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STOCK STATUS INDICATORS FOR YELLOWFIN TUNA IN THE EASTERN PACIFIC OCEAN

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SUMMARY

The model currently used for the stock assessment of yellowfin tuna in the eastern Pacific Ocean is unable to reconcile data that apparently carry contradictory signals about the status of the stock. The low values for recent years estimated for three CPUE-based indicators (CPUE for two dolphin-associated (DEL) fisheries, standardized using spatiotemporal methods, and for the southern longline (LL-S) fishery) suggest low abundance of the population, but this is inconsistent with the increased average size of the fish in the catch of these fisheries. It is therefore not clear from the indicators whether yellowfin abundance is in fact reduced, or changes have occurred in the fisheries.

Research is planned to revise the model and several of its assumptions in preparation for the benchmark assessment in 2020. Meanwhile, data-based indicators have been developed for the yellowfin stock, similar to those for the skipjack and bigeye tuna stocks.

1. INTRODUCTION

The model used for the current update assessment of yellowfin tuna in the eastern Pacific Ocean (EPO) was unable to reconcile data that apparently carry contradictory signals about the status of the stock (SAC-10 INF-F). This needs to be resolved before the model can be used as a basis for management advice, and a workplan has been developed in preparation for the scheduled benchmark assessment in 2020 (SAC-10- INF-F). In the meantime, the data-based indicators presented in this document can be used to monitor the relative status of the stock.

An indicator is a relative measure that simply compares the current status of a given value, such as catch or effort, for a particular fishery with the distribution of its historical values. Indicators can be useful for identifying causes of changes in populations (*e.g.* variability in recruitment, changes in fishing operations, changes in mortality), and can be used to complement model-based methods. They can facilitate communication among scientists, managers, and other stakeholders because they are generally based on data-derived values that are more intuitive than abstract, model-based quantities (Trenkel *et al*. 2007).

Data-based stock status indicators (SSIs) were first developed for skipjack tuna in the EPO (Maunder and Deriso 2007), and later applied to bigeye tuna (IATTC Stock Assessment Report 19).

2. METHODS

Data-based indicators were calculated for each one of the main fisheries defined in the current stock assessment model for yellowfin (Figure 1), in addition to overall indicators for the stock[1]. The fisheries are defined by gear (longline and purse seine) and geographical area of operation, and the purse-seine fisheries are further divided by set type (floating-object, unassociated, and dolphin). The **indicators for individual fisheries** are catch, effort, catch per unit of effort (CPUE), and average length of the fish in the catch, and are based on data for 1975-2018, as in the stock assessment. The **overall indicators** are total purse-seine capacity, adjusted for the seasonal closures of the fishery, and total effort, and are based on the following: (1) closure-adjusted purse-seine capacity, 2000-2018 (as for bigeye tuna, SAC-10-06); (2) purse-seine effort, in total number of sets, by set type, 1987-2018; and (3) longline effort, in total number of hooks, 1975-2017 (data from annual reports by CPCs; WSBET-02-03). The total catch on floating objects includes the four discard fisheries used in the stock assessment (IATTC Stock Assessment Report 2018). The distributions of historical values for these indicators are somewhat asymmetric; therefore, to evaluate the current value of each indicator in relation to the distribution of its historical values, we use the 5th and 95th percentiles as reference levels. The median (50^{th} percentile) is also presented.

2.1. Purse seine

Purse-seine catches are adjusted for species composition (WSBET-02-06). The average length of the fish in the catch, by year and fishery, is computed using the estimated length frequency (WSBET-02-06) by quarter weighted by the catch in that quarter. The catch per day fished (CPDF), by set type, is computed by dividing the catch by the effort, in days fished, from the IATTC catch and effort (CAE) database, which contains the observer and vessel logbook data. Vessels can make several sets of different types (floating object, unassociated, dolphin) on the same day, so days fished must be partitioned by set type, using a multiple regression for each year (Maunder and Watters 2003; WSBET-02-06). The number of days fished is calculated by apportioning each day among the vessel's activities (searching, setting, transiting to and from fishing areas, *etc*) and summing the periods classified as "fishing". Finally, additional purse-seine derived indices of abundance were estimated by standardizing the dolphin-associated CPDF for a subset of the vessels, using spatiotemporal methods (following Xu *et al*. 2019) with the most current data.

2.2. Longline

The catch by fishery is computed from the level-3 data[2] for longliners (Resolution C-03-05, WSBET-02-03). Catches reported in number are multiplied by the average weight for the fishery and added to the catch reported in weight to arrive at the total catch in weight. The standardized CPUE is obtained from the data for the Japanese longline fleet, aggregated by 5°x5°-month and hooks-between-floats, using a delta-GLM approach (Hoyle and Maunder 2006). The average annual length, by fishery, is computed using length-frequency data from Japanese commercial vessels (SAC-07-4a, SAC-07-03d).

3. RESULTS

Both the number of floating-object sets and the number of days fished in such sets generally increased during the entire period, and in 2018 were at and above, respectively, the upper reference level (Figures 2 and 3). Several related indicators for vessels that make more than 50% of their sets on floating objects, presented in SAC-10-06, show that the number of days fished and the number of vessels also increased over time, but less rapidly than the number of sets. The number of days fished per vessel has declined over time, while the number of floating-object sets per vessel has increased, indicating that the vessels have become more efficient at finding FADs with sufficient tuna associated with them to make a set.

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[1] The indicators are computed on an annual basis, while the stock assessment models have a quarterly time step

[2] Catch and effort, 5°x5°–month resolution, with information on gear configuration and target species

The reported longline effort peaked twice, around 1990 and in the early 2000s, and has increased again since 2010; it is currently above the median (Figure 2). Prior to 2000, the Japanese fleet exerted 50% or more of the total longline effort in the EPO, but this proportion has declined continuously since then, and in 2017 was 14% (SAC-10-03).

The indicators for three of the purse-seine fisheries on floating objects (OBJ-S, OBJ-C, and OBJ-N; Figure 3) are very similar, with catch, effort, and mean length increasing in the 1990s as the floating-object fishery expanded. The catch and effort of these fisheries are currently at or above the upper reference value, except for the OBJ-N effort, which fell substantially in 2018. The indicators for the OBJ-I fishery do not show any major trends, but have wide fluctuations and are currently around the median. The average length for all fisheries is currently around the median.

The catches of the unassociated (NOA) purse-seine fisheries have been between the lower reference level and the median since 2008, and are at the lower reference level in 2018 for NOA-N and slightly below the median for NOA-S (Figure 4). The lower catches in recent years coincide with the lower effort for NOA-N, but not for NOA-S, where the effort has been around the median (Figure 4). The recent CPDFs have fluctuated at or above the median for NOA-N, and at or below the median level for NOA-S. The average length for NOA-N has been fluctuating between the lower and the upper reference levels, while NOA-S has fluctuated between the median and the upper reference level in the last ten years .

The indicators for DEL-N and DEL-I are similar, and have generally fluctuated around the median, with low catch, effort, and CPUE in the late 1970s and early 1980s (Figure 4). They are currently around the median, except for the DEL-I catch and effort, which are below the median, and the average length, which in DEL-I is at the lower reference level, but in DEL-N, where it has been high since at least 2010, it is above the upper reference level. The DEL-S fishery has much lower catch and effort, with a peak in catch in the early 2000s. The average length in the DEL-S fishery increased from almost the lower reference level to the upper reference level in during 2010-2017, with a decrease towards the median in 2018.

In contrast to the nominal CPDF, the spatiotemporal model-derived indices of abundance for the DEL-N and DEL-I areas have been fluctuating below the median since 2006, and in 2017 reached some of their lowest values, with a slight increase in 2018 (Figure 5). These spatiotemporal indices take into account the "patchiness" of fisheries data (fishers tend to fish where there are good catches, neither randomly nor following a design), the area weighting, and increase in efficiency of purse-seine vessels in the recent years (SAC-10-06), but not changes in the length composition of the catches.

The catches of both longline fisheries (LL-N and LL-S) have shown some increase in recent years, mostly due to increased effort (Figure 1) from the expansion of the Chinese fleet in the EPO (SAC-10-03). The standardized CPUE for LL-N has been above the median in recent years, while that for LL-S has been around the lower reference level since 2010, coinciding with a steady increase in the average length of the fish in the catches. Because the Japanese proportion of the total longline effort has been declining (Figure 2), the representativeness of the standardized CPUE and average length for the Japanese fleet, used to represent all the longline fisheries for yellowfin in the EPO, needs to be further investigated (see also WSBET-02 Meeting).

Indicators of relative abundance, such as the standardized CPUE for LL-S and the spatiotemporal indices for DEL-N and DEL-I, have been at low levels since 2010 (LL-S) or earlier (DEL-N, DEL-I), which might indicate a low population size for yellowfin in the EPO, and may be of concern, especially given the steady increase of the number of floating-object sets. However, a decrease in population size is not consistent with the increase in the average length of the fish in the catch observed in recent years in several fisheries (LL-S, DEL-N, NOA-S, DEL-S). This increase may indicate that older, larger fish are being caught because recent strong cohorts are being harvested (DEL-N, DEL-S); alternatively, it may indicate lower natural or fishing mortality, discarding/high-grading of catches, or changes in selectivity and/or availability, which can hinder the interpretation of CPUE indicators as indices of abundance. Because the average length increased in several fisheries simultaneously, it may be an indication that a change in the population may be happening, instead of, or in addition to, changes in selectivity and/or availability.

4. CONCLUSION

The indicators based on southern longline (LL-S) CPUE and dolphin-associated (DEL) CPUE from the spatio-temporal model show low values for the recent years of the series, which may indicate low abundance. However, the increase in average size for some fisheries is inconsistent with low abundance. Therefore, it is not clear from the indicators whether yellowfin abundance is reduced, or the fisheries are changing. Several hypotheses will be explored in preparation for the benchmark assessment in 2020 (SAC-10-01, SAC-10-INF-F.)

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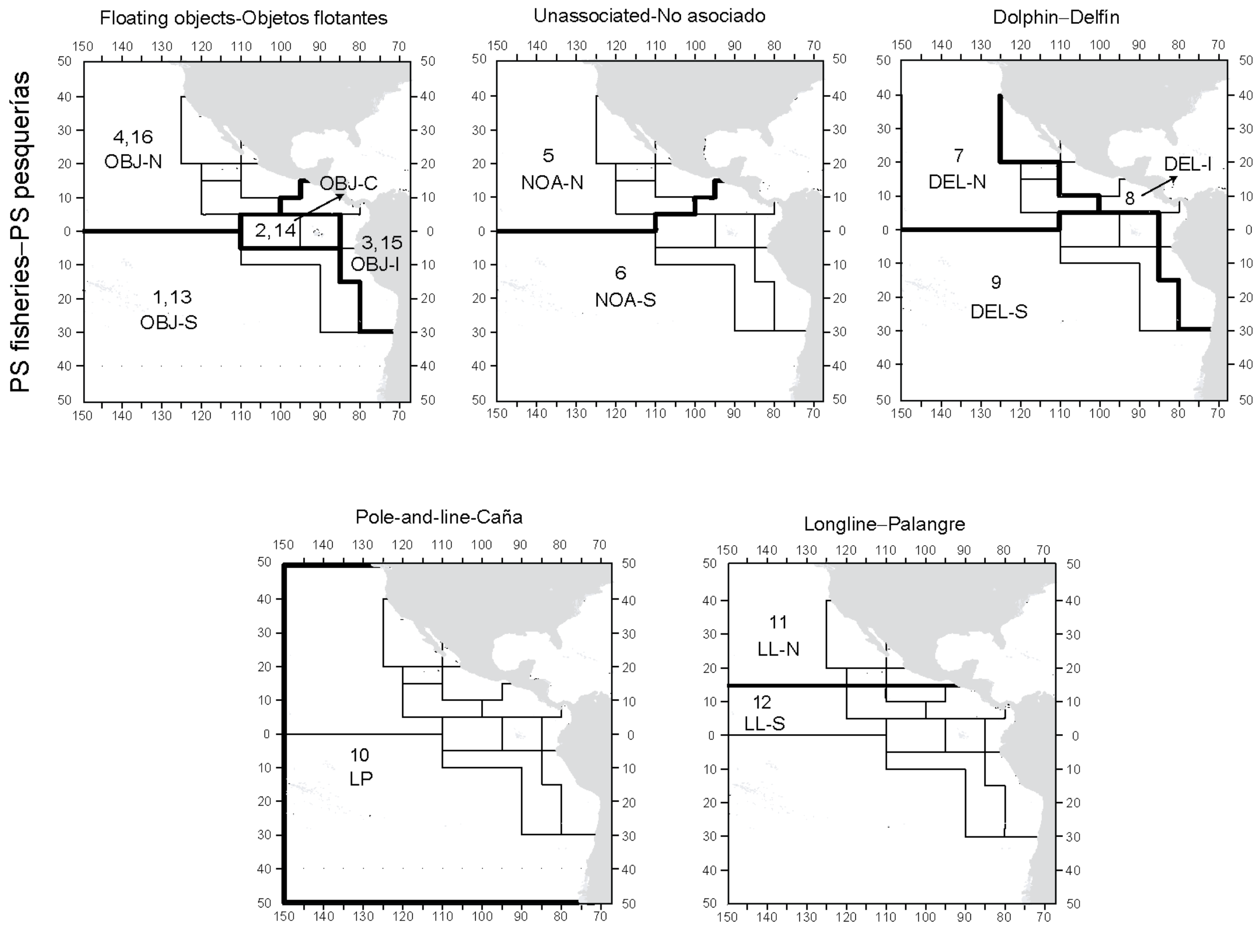

FIGURE 1. Fisheries defined for the yellowfin stock assessment and for calculating indicators.
FIGURA 1. Pesquerías definidas para la evaluación de la población de atún aleta amarilla y para el cálculo de los indicadores.

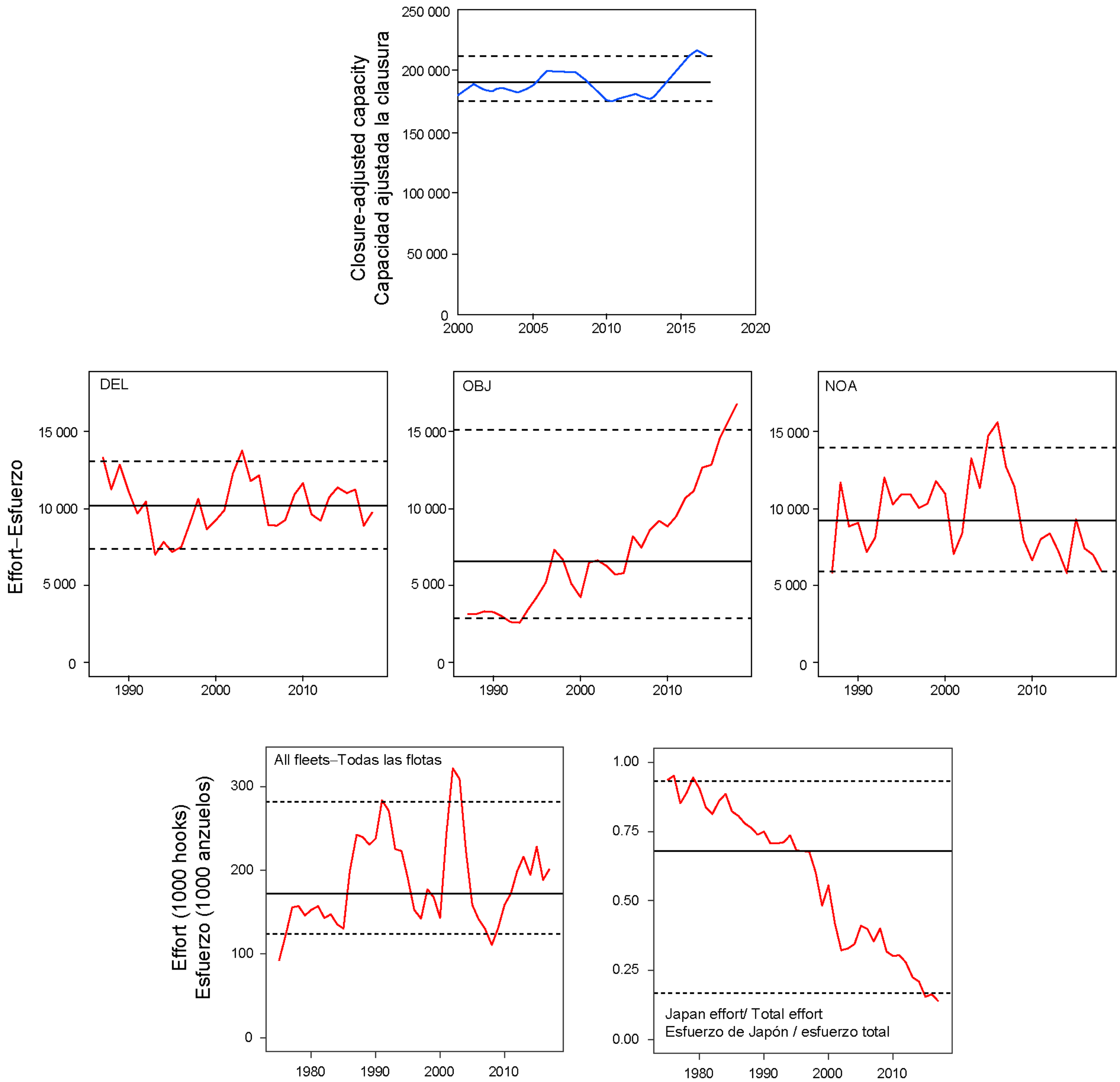

FIGURE 2. Indicators of total effort in the EPO, based on purse-seine data (closure-adjusted capacity, 2000-2018; annual total number of sets, by type, 1987-2018) and based on longline data for 1975-2017 (effort reported by all fleets, in total numbers of hooks; proportion of the effort corresponding to Japan). The dashed horizontal lines are the 5th and 95th percentiles, the solid horizontal line is the median.

FIGURA 2. Indicadores del esfuerzo total en el OPO, basados en datos de cerco (capacidad ajustada por veda, 2000-2018; número total anual de lances, por tipo, 1987-2018) y en datos de palangre de 1975-2017 (esfuerzo notificado por todas las flotas, en número total de anzuelos; proporción del esfuerzo correspondiente a Japón). Las líneas horizontales de trazos representan los percentiles de 5 y 95%, y la línea horizontal sólida la mediana.

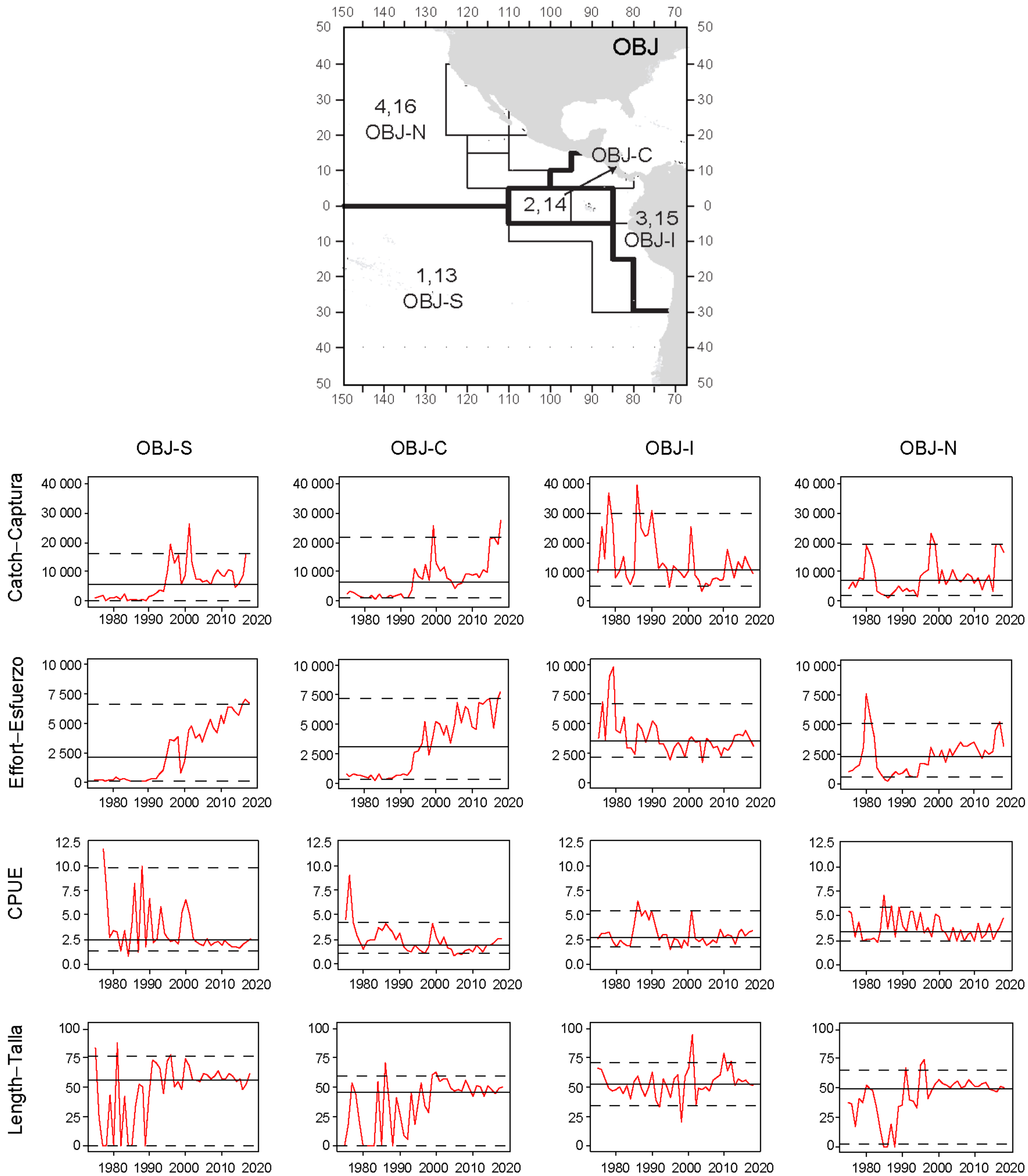

FIGURE 3. Indicators (catch (t); effort (days fished); CPUE (t/day fished); average length (cm)) for the yellowfin tuna stock in the eastern Pacific Ocean, from purse-seine fisheries on floating objects (OBJ).

FIGURA 3. Indicadores (captura (t); esfuerzo (días de pesca); CPUE (t/día de pesca); talla promedio (cm)) para la población de atún aleta amarilla en el Océano Pacífico oriental, de las pesquerías de cerco sobre objetos flotantes (OBJ).

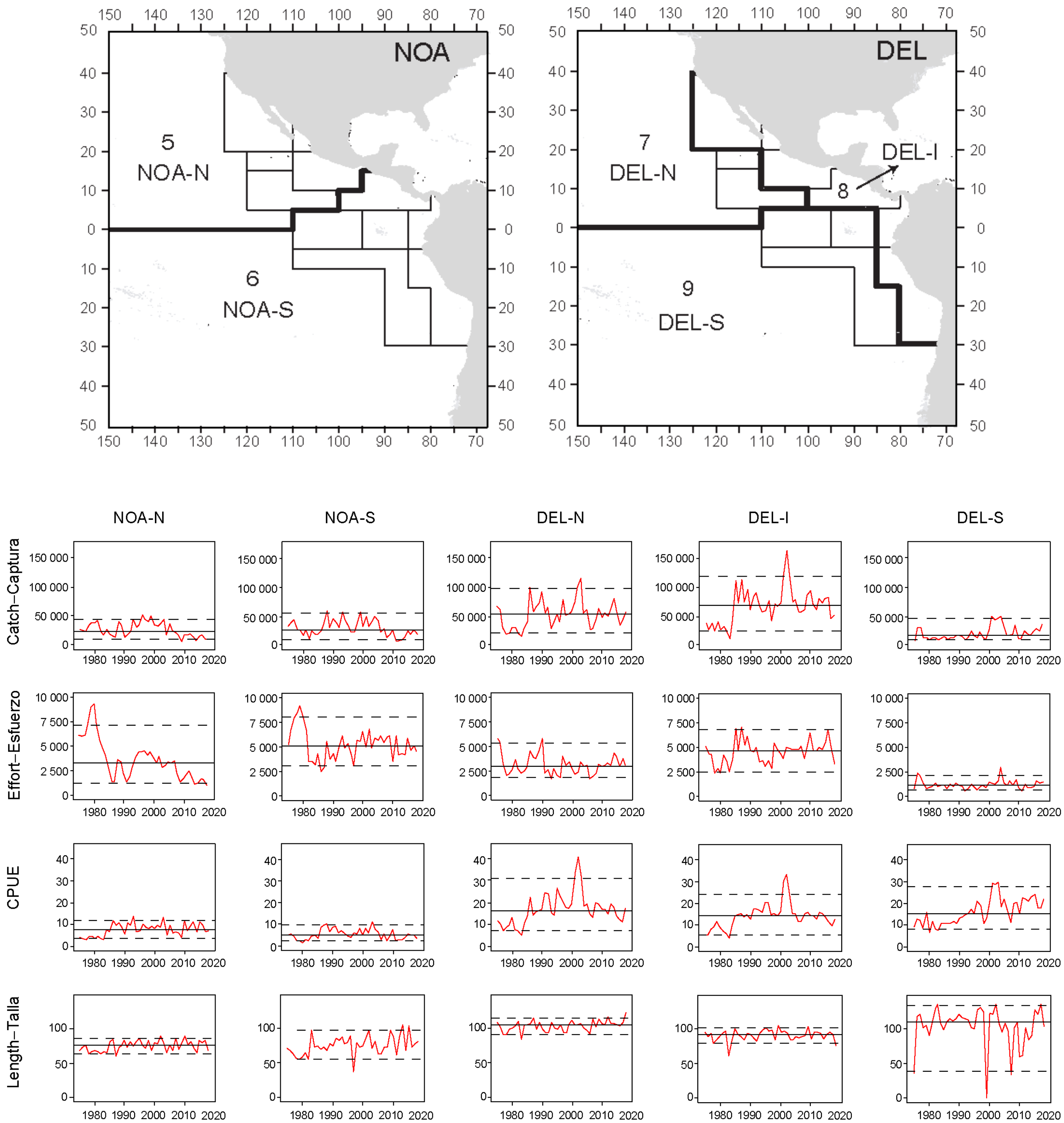

FIGURE 4. Indicators (catch (t); effort (days fished); CPUE (t/day fished); average length (cm)) for the yellowfin tuna stock in the eastern Pacific Ocean, from the unasssociated (NOA) and dolphin-associated (DEL) fisheries.

FIGURA 4. Indicadores (captura (t); esfuerzo (días de pesca); CPUE (t/día de pesca); talla promedio (cm)) para la población de atún aleta amarilla en el Océano Pacífico oriental, de las pesquerías no asociadas (NOA) y asociadas a delfines (DEL).

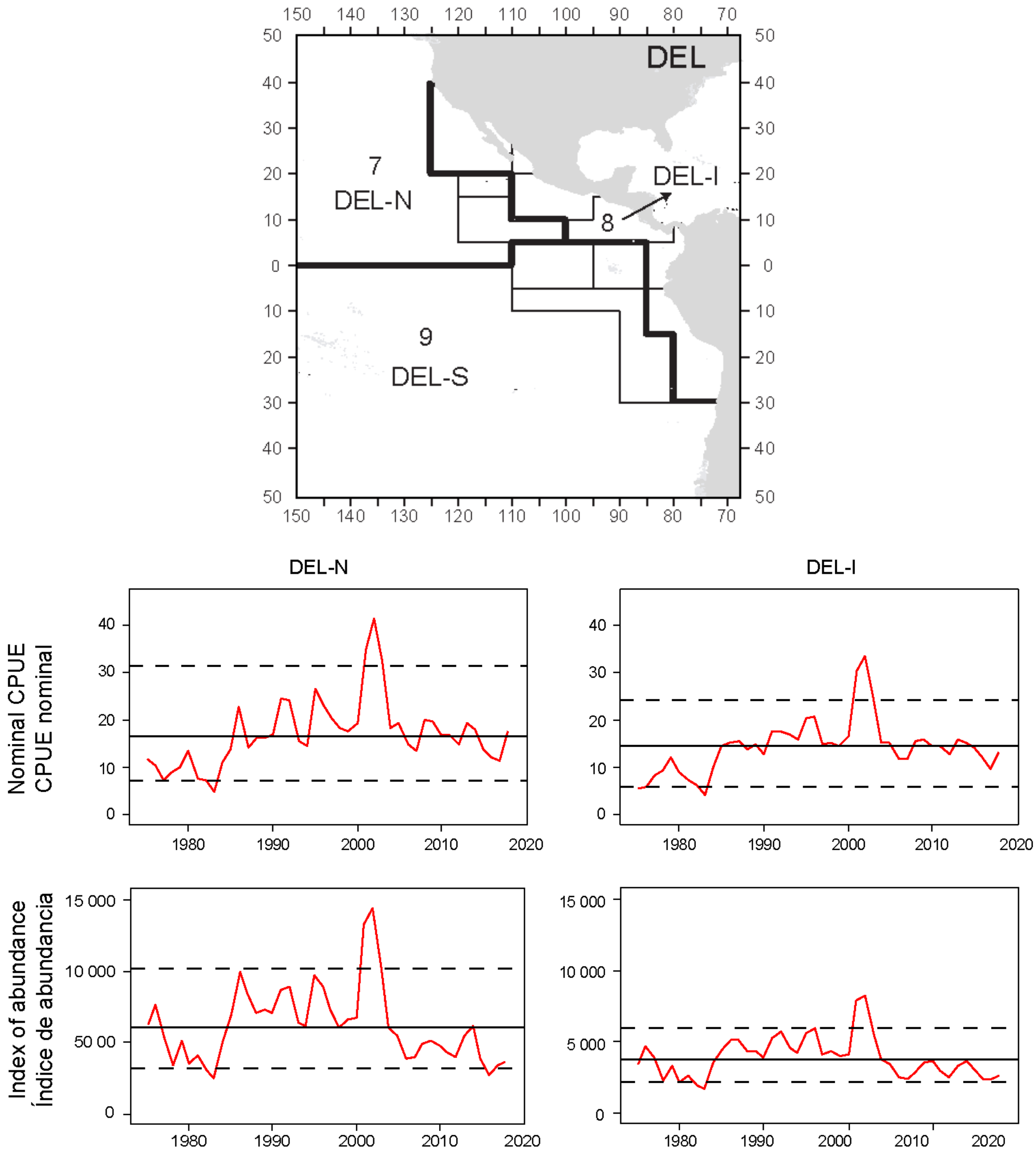

FIGURE 5. Indicators for the yellowfin tuna stock in the eastern Pacific Ocean: nominal catch per days fished (CPDF) and spatiotemporal model-derived indices of abundance.
FIGURA 5. Indicadores para la población de atún aleta amarilla en el Océano Pacífico oriental: captura nominal por día de pesca (CPDP) e índices de abundancia derivados del modelo espaciotemporal.

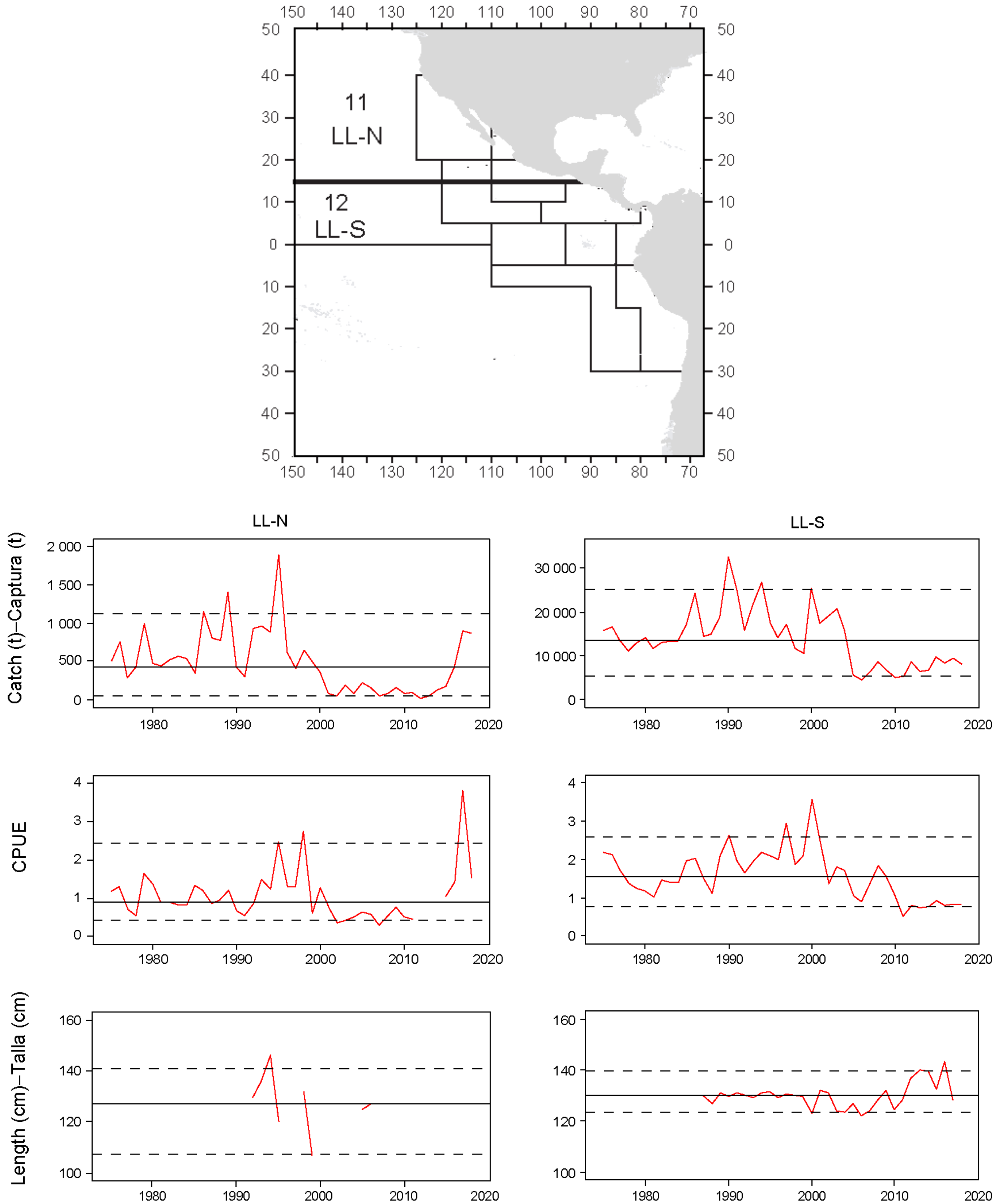

FIGURE 6. Indicators for the yellowfin tuna stock in the eastern Pacific Ocean, from longline fisheries
FIGURA 6. Indicadores para la población de atún aleta amarilla en el Océano Pacífico oriental, de las pesquerías de palangre.