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THE EFFECT OF PANDEMIC-RELATED PORT-SAMPLING DATA LOSS ON THE 2020 PURSE-SEINE CATCH ESTIMATE OF BIGEYE TUNA IN FLOATING-OBJECT SETS

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SUMMARY

The increase in the estimated purse-seine catch of bigeye tuna (BET) in floating-object (OBJ) sets in 2020, relative to the previous year (BSE; e.g., Table A-7 in SAC-13-03), despite a decrease in the number of OBJ sets (SAC-13-06), and the marked disparity between the 2020 BSE and the reported catches from observers and logbooks, has raised concern that the 2020 BSE might be biased, possibly as a result of the effect of the COVID-19 pandemic on data collection. Although some data sources, such as observer data, were only minimally impacted by the pandemic, there was a considerable reduction in the amount of port-sampling data that was collected in 2020. Port-sampling data are used in the BSE methodology to determine the species composition of the catch. To evaluate the effect of the pandemic-driven loss of port-sampling data on the 2020 BET OBJ BSE, the BSE estimation methodology was run for each of years 2010-2019, using all available cannery, observer and logbook data, but with only a subset of the port-sampling data. The results indicate that the systematic pandemic-related loss of port-sampling data in 2020 for ports where much of the EPO BET is estimated to be unloaded may have led to a bias in the BET OBJ BSE. Although the median difference between estimates, with and without the simulated data loss, was close to 0, both negative and positive biases of about 20% or more were seen over the 2010–2019 period. Thus, while results of this study indicate that the 2020 BET OBJ BSE may be biased, the exact magnitude and direction of that bias cannot be determined from these analyses. Following this study, spatiotemporal models were used to estimate the magnitude and direction of the bias (SAC-13-05).

1. BACKGROUND

The increase in the estimated purse-seine catch of bigeye tuna (BET) in floating-object (OBJ) sets in 2020, relative to the previous year (BSE; e.g., Table A-7 in SAC-13-03), despite a decrease in the number of OBJ sets (SAC-13-06), and the marked disparity between the 2020 BSE and the reported catches from observers and logbooks (Figure 1), has raised concern that the 2020 BSE might be biased due the COVID-19 pandemic impact on data collection. Although collection of some data sources, such as observer data, was only minimally affected by the pandemic, there was a considerable reduction in the amount of port-sampling data that was collected in 2020, with only about half the number of wells sampled, as compared to previous years.

The current BSE methodology for the purse-seine fishery annual catch estimates (Tomlinson 2002, 2004; Suter 2010), which is used for several purposes, including catch estimates presented in the IATTC Fishery

Status Reports and in the stock assessments, uses port-sampling data to determine the species composition. Estimation is by 'stratum', within a year, where strata are defined by: area, month, purse-seine set type and vessel size class category (Classes 1-5; Class 6). For the BSE estimates presented in the IATTC Fishery Status Reports, the estimation is based on the 13 sampling areas that are also used in the collection of the port-sampling data (Figure 2 (a)), yielding a total of 780 possible strata (= 13 x 12 x 5; small vessels are not allowed to make sets on tunas associated with dolphins). On average, only about 64% of these 780 strata had catch in any given year during 2010-2019. However, many of the strata with catch had no port-sampling data; on average, about 73% of the strata with catch, representing 24% of the total annual fleet catch, had no corresponding port-sampling data. Individually, most of these strata have proportionally little catch, and thus the catch may not have been sampled because the port-sampling is opportunistic; i.e., the protocol does not specify a certain number of samples per stratum, and the strata that will have catch in any given year are not known in advance. In addition, the catch of these strata may not have been sampled because: a) unloading took place in ports where port-sampling is not conducted; and, b) the wells containing the catch may have also contained catch from other strata and hence were not sampled (mixed-stratum wells are not sampled by the port-sampling program). To address this problem in the BSE methodology, port-sampling data from 'neighboring' strata are used to estimate the species composition of catch of strata with no port-sampling data. The normally low level of port-sampling coverage that results in this need for 'substitution' in the BSE methodology is made more problematic when large gaps in data collection occur, such as happened in 2020 as a result of the pandemic. This is because: 1) more strata will have no port-sampling data and thus require substitution; and, 2) the neighboring strata that must be used as substitutes may not be optimal (i.e. their catch composition could be quite different from the stratum with missing port-sampling data). In 2020, 82% of the strata with catch, corresponding to 49% of the fleet catch of tropical tunas, did not have corresponding port-sampling data.

Identifying specific effects of the pandemic on port-sampling data collection that would be expected to significantly affect the BSE is complicated by the fact that port-sampling data collection is opportunistic, and thus there are no predetermined sample sizes by area, month, set type or vessel size class category. Both overall lower sample sizes across all strata, as well as systematic undersampling of specific strata, could be problematic for the catch estimation methodology because both will affect the distribution of strata without port-sampling data, and the port-sampling data availability in 'neighboring' strata. Given the spatial differences in species composition of the catch in OBJ sets (Lopez *et al*. 2019), the seasonal variability in the distribution of fishing activity within the eastern Pacific Ocean (EPO) (e.g., Lopez *et al*. 2021) and the fact that fleet segments tend to unload catch in specific ports, it is assumed that systematic temporal gaps in data collection at some ports may be more problematic than lower overall sampling through time in all ports.

This document presents the results of a study to evaluate the impact of the pandemic on the BSE estimation for BET in OBJ sets. The study involved constructing reduced port-sampling data sets for each of years 2010–2019 to mimic data losses that occurred in 2020, and then comparing the BSEs computed on these reduced data sets to the actual BSEs obtained from the complete data sets. Implications for interpretation of the 2020 BET OBJ BSE are discussed.

2. DATA AND METHODS

Cannery, observer, logbook and port-sampling data from IATTC Class 1-6 vessel trips for 2010 to 2020 were used in this study. In the BSE methodology (Tomlinson 2002, 2004; Suter 2010; overview provided in BET-02-06), cannery, observer and logbook data are used to estimate the total annual purse-seine fleet catch of tropical tunas (yellowfin + bigeye + skipjack) by stratum, and the port-sampling data are used to estimate the species composition of the catch within each stratum. The BSE methodology can be summarized by the following three steps:

1) Obtain the total annual purse-seine fleet catch of tropical tunas. This total is based on catches from: cannery data, observer data (if no cannery data for a trip are available), logbook data (if no cannery or observer data are available for a trip), and finally observer at-sea reports if no other data for the trip are available and the trip carried an observer.
2) Distribute the fleet total from (1) to strata (area x month x purse-seine set type x vessel size class category), using the proportion of total tropical tuna catch in each stratum (proportions computed from the combination of observer and logbook data (i.e., from the IATTC Catch and Effort (CAE) database).
3) For each stratum, distribute the catch from (2) to species and size (1 cm length bins), using estimates of the species and size composition of the catch from the port-sampling data. Because there are always strata with catch but no port-sampling data, species and size composition in some strata are based on port-sampling data from 'neighboring' strata. The 'best' neighboring stratum to a stratum without port-sampling data is determined by a series of hierarchical rules. In general, priority is given to set type – which means that to the extent possible, the 'neighbor' stratum should have the same set type. Then priority is given to area or month, depending on the computer program being used (see below), and finally vessel size class category. For example, a stratum that has catch from OBJ sets in area 7, month 3, and Class-6 vessels would be considered 'closer' to a stratum with catch from OBJ sets in the area 7 and month 3 but from Class 1-5 vessels than to a stratum with catch from OBJ sets in area 3 and month 3 and Class-6 vessels.

There are two computer programs that have been used in recent years to generate BSEs, both of which implement the BSE equations of Tomlinson (2002, 2004), but have somewhat different substitution rules and stratum definitions. The first computer program is used to generate the BSE values that are presented in the IATTC Fishery Status Reports (e.g., Table A-7). This program uses the 13 sampling areas (Figure 2 (a)) for the spatial component of the stratum definitions. It is inflexible with respect to changing spatial strata and data sources. Hereafter, for simplicity, this program will be referred to as the "BSE program". The second computer program, which was developed as part of the transition to spatial stock assessments at IATTC, allows for different spatial stratifications and/or different data sources to be used to compute BSEs. This computer program was used to compute the BSE values for the most recent BET assessment; the spatial stratification was derived from the BET stock assessment fishery definitions (Figure 2 (b)). Hereafter, this program will be referred to as the "SA program", although it can be run with any spatial stratification that is defined using 5° areas, including the 13 sampling areas. The SA program also differs from the BSE program in the definitions of some of the substitution rules that are used to identify 'neighboring' strata. It puts a priority on preserving area when identifying a substitute stratum, whereas the BSE program puts a priority on preserving month when searching for a substitute stratum. The SA program was used in this study to generate various time series of BSEs, which are described below.

To evaluate the effect of the pandemic on the 2020 BET OBJ BSE, the SA program was run for each of years 2010-2019, using all available cannery, observer and logbook data, but with only a subset of the port-sampling data. In principle, the subset of port-sampling data used would be based on a determination of which strata were significantly impacted by the pandemic. However, identification of such strata is made problematic by the inherent variability in sampling that occurs as a result of opportunistic data collection in the presence of variable fishing effort in space and time within the EPO. Therefore, in this analysis the effect of the pandemic on data collection was identified at the level of ports of unloading. Specifically, at the main ports of unloading, the monthly proportions of trips unloading that were sampled by the port-sampling program in 2010-2019 were compared to the same for 2020. Months with no unloadings sampled in 2020, but for which a non-zero proportion of unloadings were sampled in each of the previous 10 years, were considered to be impacted by the pandemic, and all port-sampling data collected from trips arriving in those months were excluded to produce a reduced port-sampling data set.

For each year, two different spatial stratifications were used to define strata when implementing the BSE methodology. The first spatial stratification was the 13 sampling areas (Figure 2 (a)), which will be referred to as the "BSE strata", and the second was the spatial stratification derived from the BET stock assessment fishery definitions (Figure 2 (b)), which will be referred to as the "SA strata". The use of the two different spatial stratifications allows the effects of several factors on the BSE methodology to be quantified: 1) different substitution rules, by comparison of estimates from the SA program with the BSE strata to estimates from the BSE program; 2) different spatial strata, with the same and different substitution rules, by comparison of estimates from the SA program with BSE strata to those from the SA program with SA strata, and comparison of estimates from the SA program with BSE strata to those from the BSE program; and, 3) the effect of pandemic data loss, by comparison of the SA program estimates, with and without the reduced port-sampling data, using the BSE strata and the SA strata.

3. RESULTS

3.1. Simulating the pandemic-related port-sampling data loss

The cumulative proportion of fleet unloadings by port for 2010–2020 shows that most of the unloadings in recent years have occurred in only a relative small number of ports (Figure 3). For example, the first 5 ports with the most unloadings accounted for 79.5% of all unloadings over the 11 year period. To look at the affect of the pandemic on port-sampling data collection, 6 ports were selected: Manta, Posorja, Mazatlan, Guayaquil, Manzanillo and Cartagena. These 6 ports represented about 82% of trips that unloaded during 2010–2020 (Figure 3) and about 97% of all well samples collected by the port-sampling program during 2010–2020 (port-sampling is not conducted in all ports of unloading for logistical reasons). Of the 51 ports where unloading occurred in 2010-2020, these 6 ports were the only ports where the proportion of trips *not* sampled in 2020 exceeded the maximum proportion of trips *not* sampled in the previous 3 years (2017 – 2019), even though the number of trips unloading in 2020 in these 6 ports was relatively similar to that in previous years (Figure 4).

The level of port-sampling varied among months and years within each of these 6 ports. The effect of the pandemic on port-sampling data collection is most evident in Manta (Figure 5). In clear contrast to the level of monthly sampling in 2010-2019, no unloadings were sampled in Manta in 2020 for trips arriving between April and December. In Posorja, the pandemic appears to have led to no sampling of unloadings for trips arriving in April and May of 2020, and possibly in April of 2020 in Mazatlan. For the other 3 ports (Guayaquil, Manzanillo, Cartagena), the effect of the pandemic is less clear, given the high degree of variability in sampling among months and years during 2010-2019. Manta and Posorja are the two ports at which most of the BET catch, as reported by observers and in logbooks, was unloaded (Figure 6). Given this, to evaluate the affect of the pandemic on the 2020 BET OBJ BSE, the BSE methodology was run for each of years 2010–2019, excluding the port-sampling data from unloadings of trips that arrived to port in April through December in Manta, April through May in Posorja and April in Mazatlan.

3.2. Effect of port-sampling data loss on the BSE methodology

The effect of the simulated port-sampling data loss in 2010–2019 on the BET OBJ BSE was about a doubling of the range of differences in estimates that resulted from the use of complete data sets but different strata and substitution rules (Figures 7-8). The three BSE series based on all available data, the BSE program estimates, the SA program estimates based on BSE strata and the SA program estimates based on SA strata, were reasonably similar in most years (Figure 7). Differences in substitution rules led to about a 5-10% difference in the estimates (Figure 8(a)) and differences in both spatial stratifications and substitution rules led to a 10% difference in the estimates (Figure 8 (b)). The simulated pandemic data loss led to small differences in estimates in some years (e.g., 2013, 2017, 2018) but large differences in the estimates in other years (e.g., 2011, 2014 – 2016) (Figure 7). The effect ranged from an underestimation of as much as about 25% to an overestimation of as much as about 30%, depending on the spatial stratification used (Figure 8 (c)-(d)).

4. DISCUSSION

In these analyses it has been assumed that the underlying processes affecting catch composition, such as operational characteristics and distribution of tuna abundance in space and time, were either similar from year to year or had lesser impact on the BSE as compared to the loss of port-sampling data. It is possible that the range of differences seen in the estimates (Figure 7, Figure 8 (c)-(d)) reflect an interaction between changes in processes from one year to the next, as well as simulated data loss. Separating these two types of effects is problematic because the true catch composition is not known and a good measure of error for the BSE is not available and would be difficult to compute given aspects of the methodology whose effects cannot be quantified, such as the asumption that the species and size composition of mixed-stratum wells is similar to that in single stratum wells, and the effect of substitution rules.

The work conducted in this study has highlighted the importance of reviewing, and possibly revising, the current port-sampling data collection protocol, as well as the BSE catch estimation methodology. In the case of the port-sampling data collection, transitioning to a systematic sampling protocol for vessels and establishing a formal protocol for wells to be sampled would remove the opportunistic nature of the data collection, allowing for development of a potentially improved estimation methodology and error estimation. In the case of estimation, transitioning to a methodology that takes maximum advantage of all available data sources for estimating species and size composition, rather than relying solely on port-sampling data, could prove beneficial. Spatio-temporal modeling, such as the type of model used to estimate the magnitude and direction of the bias associated with the 2020 BSE (SAC-13-05), as well as spatio-temporal models for finer-scale, data would be useful to explore in the future for catch estimation.

5. CONCLUSIONS

The results presented in this study indicate that the systematic pandemic-related loss of port-sampling data in 2020 for ports where much of the EPO BET is estimated to be unloaded may have led to a bias in the BET OBJ BSE. Although the median difference between estimates, with and without the simulated data loss, was close to 0, both negative and positive biases of about 20% or more were seen over the 2010–2019 period.

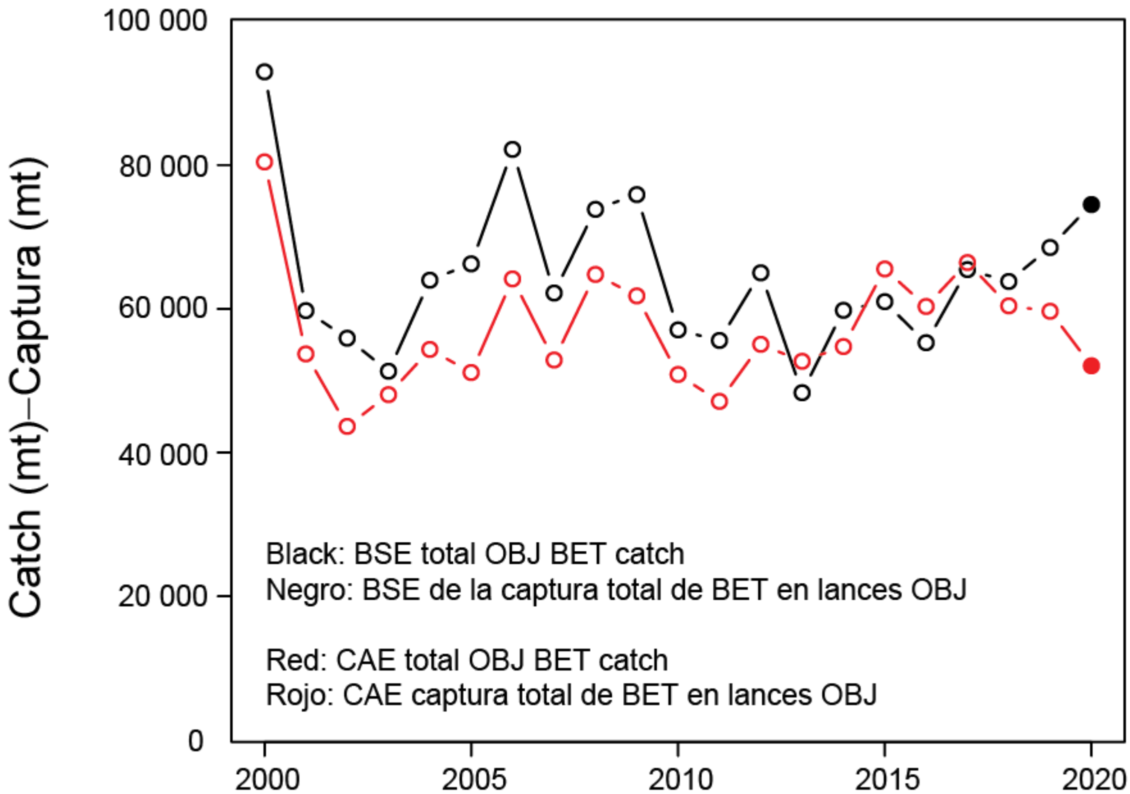

FIGURE 1. Estimates of BET catch in OBJ sets for 2000–2020 shown at the IATTC 97th Extraordinary meeting (https://www.iattc.org/Meetings/Meetings2021/IATTC-97/Docs/_English/IATTC-97-PRES_Staff%20responses%20to%20requests.pdf). BSE: BET OBJ estimates shown in Table A-7 of the IATTC Fishery Status Report. CAE: sum of BET catches in OBJ sets reported by observers and in logbooks (the Catch and Effort database); uncorrected for coverage.

FIGURA 1. Estimaciones de la captura de BET en lances OBJ para 2000-2020 presentadas en la 97ª reunión extraordinaria de la CIAT (https://www.iattc.org/Meetings/Meetings2021/IATTC-97/Docs/_English/IATTC-97-PRES_Staff%20responses%20to%20requests.pdf). BSE: estimaciones de captura de BET de lances OBJ presentadas en la Tabla A-7 del Informe de la situación de la pesquería de la CIAT. CAE: suma de capturas de BET en lances OBJ reportadas por observadores y en bitácoras (la base de datos de captura y esfuerzo); no corregida por la cobertura.

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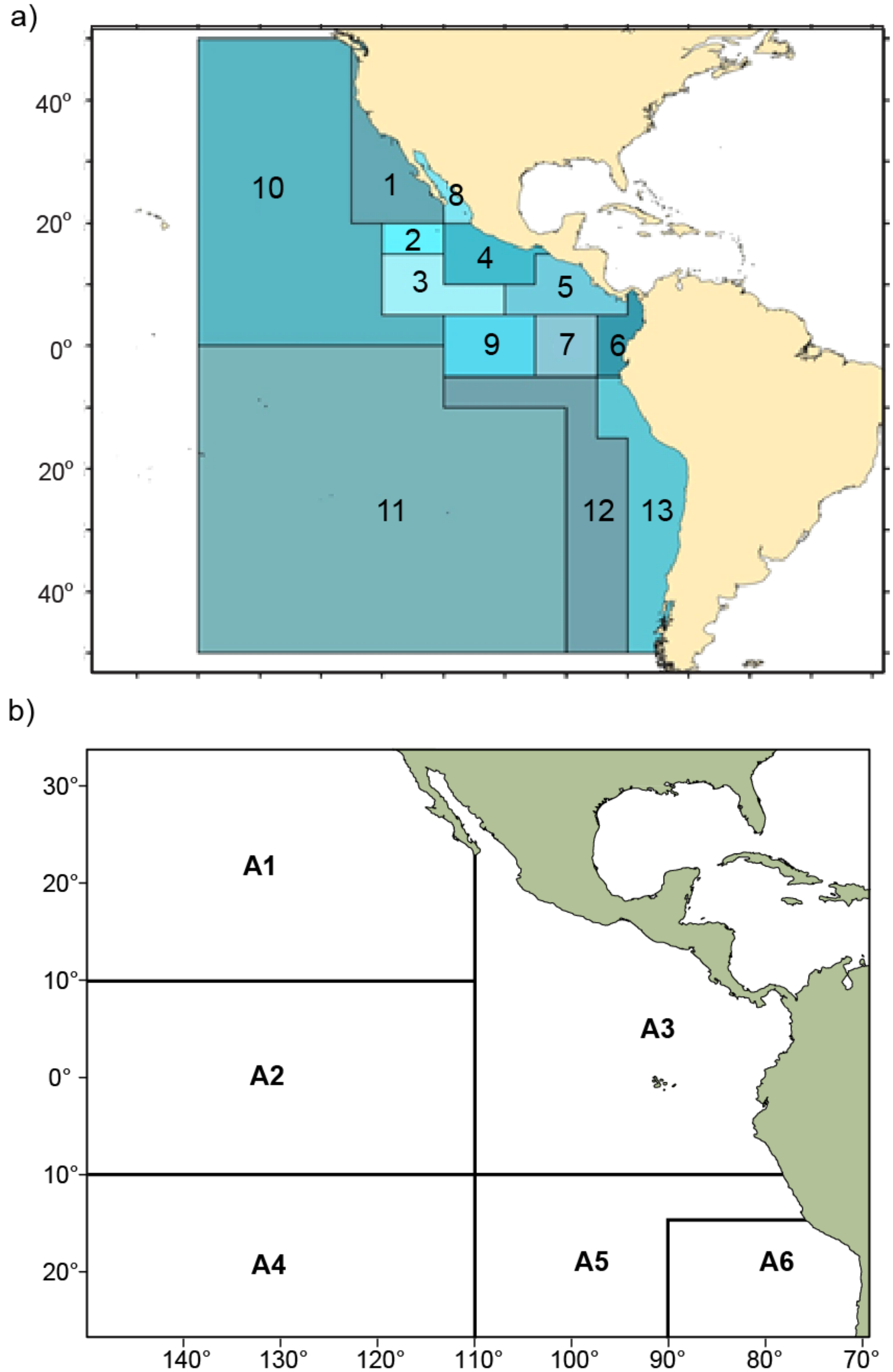

FIGURE 2. Sampling areas used for the BSE (a), and the BET stock assessment fishery definitions (b).
FIGURA 2. Áreas de muestreo utilizadas para la BSE (a), y las definiciones de las pesquerías de la evaluación de la población de BET (b).

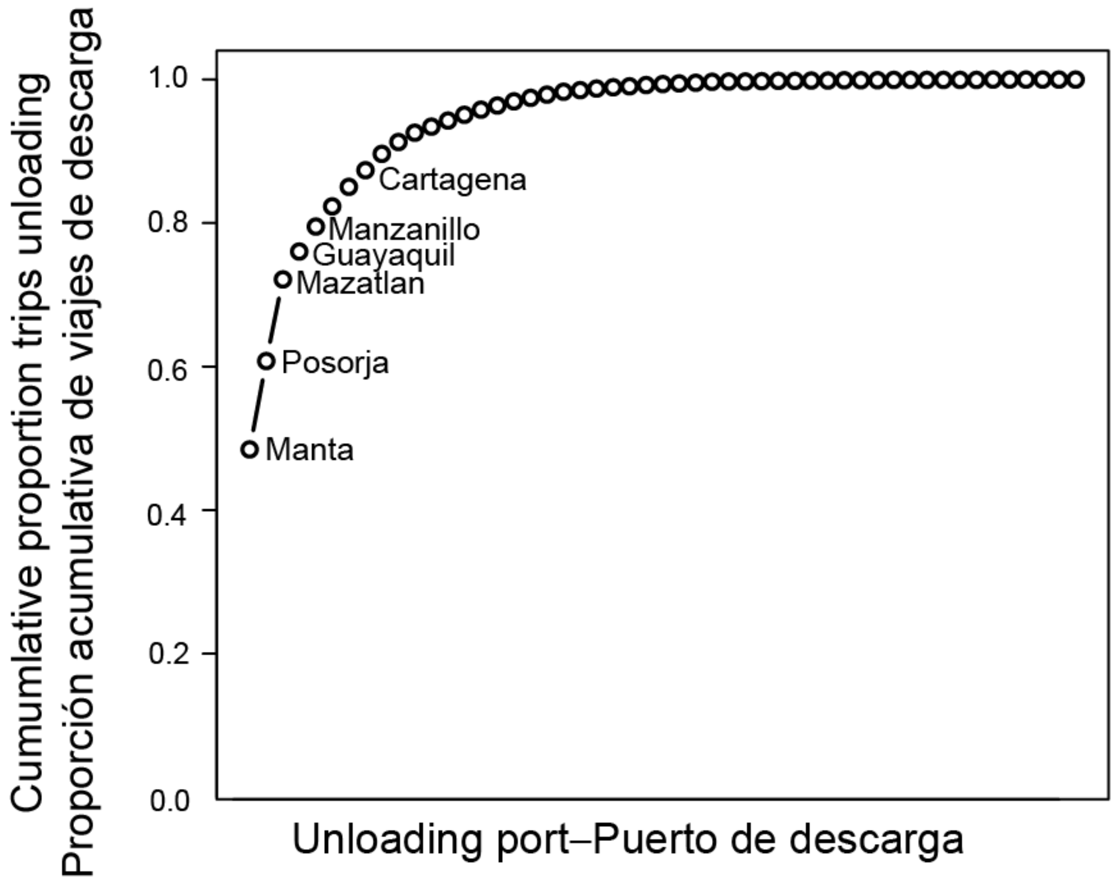

FIGURE 3. Cumulative proportion of trips that unloaded in each of the 51 ports during 2010–2020.
FIGURA 3. Proporción acumulativa de viajes que descargaron en cada uno de los 51 puertos durante el periodo 2010-2020.

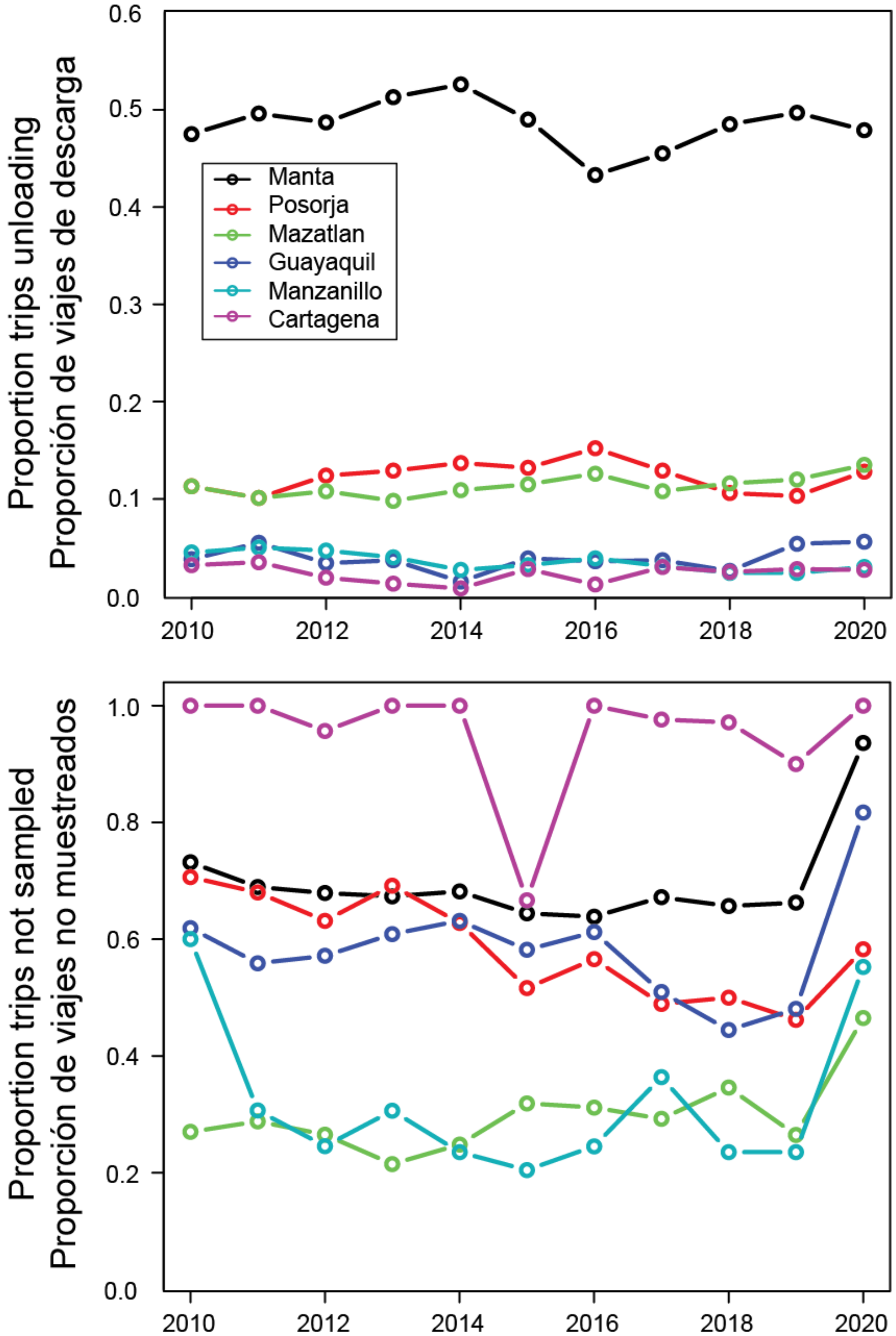

FIGURE 4. Top panel: proportion of unloadings (within a year), by port, for the 6 ports considered in this study. Bottom panel: annual proportion of trips *not* sampled, by port of unloading, for 2010–2020 in the 6 ports.

FIGURA 4. Panel superior: proporción de descargas (en un año), por puerto, para los seis puertos considerados en este estudio. Panel inferior: proporción anual de viajes *no* muestreados, por puerto de descarga, para el periodo 2010-2020 en los seis puertos.

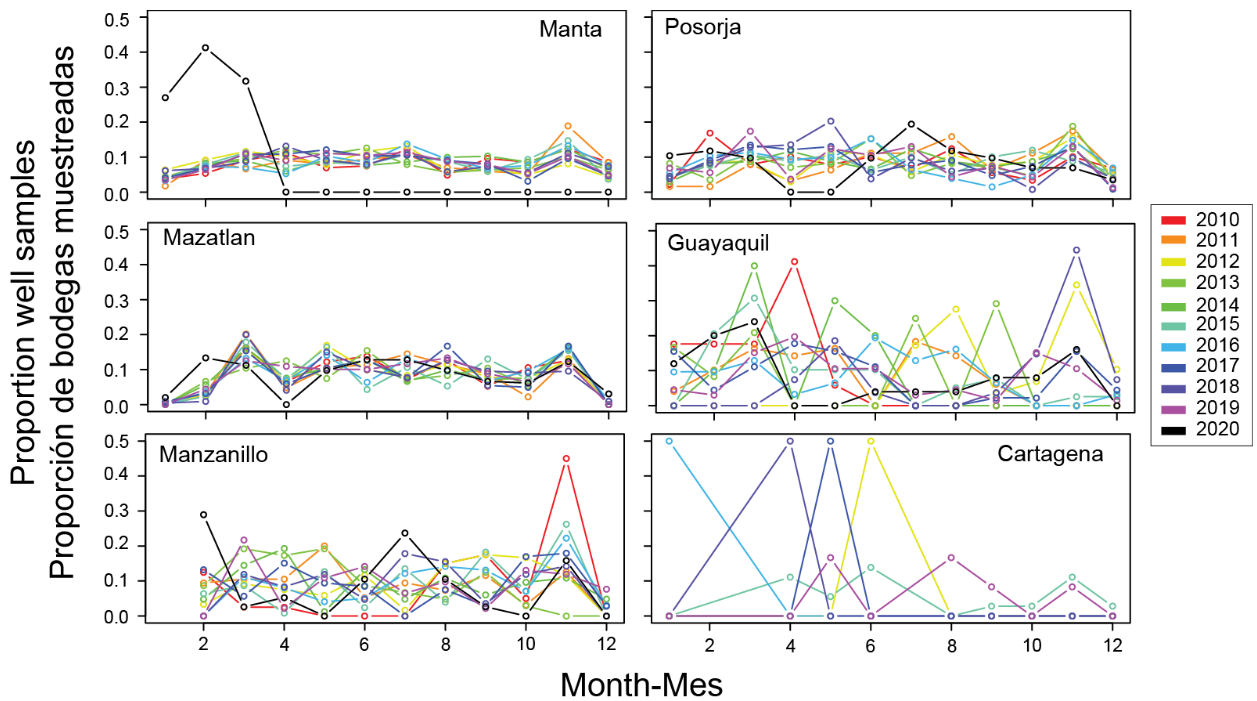

FIGURE 5. Proportion of wells sampled, by trip arrival month, for 2010–2020 in the 6 ports. Proportions sum to one within a year, by port.

FIGURA 5. Proporción de bodegas muestreadas, por mes de llegada del viaje, para el periodo 2010-2020 en los seis puertos. Las proporciones suman uno en un año, por puerto.

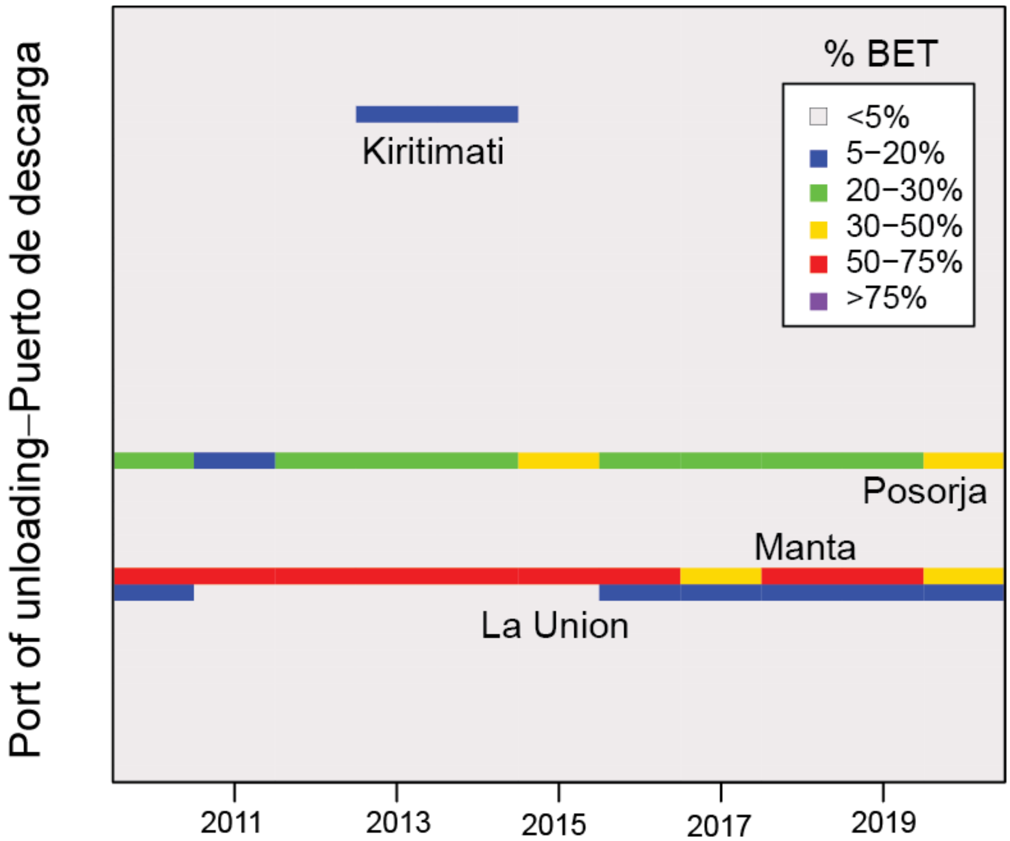

FIGURE 6. Percentage of BET catch in the CAE database (uncorrected for coverage), by year (x-axis) and port of unloading (y-axis), 2010–2020.
FIGURA 6. Porcentaje de captura de BET en la base de datos CAE (no corregido por la cobertura), por año (eje ‘x’) y puerto de descarga (eje ‘y’), 2010-2020.

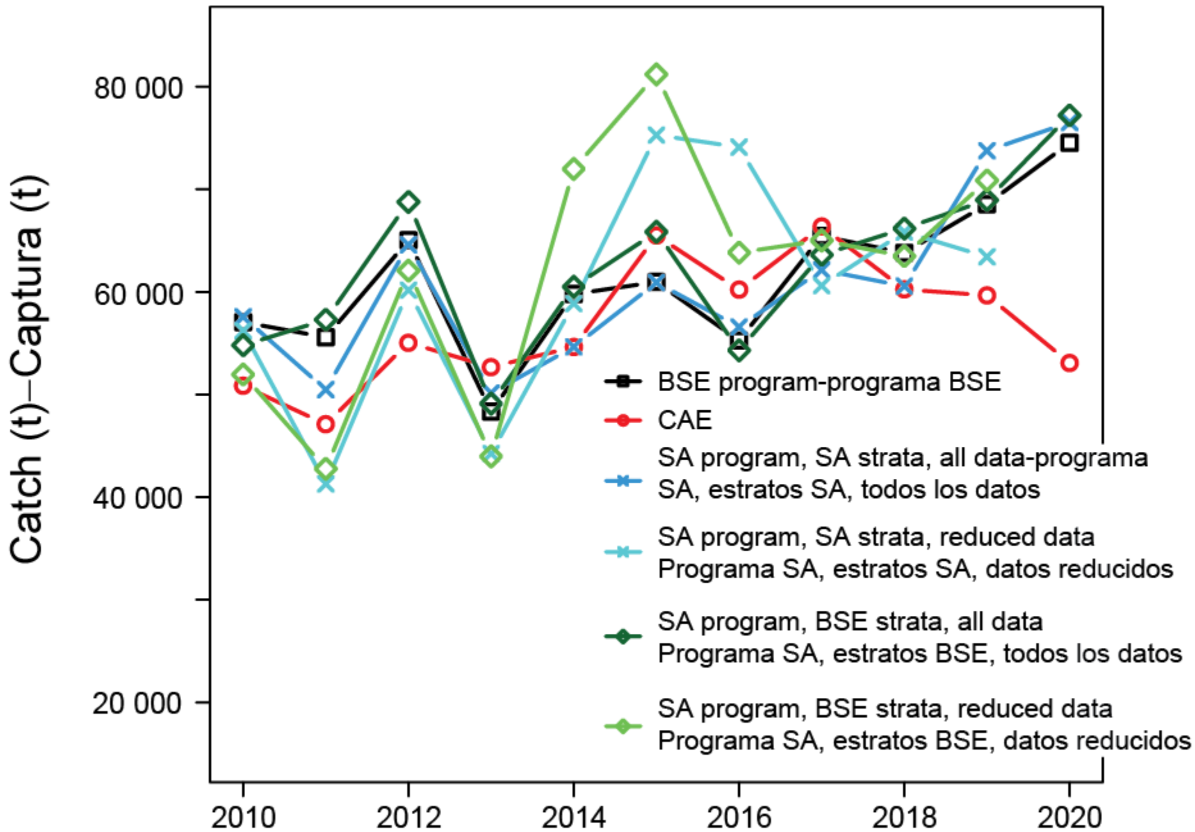

FIGURE 7. BET OBJ catch estimates for years 2010-2020. BSE program: BSEs shown in Table A-7 of the IATTC Fishery Status Report 19; SA program, BSE strata: BSEs from the SA program using the BSE strata; CAE: IATTC Catch and Effort database summary (not adjusted for coverage); SA program, SA strata: BSEs from the SA program using the SA strata; reduced data: program used the reduced port-sampling data set (see text for details).

FIGURA 7. Estimaciones de captura de BET en lances OBJ para el periodo 2010-2020. Programa BSE: las BSE presentadas en la Tabla A-7 del Informe de la situación de la pesquería 19 de la CIAT; programa SA, estratos BSE: las BSE del programa SA utilizando los estratos BSE; CAE: resumen de la base de datos de captura y esfuerzo de la CIAT (no ajustado por la cobertura); programa SA, estratos SA: las BSE del programa SA utilizando los estratos SA; datos reducidos: el programa utilizó el conjunto de datos de muestreo en puerto reducidos (ver texto para más detalles).

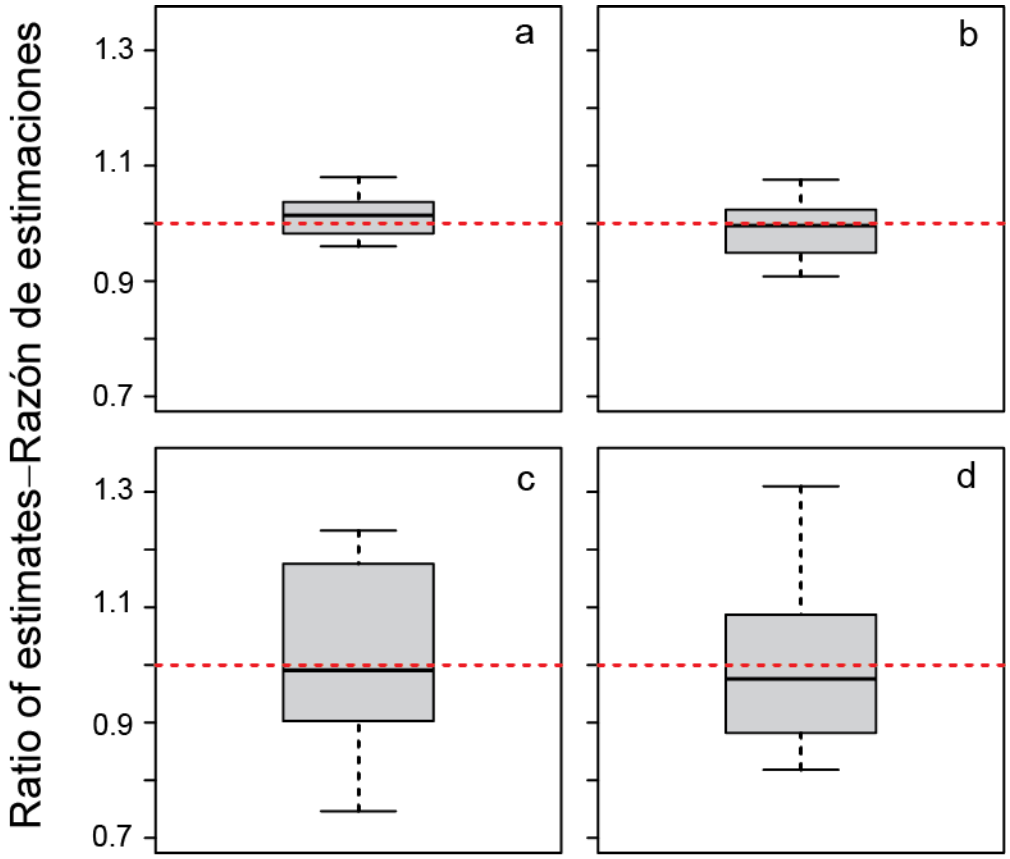

FIGURE 8. Box-and-whisker plots of ratios of various BET OBJ estimates shown in Figure 4.5, 2010-2019: a) SA program, BSE strata divided by BSE program; b) SA program, SA strata divided by BSE program; c) SA program, BSE strata, all data, divided by SA program, BSE strata, reduced data; and, d) SA program, SA strata, all data, divided by SA program, SA strata, reduced data. BSE program: BSEs shown in Table A-7 of the IATTC Fishery Status Report; SA program, BSE strata: BSEs from the SA program using the BSE strata; CAE: IATTC Catch and Effort database summary (not adjusted for coverage); SA program, SA strata: BSEs from the SA program using the SA strata; reduced data: program used the reduced port-sampling data set (see text for details).

FIGURA 8. Diagramas de caja y bigotes de las razones de varias estimaciones de captura de BET en lances OBJ presentadas en la Figura 4.5, 2010-2019: a) programa SA, estratos BSE divididos por el programa BSE; b) programa SA, estratos SA divididos por el programa BSE; c) programa SA, estratos BSE, todos los datos, divididos por el programa SA, estratos BSE, datos reducidos; y, d) programa SA, estratos SA, todos los datos, divididos por el programa SA, estratos SA, datos reducidos. Programa BSE: las BSE presentadas en la Tabla A-7 del Informe de la situación de la pesquería de la CIAT; programa SA, estratos BSE: las BSE del programa SA utilizando los estratos BSE; CAE: resumen de la base de datos de captura y esfuerzo de la CIAT (no ajustado por la cobertura); programa SA, estratos SA: las BSE del programa SA utilizando los estratos SA; datos reducidos: el programa utilizó el conjunto de datos de muestreo en puerto reducidos (ver texto para más detalles).