. In addition, abundance may fluctuate due to environmental conditions, particularly given its impact on recruitment, which is more influential on fisheries that catch mainly juveniles like the OBJ fishery. Catch may increase due to the fishing mortality increasing faster than the stock is declining, possibly because the stock-recruitment relationship is weak and fisheries catch mainly juveniles, or decrease due to the fishing mortality increasing slower than the stock is declining. The mean size in the catch could decrease due to increased fishing mortality, but it could also decrease due to increasing recruitments (i.e., more small fish entering the fishery) or increase due to low recruitments. As indicated above, the age range of the fish caught by a fishery also needs to be taken into consideration when interpreting the indicators.

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 due to the negative impact of the COVID-19 pandemic on fishery operations (Figure 1). Since then, the closure-adjusted fishing capacity and the number of sets in the floating-object fishery have recovered from the COVID-19 pandemic. The closure-adjusted fishing capacity for 2024 was about 2% above the benchmark reference level. In 2022, the number of sets in the floating-object fishery increased to the highest level since 2000. This number dropped slightly since 2023, reaching 9% below the benchmark reference level in 2024. The number of sets in the unassociated fishery for 2023 was at the lowest level since 2000 but that for 2024 increased back to 47% above the benchmark reference level. In comparison, the number of sets in the dolphin-associated fishery for 2024 was near the mean level of the historical time series.

Some 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 as described above (see FAD-05 INF-D for details on the relationship between the number of floating-objects sets and the fishing mortality for juvenile bigeye). Overall, there have been increasing trends in catch for skipjack and yellowfin on floating-object sets since 2000 (Figure 2). In 2024, the catch for skipjack in both floating-object sets and unassociated sets reached the highest level since 2000 (Figure 2). The catch-per-set for yellowfin and skipjack in floating-object sets has not shown an obvious trend since 2010, while that for bigeye in floating-object sets has kept declining since 2005 (Figure 3). The average length for the three tropical tunas on floating-object sets showed similar temporal trends: decreased between 2000 and 2015 and remained relatively stable thereafter (Figure 4).

Of all three tropical tuna species, the SSIs are particularly concerning for bigeye. Bigeye is caught mainly in the floating-object fishery for which the catch per set (Figure 3) and the average length (Figure 4) have shown a consistent decline over time. The catch for bigeye in the floating-object fishery has been somewhat stable, except in 2022-2024 when catches reached low historical levels (Figure 2a). These all indicate that, for bigeye, fishing mortality has been increasing and the abundance has been decreasing. During 2022-2024, both the catch in weight (Figure 2a) and catch-per-set (Figure 3) for bigeye in floating-object sets were at the lowest levels since 2000, which may partly be a result of the introduction of the individual vessel threshold (IVT) scheme to provide incentives to reduce bigeye catches under Resolution C-21-04. An evaluation of the impact of the IVT scheme confirmed that it likely had a positive effect on reducing bigeye catches in 2022 and 2023 (SAC-15 INF-K). In addition, updated analyses including the 2024 data indicated that the IVT program had a similar effect on bigeye catches in 2024 (SAC-16 INF-S).

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 the increase in the number of floating-object sets. Positive trends were observed in the catch-per-set for skipjack and yellowfin in unassociated and dolphin-associated sets, respectively (Figure 3). However, these may also be reflective of increased fishing efficiency due to improved technology. Both the dolphin-associated purse-seine (Figure 5) and longline (Figure 7) indices of abundance for yellowfin have been increasing since about 2015. The longline index of abundance for bigeye has not shown a noticeable long-term trend since 2005 (Figure 7). It is worth noting that the longline indices of abundance for bigeye and yellowfin are from a spatiotemporal model that incorporates catch and effort data from both Japan and Korea (Figure 7). The rationale for selecting these joint longline indices of abundance for both species is detailed in SAC-16 INF-U. The joint longline index for yellowfin is generally consistent with the Japanese index, whereas the joint index for bigeye shows marked differences from the Japanese index (Figure 7). SAC-16 INF-U focuses on developing a joint longline index of abundance for use in the benchmark assessment of yellowfin tuna, so the joint index of abundance for bigeye developed for this document is considered preliminary and requires further investigation.

Identifying the causes of different trends in the SSIs for a stock 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).

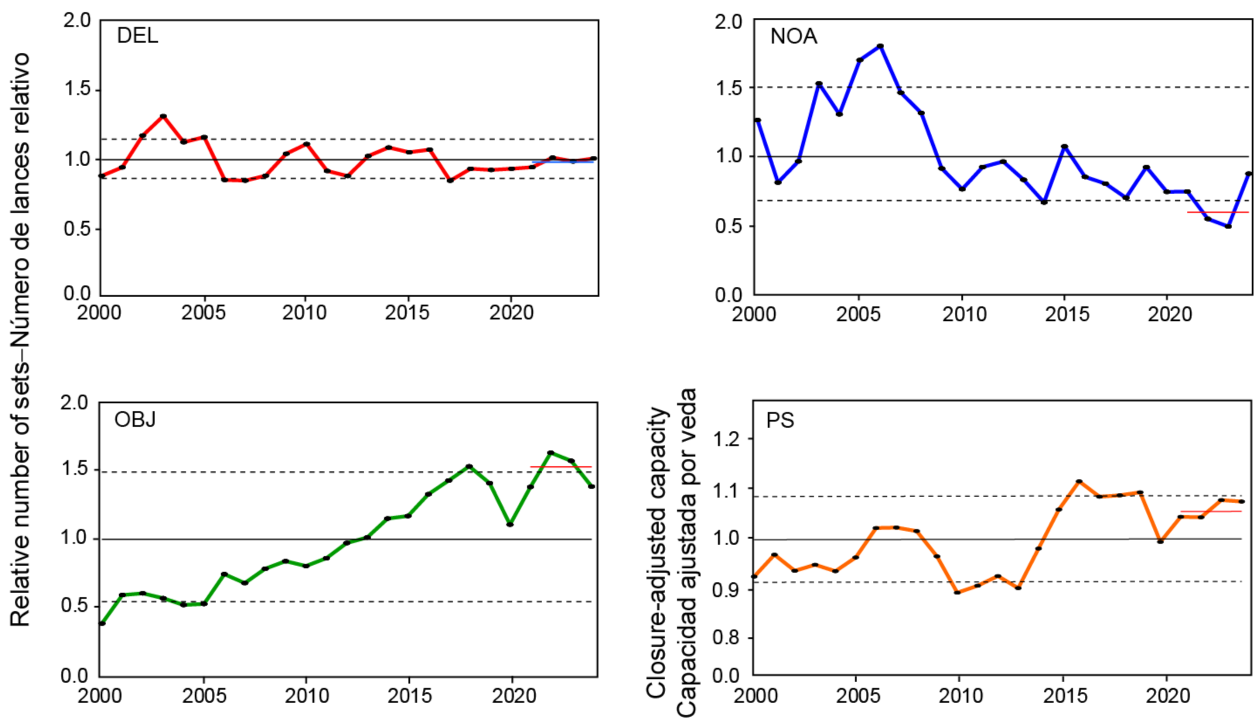

FIGURE 1. Indicators based on purse-seine fishing effort, 2000-2024. The red horizontal lines mark the benchmark reference levels (average conditions in 2021-2023).

FIGURA 1. Indicadores basados en el esfuerzo de pesca de cerco, 2000-2024. Las líneas horizontales rojas marcan los niveles de referencia (condiciones promedio en 2021-2023).

FIGURE 2a. Indicators based on purse-seine catch in weight, 2000-2024. The OBJ catches during 2020 and 2021 (COVID-19 years) are biased-adjusted according to SAC-14-INF-D. The red horizontal lines mark the benchmark reference levels (average conditions in 2021-2023).

FIGURA 2a. Indicadores basados en la captura cerquera en peso, 2000-2024. La captura por lance OBJ durante 2020 y 2021 (años de COVID-19) es ajustada por sesgo acorde a SAC-14-INF-D. Las líneas horizontales rojas marcan los niveles de *statu quo* (condiciones promedio en 2017-2019). Las líneas horizontales rojas marcan los niveles de referencia (condiciones promedio en 2021-2023).

FIGURE 2b. Indicators based on purse-seine catch in number, 2000-2024. The OBJ catches during 2020 and 2021 (COVID-19 years) are biased-adjusted according to 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 horizontal lines mark the benchmark reference levels (average conditions in 2021-2023).

FIGURA 2b. Indicadores basados en la captura cerquera en número, 2000-2024. La captura por lance OBJ durante 2020 y 2021 (años de COVID-19) es ajustada por sesgo acorde a 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 horizontales rojas marcan los niveles de referencia (condiciones promedio en 2021-2023).

FIGURE 3. Indicators based on purse-seine catch-per-set, 2000-2024. The OBJ catch per set during 2020 and 2021 (COVID-19 years) are biased-adjusted according to SAC-14-INF-D. The red horizontal lines mark the benchmark reference levels (average conditions in 2021-2023).

FIGURA 3. Indicadores basados en captura por lance cerquero, 2000-2024. La captura por lance OBJ durante 2020 y 2021 (años de COVID-19) es ajustada por sesgo acorde a SAC-14-INF-D. Las líneas horizontales rojas marcan los niveles de referencia (condiciones promedio en 2021-2023).

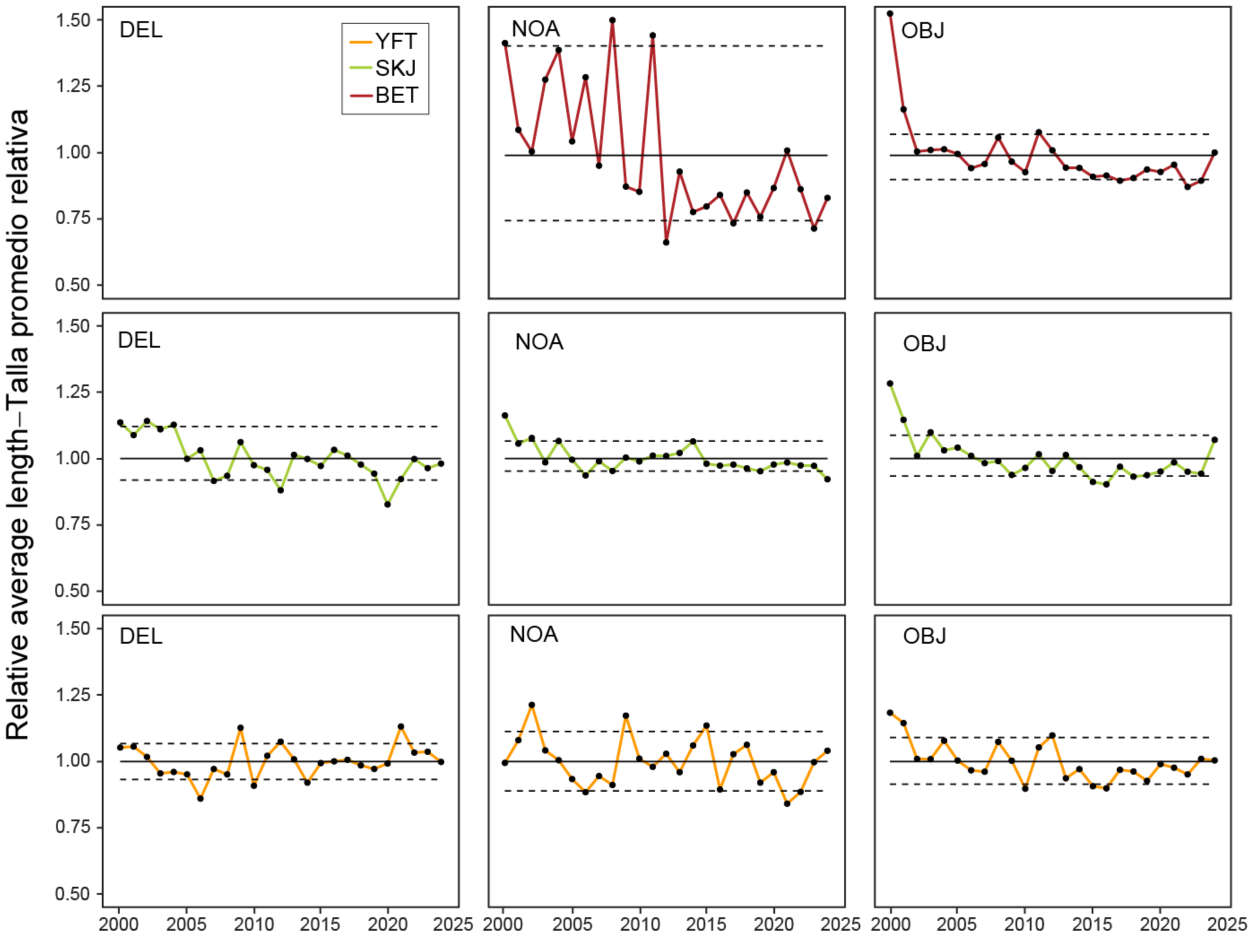

FIGURE 4. Indicators based on the average length of fish in the purse-seine catch, 2000-2024. The y-axis limits differ from the figures for the other indicators to accentuate the changes because average length is less sensitive to fishing mortality.

FIGURA 4. Indicadores basados en la talla promedio de los peces en la captura cerquera, 2000-2024. 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.

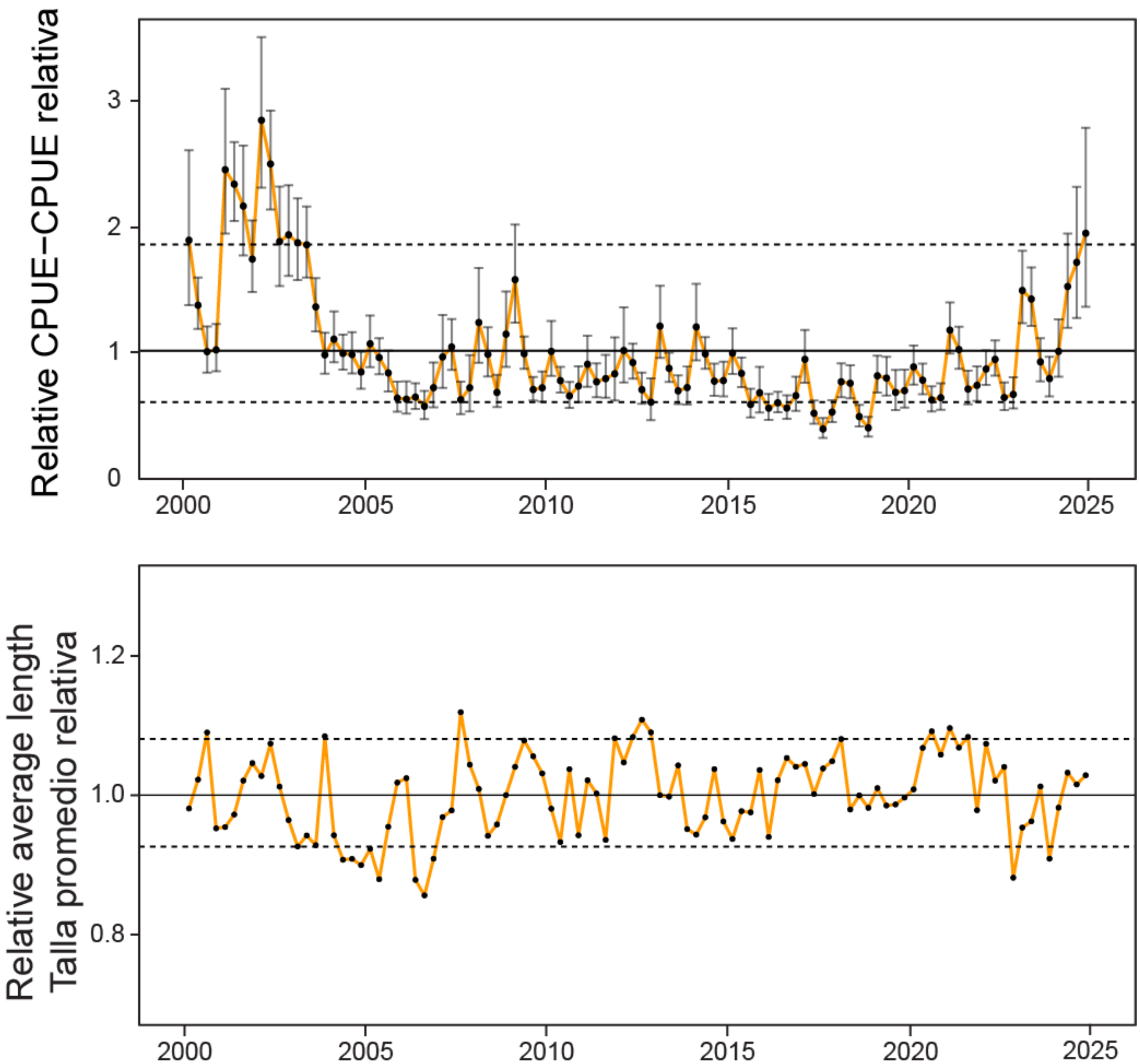

FIGURE 5. Quarterly indicators based on spatio-temporal modeling of catch-per-day-fished and length compositions for the purse-seine fishery on yellowfin associated with dolphins, 2000-2024. The error bars represent the 95% confidence intervals.

FIGURA 5. Indicadores trimestrales 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, 2000-2024. Las barras de error representan los intervalos de confianza del 95%.

FIGURE 6. Indicators based on longline catch and effort data for all fleets combined, 2000-2024 (catch data for 2024 included only that for bigeye tuna from monthly reports and effort data for 2023 is preliminary).

FIGURA 6. Indicadores basados en datos de captura y esfuerzo de palangre para todas las flotas combinadas, 2000-2024 (los datos de captura para 2024 solo se incluyen para atún patudo, obtenidos de los informes mensuales, y los datos de esfuerzo para 2023 son preliminares).

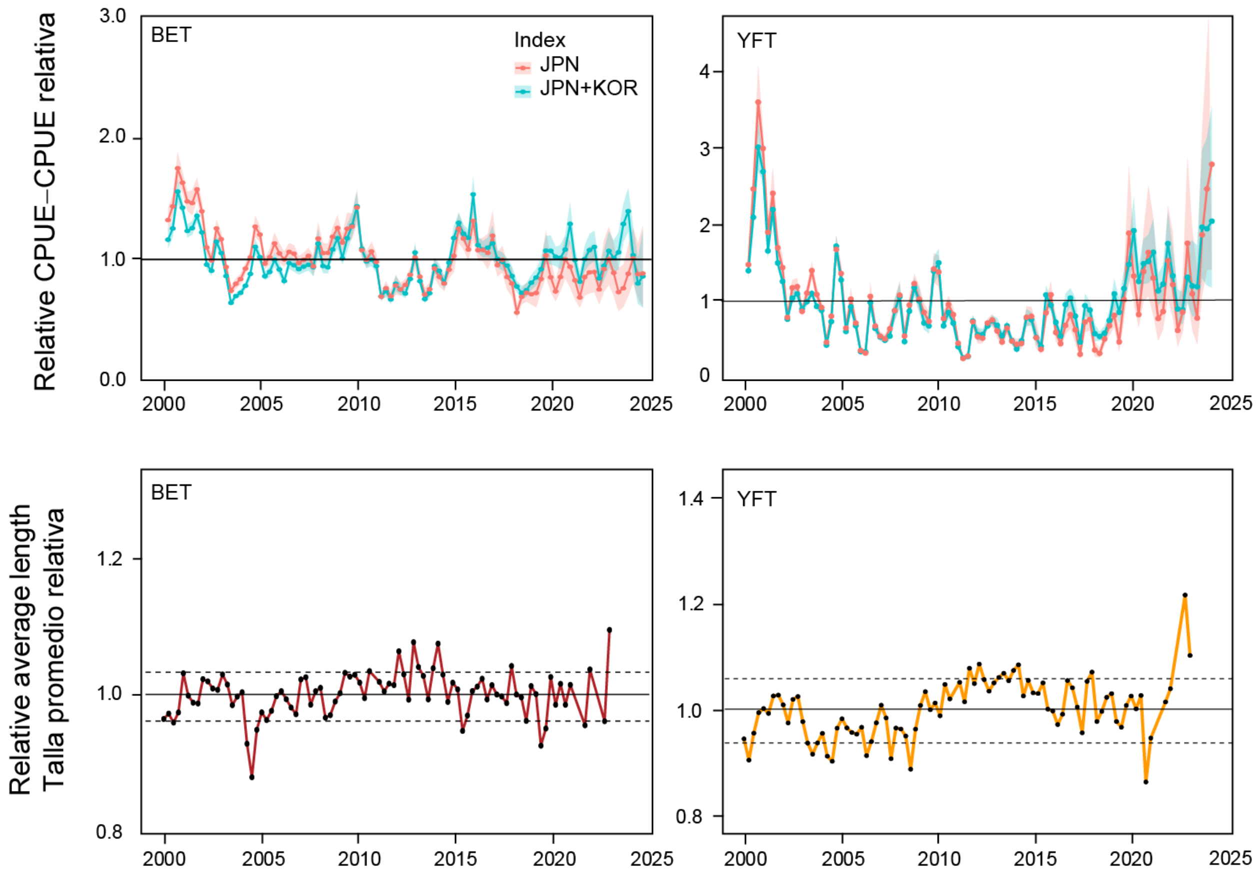

FIGURE 7. Quarterly indicators based on spatio-temporal modeling of Japanese + Korean or Japanese longline CPUE data (top row) and length composition data (bottom row), 2000-2024. The longline CPUE data for 2024 is available only from Japan so the joint indices for 2024 are less accurate and precise. 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 trimestrales basados en el modelado espaciotemporal de datos de CPUE de palangre de Japón + Corea o Japón (fila superior) y de los datos de composición por talla (fila inferior), 2000-2024. Los datos de CPUE de palangre para 2024 solo están disponibles para Japón, por lo que los índices conjuntos para 2024 son menos exactos y precisos. 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.