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# DOCUMENT SAC-16 INF-M

# A COMPARATIVE ANALYSIS OF THE SORTING GRIDS USED IN THE EPO TROPICAL TUNA PURSE-SEINE FISHERY

This document was produced by the IATTC staff in response to a SAC-15 recommendation that, "*a) the scientific staff provide an evaluation of the conservation value of sorting grids and conduct a comparative analysis of the catch between sets with and without the use of sorting grids for fish in order to detect changes in the composition of the target and non-target catch, and b) that a workshop be held in Ecuador with IATTC scientific staff, industry, and fishing technicians in order to: i: learn about prototype sorting grids used during fishing maneuvers, use, experiences, benefits and problems, and ii: analyze the possibility of quantifying the amount of fish that are extracted by this method as well as their survival or condition, by means of the design of an experiment and/or sampling during sets in which the grids are used (e.g., through the use of underwater cameras)*."

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## 1. SUMMARY

At the 15th meeting of the SAC a recommendation was endorsed stating that, "*a) the scientific staff provide an evaluation of the conservation value of sorting grids and conduct a comparative analysis of the catch between sets with and without the use of sorting grids for fish in order to detect changes in the composition of the target and non-target catch, and b) that a workshop be held in Ecuador with IATTC scientific staff, industry, and fishing technicians in order to: i: learn about prototype sorting grids used during fishing maneuvers, use, experiences, benefits and problems, and ii: analyze the possibility of quantifying the amount of fish that are extracted by this method as well as their survival or condition, by means of the design of an experiment and/or sampling during sets in which the grids are used (e.g., through the use of underwater cameras).*" In response to this recommendation, the IATTC staff, in collaboration with experts in the region, conducted analyses on sorting grid usage, proportion of tuna evasion, and the composition of small tuna catches relative to total tuna catches based on four different data sources. Each of these data sources corresponds to specific data collection periods: IATTC observer data (2008-2009), Ecuadorian national observer program data (PROBECUADOR; 2009-2024), Tuna Conservation Group data (TUNACONS; 2018-2020), and IATTC observers' survey data (2024-February 2025). These data sources varied in nature, time series, and data collecting methods.

Unlike historical datasets, contemporary findings indicate that sorting grids used in recent years have operated more frequently at depths of 75% or greater, regardless of the amount of tuna caught—likely improving their capacity to operate deeper, including in sets with large tuna catches. Grid dimensions and positioning within the net may have contributed to this deeper operation, allowing for greater catches. Analysis of tuna evasion patterns produced inconsistent and contradicting results across data sources, with varying effectiveness observed by species and size. These discrepancies may stem from differing grid designs or data collection limitations (e.g., observer's capacity to collect underwater data). Similarly, trends in the composition of small tunas in catches were inconclusive due to variation across species, catch size, and datasets. Spatiotemporal and operational factors also complicate interpretation. The study highlights the need for standardized sampling, improved data collection methods, and the integration of electronic tools to enhance the accuracy and reliability of future studies.

Given the results of this analysis, the IATTC staff recommends that, if a 2nd Sorting Grid Workshop is organized, it should consider all the relevant information presented in this report and existing literature (e.g., report of the first IATTC sorting grids workshop), and grant the participation of all relevant stakeholders, including global experts, fishers, fleet owners and net engineers and manufacturers, so that the design and parameters of an eventual dedicated experiment are established.

## 2. INTRODUCTION

The tuna purse-seine fishery in the eastern Pacific Ocean (EPO) captures both target and non-target species, including a wide range of bony fishes of varying sizes and vulnerable[3] taxa, as bycatch. The vast majority of these are caught most frequently, and in the greatest numbers, in sets targeting tunas associated with floating objects (IATTC, 2024; Hall and Román, 2013). The use of floating objects in the EPO tuna purse-seine fishery has increased significantly since 2005 (IATTC, document SAC-07-07f.i),

[3] Unless specified otherwise, including but not limited to citations to vulnerability assessments and any qualitative/quantitative scores (e.g., BYC-10 INF-B; SAC-13-11; SAC-14-12), the staff's definition of "vulnerable species" refers to the species that, in the *sensu latu*, and due to their low-productive life-history traits (i.e. K species in r/K selection theory), are more susceptible to the impacts of fisheries and other anthropogenic activities on these species or their habitat and ecosystem. This includes the marine mammals, seabirds, sea turtles and the elasmobranchs

primarily due to the widespread use of fish aggregating devices (FADs). This increase in the FAD fishing effort has been linked to a rise in fishing mortality of small-sized tunas , particularly for bigeye tuna (Aires-da-Silva and Maunder, 2015, Xu et al., 2021).

To mitigate this issue, the IATTC implemented measures to reduce bigeye tuna catches, including, but not limited to, a closure of the fishery for 72 days, additional time-area closures (e.g., the Corralito), an individual vessel limit incentive system (Resolution C-21-04, C-24-01) and recommendations to develop technologies such as excluder devices (e.g., sorting grids) installed in purse-seine nets that would facilitate the release of small tunas (Resolution C-04-05). The effectiveness of sorting grids in the tropical purse-seine fisheries has been assessed in various studies (Nelson, 2004; SRP, 2010; Rios and Sondheimer, 2011). In an evaluation of their use in FAD-associated tuna fisheries in the EPO, Rios and Sondheimer (2011) analyzed tuna evasion rates across five different sorting grid designs and identified the use of grids as a potential tool to possibly reduce fishing mortality of undesirable-sized fish. However, the authors did not definitively conclude impacts of sorting grids on reducing fishing mortality of small-sized bigeye tuna, as evasion percentages were estimated for yellowfin (YFT; *Thunnus albacares*), bigeye (BET; *Thunnus obesus*), and skipjack (SKJ; *Katsuwonus pelamis*) tunas combined, and data on post release survival was not available.

A study conducted by the Ecuadorian Fisheries Resource Subsecretary (SRP, 2010) estimated tuna evasion percentages by species across five sorting grid designs. Results indicated that evasion rates ranged from 0.24% to 0.85% for YFT-BET of < 2.5 kg and 0.17% to 1.62% for medium-to-large individuals (i.e., ≥ 2.5 kg). For SKJ, evasion rates ranged from 0.3% to 1.48% for fish < 2.5 kg and from 0.14% to 1.6% for fish ≥ 2.5 kg. The study found that sorting grids were more effective for SKJ < 2.5 kg than YFT-BET < 2.5 kg, with the net depth at which the sorting grid is installed playing a crucial role in their performance. The authors recommended testing sorting grids at different depths to assess their effect on the evasion of BET < 2.5 kg. Additionally, they found that the efficiency of sorting grids was compromised when tuna catches exceeded 100 metric tons (t), highlighting the need for special considerations regarding sorting grid placement within the net for large catches.

To further discuss these findings, the IATTC-TUNACONS *Workshop on Analysis and Improvement of the use and function of sorting grids for juvenile tunas in the EPO* was organized in Manta, Ecuador, in 2019. The workshop concluded that a series of experiments should be conducted on different vessels using varying numbers and designs of sorting grids with specific dimensions and mesh sizes, ensuring the device operates fully submerged. The workshop also suggested that the evasion of individuals should be recorded either by a diver or a submerged onboard camera (for the report of the workshop, see document IATTC-94 M-1).

In 2024, during its 15th meeting, the IATTC Scientific Advisory Committee, revisited this matter and recommended a stepwise approach to assess the conservation value of the sorting grid and tasked the IATTC staff to conduct:

1. A comparative analysis of the catch between sets with and without the use of sorting grids for fish in order to detect changes in the composition of the target and non-target catch.

2. A workshop to learn about prototype sorting grids used during fishing operations and assessment of their performance, as well as the possibility of quantifying the amount of fish that are extracted by this method including their survival or condition (see document SAC-15 Recommendations for further details).

This document addresses the first task by conducting exploratory analyses using all the available sorting grid data from the EPO tuna purse-seine fishery, collected by the IATTC and national observer programs, as well as by a Non-governmental Organizations (NGO), and across different time periods. For that purpose, the IATTC staff: i) assessed the operation level and configuration of sorting grids and analyzed operational trends over time; ii) evaluated evasion proportions of YFT, SKJ, and BET tunas based on percentage of immersion depth of the grid, and iii) compared the total catch of small tuna relative to total tuna catches in sets with and without sorting grids. The results of these analyses aim to inform the SAC and the potential workshop recommended in task No. 2 above, as well as support an eventual development of standardized data collection methods to better understand sorting grid performance, including quantifying evasion rates and post-evasion survival of the species and sizes of interest.

## 3. MATERIALS AND METHODS

### 3.1. Data sources

For the analyses included in this document, the staff used different data sources, among them historical IATTC Observer program (hereafter referred to as "Observer data"), the Ecuadorian National Observer program - PROBECUADOR, (hereafter referred to as "PROBECUADOR data"), the Tuna Conservation Group - TUNACONS observer program - a consortium of Ecuadorian tuna fishing companies, (hereafter referred to as "TUNACONS data"), and a recent survey launched by the IATTC observers (hereafter referred to as "Survey data"). These four data sources provided information for assessing the performance of sorting grids on target species of the tuna purse-seine fishery in the EPO (see below). Each dataset has distinct characteristics regarding data collection periods, sorting grid variables, and other parameters collected (Table 1). A summary of the details and number of observations for these data sources is presented in Table 2.

#### 3.1.1. IATTC observer data

To better understand usage of tuna sorting grids in the EPO purse-seine fleet, the IATTC established a data collection program for sorting grids from 2008 to 2009. As part of the IATTC observer program on large purse seiners (class 6, >363 t) with regular 100% coverage, observers recorded set-level data, including date, location, tuna catch (estimated in metric tons [t]) by species and size category (small <2.5 kg, medium 2.5-15 kg, large >15 kg), the percentage of sorting grid immersion, and tuna species evasion by size category (estimated in t). Observers also documented catch composition by species and size category when the sorting grid was not used.

Estimating underwater evasion of species and sizes posed significant challenges for observers due to high turbidity, strong winds, and the need to maintain a safe distance from the fishing operation to avoid interference. In addition, observers had to collect information on the remaining fishing activities of the vessel. These factors often resulted in reduced visibility or loss of visual contact with the area where the grid was operating.

Because accurately identifying tuna species underwater is difficult, particularly smaller individuals with similar characteristics, estimates for YFT and BET were combined in the analysis. Tuna species were further categorized into two groups (small, < 2.5 kg, medium-large ≥2.5 kg.) based on a reference weight of 2.5 kg.

#### 3.1.2. PROBECUADOR data

Since 2009, observers from the Ecuadorian National Observer Program have been collecting sorting grid-related data, making this dataset the longest time series available up to date, spanning from 2009 to 2024. Note that the Ecuadorian fleet is the fleet with highest usage of sorting grids, both historically and at present. The data is recorded at trip level and includes trip number, total number of sets, total tuna evasion (in number of individuals), sorting grid usage, and the percentage of grid submersion. In this data collection program, tuna evasion data was only provided at a general taxonomic level (fam. Scombridae). Although the data was collected at trip level and the tuna evasion at family taxon level, this information was linked to the IATTC observer database to obtain the tuna catch composition by species and size category associated to that trip.

In an exploratory analysis of the data, it was observed that grid immersion proportion used in a set did not follow a consistent trend over the years (Figure 1). In the early years of the time series, immersion proportion was around 20%, while more recent years show an immersion rate of approximately 45%, on average. Additionally, the percentage of grid immersion proportion relative to the total tuna catch fluctuated over time (Figure 2), suggesting operational changes in sorting grid use over the years, which may affect consistency and comparability to the other data sources. To address these potential issues, the analyses using PROBECUADOR data were grouped into three periods, closely matching the other three data sources available:

- PROBECUADOR early data: 2009
- PROBECUADOR middle data: 2018-2020
- PROBECUADOR recent data: 2024

#### 3.1.3. TUNACONS data

During 2018 to 2020, the vessels belonging to the Tuna Conservation Group (TUNACONS)—a consortium of Ecuadorian tuna fishing companies, have collected information related to the use of sorting grids. This dataset shares some similarities with the Observer data mentioned above, including set-level information such as location, estimated tuna catch (t) by species, the percentage of sorting grid immersion, and tuna species evasion by size category (estimated in t), but was collected by the vessel's crew (i.e., skippers) and not by onboard observers. Unlike the observer data, the TUNACONS data did not include information about the sets where sorting grids were not used and lacked tuna catch data by size category. For the purpose of this work, the latter was obtained, for every set, either from the IATTC or the Ecuadorian national observers who sampled these trips.

#### 3.1.4. Survey data

The survey data collection began in 2024, after a SAC-14 recommendation to better understand current use of sorting grids by the purse-seine fleet in the region. Upon completion of a trip, and during their data debriefing, IATTC observers were interviewed on different aspects related to sorting grids, including among others, the grid usage during the entire fishing trip (yes, no), percentage of grid immersion, mesh size, etc. Once linked to the catch data, the information on tuna catch composition by species and size category was retrieved for the trip. Data on tuna evasion was not available for this survey.

### 3.2. Data analysis

Dedicated analyses on tuna evasion and small-size composition of tuna catches (< 2.5 kg) were conducted based on data availability from the four different sources (see details below). All the analyses were implemented in the statistical freeware R (R Core Team, 2021).

The package ggplot2 (Wickman, 2016) was used for running generalized additive models (GAMs; Wood, 2011) and comparing between sorting grid data sources and different parameters, as well as for visualizing the statistical models with predicted 95% confidence bands. GAMs were selected because the relationship between sorting grid efficiency and grid immersion depth or catch ranges is believed to be non-linear (SRP, 2010).

#### 3.2.1. Sorting grid usage

To investigate changes in sorting grid dimensions used over time, comparisons were made between two periods and two data sources (Observer data (2008-2009) and Survey data (2024-2025) - the other two datasets, PROBECUADOR and TUNACONS lack detailed information on the grid dimensions; see table 1).

To assess temporal changes in sorting grid usage, the percentage of sets as a function of grid immersion levels (≤ 25%; 25-50%; 50-75%, and >75% submerged) was examined through four data sources from three year-periods: i) Observer data (2008-2009); ii) TUNACONS data (2018-2020); iii) Survey data (2024-2025), and iv) PROBECUADOR data, categorized into early (2009), middle (2018-2020) and recent time periods (2024). Additionally, sorting grid immersion levels in relation to total tuna catches were analyzed to examine temporal changes in grid immersion depth usage and efficiency. Observer data, TUNACONS data and Survey data were used for this analysis. Additionally, a fourth data source (PROBECUADOR data, 2010-2015), was included to cover years not present in the previous data sources. Total tuna catches were categorized into 5 groups (<=20 t; 20-40 t; 40-60 t; 60-100 t, and >100 t).

Since the resolution of the PROBECUADOR data was at the trip level, the average of the percentage of sorting grid immersion levels during the trip was used for this analysis. Likewise, for survey data, only the trips where observers reported that the grid remained submerged at the same percentage throughout the entire trip were included in this analysis.

### 3.2.2. Tuna evasion

Analyses of the proportions of tuna evasion were conducted using Observer data and TUNACONS data. Evasion proportions were analyzed according to two size categories, using a reference weight of 2.5 kg. The evasion proportion for SKJ was assessed separately, while YFT and BET were grouped to estimate their combined evasion proportion in relation to the percentage of grid immersion.

To investigate changes in proportions of tuna evasion as a function of tuna catch, the proportion of evasion was estimated for four categories of total tuna catches (20-40 t; 40-60 t; 60-100 t, and > 100 t).

Since tuna catch data by size category was not originally reported by TUNACONS, this data was extracted from the Observer database, and a validation process was performed. For this validation, comparisons between Observer data on tuna size composition and TUNACONS evasion data revealed that, in many sets, tuna size composition in catches reported by the Observer data was less than the corresponding evaded tuna size composition reported in the TUNACONS data. While observers typically consult with the chief engineer to verify their catch estimates, the provided catch information is generally given at species level rather than by size category. To address discrepancies in catch-at-size of tuna species between these two data sources and ensure a conservative approach, sets with evasions exceeding half of the corresponding retained catch in a given size category were excluded from the analysis.

### 3.2.3. Size composition of the catch

In response to the SAC-15 request for a comparative analysis of catch data from sets with and without sorting grids, the changes in the size composition of total tuna catches (the retained catch plus any potential discards) were examined, with particular emphasis on small-sized individuals (< 2.5kg). The underlying assumption is that if small tuna evade capture by escaping through the grid, their proportion in the total catch should be lower when a sorting grid is used.

Unlike sets targeting tuna associated with dolphins (DEL) or those not associated with any structure (NOA), sets associated with floating objects (OBJ) show the highest species diversity in the catch data (Figure 3), including the highest proportion of juvenile tuna (Hall & Román, 2013). DEL sets typically capture medium to large sizes of yellowfin tuna (≥2.5 kg), while NOA sets predominantly catch SKJ, with juveniles' presence depending on surface availability and the fishery's spatiotemporal dynamics (Figure 3). Due to the larger size of individuals caught in DEL and NOA sets, most tuna in these sets are unlikely to pass through the sorting grid. Therefore, the analysis of small tuna composition in relation to total tuna catch, based on sorting grid utilization, focused exclusively on OBJ sets.

Since TUNACONS data lacked information on sets without sorting grids, comparisons of tuna catch by species and size category were made using PROBECUADOR, Observer, and Survey data. The proportion of small-sized SKJ and YFT-BET relative to total catch was estimated for sets without grid use (0% immersion) and for sets with grid use (>0% to 100% immersion levels). As mentioned earlier, PROBECUADOR data was recorded at the trip level, hence for this analysis, the average percentage of immersion levels for sorting grids during each trip was used. Similarly, for Survey data, only trips where observers reported that the grid remained submerged at a consistent level throughout the entire trip were included. Additionally, size composition of the catch was analyzed in relation to four total tuna catch categories (20–40 t, 40–60 t, 60–100 t, and >100 t).

## 4. RESULTS AND DISCUSSION

### 4.1. Sorting grid usage

The Observer data collected in the early period indicated smaller sorting grid dimensions, both in length and height (Length: Median = 2.20; interquartile range (IQR): 2.18-2.30; Height: Median = 1.64; IQR: 1.6-1.72) compared to the contemporary Survey data (Length: Median = 3.0; IQR: 2.90-3.85; Height: Median = 2.70; IQR: 2.4-3.0; Figure 4). These results indicate that larger sorting grids have been used in recent years, suggesting that fleets may have made size modifications to the sorting grid design to improve performance. Note that information on the dimension of sorting grids is not available in all data sources (e.g., TUNACONS and PROBECUADOR data [Table 1]), which would have added robustness to this analysis across time periods. On the other hand, there is no mandatory regulation at the IATTC level requiring the use of sorting grids or providing standardized designs or installation guidelines, considering variations in vessel design and size.

In line with these findings, should the effectiveness of sorting grids be demonstrated, and the Commission eventually mandates their use, detailed guidelines on their construction and installation would be desirable to ensure standardized and optimal performance.

The number of sets as a function of the immersion level of the sorting grid varied across datasets, both in sample size and trends across time periods. TUNACONS and PROBECUADOR data for 2018-2020 represented 18,100 sets (Figure 5c), a substantially larger number than the total of the other data sources combined (10,130 sets; Figure 5b-d).

In terms of percentages, PROBECUADOR early data (2009), showed the highest percentage of sets (53%) with the grid submerged at a maximum of 25% (Figure 5b). TUNACONS data (2018-2020), showed higher percentages of sets with the grid submerged at 25-50% (max = 41%) (Figure 5c). Lastly, Survey and PROBECUADOR recent data showed higher percentages of sets with the grid submerged more than 50% (Figure 5d), which suggests that the sorting grid has been progressively operating at deeper depths in recent years.

A comparison of grid immersion levels relative to total tuna catch revealed higher median immersion levels across all total tuna catch categories in data collected from 2018 onward (TUNACONS and Survey data). In contrast, historical data (Observer data [2008-2009] and PROBECUADOR data [2010-2015]) showed lower median immersion levels across total tuna catch categories (Figure 6).

These results, consistent with previous findings, suggest that after 2009, the dimensions and immersion levels of the grid—particularly grid positioning in the net—may have been adjusted to allow them to sink deeper, better accommodating large tuna catches, as recommended by SRP (2010). It is important to note that information on the positioning of sorting grids within the vessel nets is not available for all data sources or for all vessels equipped with grids. As a result, this study was unable to compare grid positioning across different time periods; however, gaining a better understanding of how grid placement within the net affects its efficiency would be valuable for future research.

### 4.2. Tuna evasion

Figure 7a-d illustrates the predicted values of the proportions of tuna evasion by species and total tuna catch by category from the GAM. For small SKJ, Observer data (2008-2009) shows a positive relationship between evasion proportion and grid immersion level, particularly for catches up to 100 t. Higher evasion proportions (0.08) were observed at full grid immersion for catches ranging 60-100 t (Figure 7a). In contrast, there is no support in the TUNACONS data for this positive relationship, with tuna evasion proportions around 0.03 across grid immersion levels and total tuna catches (Figure 7a). These results suggest that contrary to data collected in 2008-2009, in years 2018-2020 the grid immersion levels do not seem to have a positive effect on the proportion of small SKJ evading the grid. For medium-to-large SKJ (≥ 2.5 kg), evasion proportions remained minimal (close to zero), and consistent across data sources with up to 75% grid immersion levels (Figure 7b). However, at full immersion, Observer data exhibited a peak of evasion proportions, particularly in catches ranging from 20 to 40 t (0.05). Given that medium-to-large individuals are unlikely to evade the sorting grid, this observed evasion likely reflects the use of several experimental grid designs during the early years, some of them with large mesh sizes that were later discontinued (SRP, 2010). Furthermore, the evasion of tuna could be overestimated. It is worth noting that observers' estimations were based on visual assessments from the main deck without underwater verification. Observations of species and sizes, especially medium-to-large, evading the grid should be interpreted with caution, as the grid's mesh size was designed primarily for the escape of smaller individuals, and results are often inconclusive and contradictory.

For small-sized YFT-BET, TUNACONS data generally showed higher evasion proportions than Observer data, particularly for tuna catches up to 60 t. Moreover, no clear trends were observed between evasion proportion, and either grid immersion levels or total tuna catches, particularly in TUNACONS data (Figure 7c). Observer data results indicated that small SKJ exhibited higher evasion rates than small YFT-BET. These findings are consistent with SRP (2010). However, observations of TUNACONS data showed the opposite pattern, with higher evasion rates for small YFT-BET than for small SKJ, and evasion proportions remaining relatively constant across different grid immersion levels (Figure 7a,c).

For medium-to-large YFT-BET, evasion proportions remained close to zero across data sources and levels of grid immersion depth (Figure 7d). These results support the intended function of the grid to prevent the escape of YFT-BET tunas weighing 2.5 kg or more.

The weak relationship between data sources and small tuna evasion—both in terms of grid immersion levels and total tuna catch categories—underscores the need for standardized experimental designs with reliable data collection and methodologies (e.g., state of the art technologies, cameras, sensors, tags) to accurately quantify species and size-specific evasion rates. Additionally, any future dedicated study on this topic should investigate the post-release survival of fish passing through sorting grids, as the fate (e.g., level of injury) of tunas may be compromised after evasion, and thus the expected conservation benefits of sorting grids could also be diminished.

### 4.3. Size composition of the catch

Figure 8 summarizes the composition of the catch (i.e., proportion of small tuna relative to total tuna) as a function of sorting grid utilization (yes or no) and percentage of grid immersion level (>0% to 100%). The comparisons yielded contrasting results across species and data sources.

For small SKJ, Observer data (2008-2009) showed decreasing trends in the proportion of small SKJ relative to total SKJ, regardless of total tuna catch size. The lowest proportion of small SKJ was found at full grid immersion in catches of 60-100 t (0.172; 95% CI [0.000, 0.393]). These findings suggest that fewer small

SKJ were present when the grid was fully submerged, while more were observed when the grid was not used. In contrast, in the early data from PROBECUADOR, no clear decreasing trend was observed, except in catches of 60-100 t. Since both datasets were collected during similar time periods, these discrepancies are difficult to explain with the information currently available. Although observers receive training on a clear protocol to collect the data, the reliability of underwater species identification, size estimation, and evasion quantification—relying on visual observations from the vessel while performing numerous other duties—remains a persistent challenge.

Compared with earlier data, neither Survey data nor PROBECUADOR recent data (2018-2020) showed a clear relationship between the proportion of small SKJ composition and grid usage levels. The temporal discrepancies among data sources also warrant further consideration. Differences may arise from data collection limitations or from spatiotemporal operational characteristics of the fleet or oceanographic events affecting tuna size composition in a set. Future studies on sorting grids should ideally also consider fishing operational characteristics, along with seasonal and other spatial factors (e.g., environmental variables).

For small YFT-BET relative to total YFT-BET catch; overall, there was not a clear relationship indicating a higher proportion of small individuals when the grid was not used compared to when it was. Only a few declining trends related to grid usage and grid immersion levels were observed in the Observer data (2008-2009; 20-40 t) and PROBECUADOR early data (2009; 20-60 t).

Concerning more recent data, neither PROBECUADOR (2018-2020) nor Survey data (2018-2020) showed meaningful trends linking catch composition of small YFT-BET to grid usage or immersion levels. The absence of consistent patterns in the analysis suggests that in recent years the sorting grid may have little to no significant impact on the catch composition of small YFT-BET.

Finally, the proportion of small SKJ and YFT-BET relative to total tuna as a function of sorting grid utilization (yes or no) revealed, in most of the cases, no meaningful variations across total tuna catch categories, suggesting that the composition of small tuna may not be significantly impacted by the amount of total tuna catch. To better assess the impact of total tuna catch on sorting grid performance, future analyses should explore, in dedicated experiments, the potential effect of total tuna catch on the efficiency of the sorting grid and develop protocols to optimize its efficiency on releasing small tuna based on its design and disposition within the net and the behavior of tuna during the fishing operation.

## 5. CONCLUSIONS AND RECOMMENDATIONS

This report compares various data sources and time periods to assess the performance of the sorting grid, focusing on both its usage and its effectiveness in evading different tuna species and sizes. Each data source has unique characteristics (Table 1) that made it suitable for some, but not all, of the analyses conducted in this report.

The data sources varied in nature and time-series, as well as in the methods and data fields collected. One source involved data collected by the vessel crew during the fishing trip, another provided sorting grid data collected during debriefing at the observer program office upon trip completion, and the remaining sources offered data collected by onboard observers. Although every data source was maximized in the present analyses, the staff identified caveats and potential gaps in the data (partly due to the inherent variability among these data sources) that could affect the validity and representativeness of the final results.

Regarding the sorting grid configuration, its dimensions have increased over recent years compared to 15 years ago, suggesting that size adjustments have been made over time to improve its performance.

Our results indicate that, contrary to earlier data, a higher percentage of sets in recent years have had the grid operating while submerged at levels of 75% or more. Moreover, recent data show that this level of immersion has remained relatively consistent across all total tuna catch sizes, suggesting that the grid may be able to effectively accommodate large catches (possibly due to the increase in grid dimensions in recent years). However, a key factor appears to be the positioning of the sorting grid within the vessel's net. This study did not include a comparative analysis of grid configurations within the purse-seine net, since that information was not available. To better understand the role of installation and configuration in the grid's performance—particularly with large catches—further studies would be desirable.

The performance of the sorting grid with regards to tuna evasion, including its variability by species and size provided contradictory insights across data sources. Observer data showed higher evasion proportions of small SKJ while TUNACONS data showed no such correlation. Additionally, recent TUNACONS data indicated that the grid might also be effective for small YFT-BET, whereas Observer data showed lower evasion rates for these species. These contrasting results complicate efforts to draw firm conclusions about tuna evasion patterns by species and size category. These discrepancies may be due to, among others, differences in grid designs across time periods, their placement within the net, or data collection limitations, particularly the challenges observers face in quantifying underwater evasion by species and size category. The inclusion of standardized data collection and more precise methods (e.g., the use of electronic tools such as cameras, sensors and/or tags) should be considered in future experiments. Similarly, investigations that improve our understanding on the effect of sorting grids on the post-release mortality of evaded tuna are necessary to better understand the conservation outcomes of these devices, since the fate of released tuna, often injured, remains unknown.

The composition of small tunas relative to total catch could be a useful indicator to help assess the performance of sorting grids, particularly if the volume of evaded fish is substantial enough to shift the small-size catch composition. However, the analysis revealed contrasting and inclusive trends across species and data sources, and  the effect of total tuna catch on the proportion of small tuna species has not been fully explained either. These issues, along with challenges in estimating individual tuna size, weight and species composition by the different data collection methods and programs, may affect the representativeness and reliability of results presented here, and thus, would need to be further discussed with experts in the field.

Additionally, spatiotemporal factors (Figure 3), including other operational characteristics of the fleet, the dynamics of tuna aggregations or the environmental conditions, may influence the composition of the catch (i.e., amount of small tuna species in the catch), which should be better understood before inferring definitive conclusions from this analysis.

To ensure reliable data and better understand and detect changes in sorting grid usage and performance over the years, future sorting grid analyses would benefit from standardized operational and data collection procedures, methods, and sampling designs, including the use of electronic tools, such as those previously mentioned.

Lastly, the staff recognizes that input and expertise from various stakeholders is crucial to achieving more definitive results. Feedback from global experts, fishers and vessel owners is essential for assessing the feasibility of future sorting grid use and experiments. Additionally, net engineers and manufacturers can provide valuable insights into the best materials and optimal placement of sorting grids within purse-seine nets. To foster collaboration and exchange of knowledge among stakeholders and codesign the guidelines of a dedicated sorting grid experiment, a second sorting grid workshop could be desirable. Such a workshop should focus on discussing the validity of conducting such an experiment, the different sorting grid prototypes and their advantages and disadvantages, establishing criteria to assess performance, including quantifying fish evasion and post-evasion survival, and should develop, as appropriate, standardized protocols, methods and sampling designs for a potential dedicated experiment. If experts believe that such a project should be conducted, a series of recommendations, guidelines and conditions would need to be defined for successful implementation. To ensure that the workshop considers all necessary elements for the development of a potential future experiment, the IATTC staff recommends:

*A potential second workshop on sorting grids, if organized, should consider all the relevant information presented in this report and existing literature (e.g., report of the first IATTC sorting grids workshop), and grant the participation of all relevant stakeholders, including global experts, fishers, fleet owners and net engineers and manufacturers, so that the design and parameters of an eventual dedicated experiment are established.*

## 6. REFERENCES


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## 7. TABLES

**TABLE 1.** Characteristics of the data sources used in this report. Sp = species.
**TABLA 1.** Características de las fuentes de datos utilizadas en este informe. Sp = especie.

| Data source | Period | Grid data resolution | Tuna catch (sp. and size) | Tuna evasion (sp. and size) | Grid usage (yes-no) | Grid immersion percentage | Grid dimensions |
|---|---|---|---|---|---|---|---|
| Observer data | 2008-2009 | Set level | ✓ | ✓ | ✓ | ✓ | ✓ |
| TUNACONS data | 2018-2020 | Set level | *only sp.* | ✓ | *"Yes" only* | ✓ | |
| PROBECUADOR data | 2009-2024 | Trip level | ✓ | *sp. combined* | ✓ | ✓ | |
| Survey data | 2024-2025 | Trip level | ✓ | | ✓ | ✓ | ✓ |

**TABLE 2**. Data collection of the data sources used in this report.
**TABLA 2**. Recopilación de las fuentes de datos utilizadas en este informe.

| Data source | Vessel class | Vessel flag | Number of trips: Grid installed | Number of trips: Grid not installed | Number of sets with grid installed: DEL | Number of sets with grid installed: NOA | Number of sets with grid installed: OBJ |
|---|---|---|---|---|---|---|---|
| Observer data | 6 | COL | 0 | 9 | | | |
| | 6 | ECU | 69 | 21 | 1 | 516 | 920 |
| | 6 | MEX | 0 | 1 | | | |
| | 6 | PAN | 11 | 8 | 32 | 123 | 235 |
| | 6 | PER | 0 | 3 | | | |
| | 6 | USA | 0 | 3 | | | |
| | 6 | ESP | 5 | 0 | 0 | 18 | 124 |
| | 6 | VEN | 0 | 2 | | | |
| | 6 | NIC | 0 | 2 | | | |
| | 6 | SLV | 0 | 8 | | | |
| | 6 | VUT | 4 | 2 | 0 | 37 | 61 |
| | 6 | HND | 5 | 2 | 0 | 66 | 35 |
| | 6 | GTM | 0 | 3 | | | |
| Total | | | 94 | 64 | 33 | 760 | 1375 |
| TUNACONS data | 4 | ECU | 9 | | 0 | 40 | 113 |
| | 5 | ECU | 5 | | 0 | 19 | 77 |
| | 6 | ECU | 238 | | 65 | 1803 | 4352 |
| | 6 | PAN | 21 | | 0 | 99 | 291 |
| Total | | | 273 | | 65 | 1961 | 4833 |
| Survey data | 4 | ECU | 0 | 6 | | | |
| | 5 | ECU | 0 | 7 | | | |
| | 6 | COL | 0 | 18 | | | |
| | 6 | ECU | 191 | 96 | 87 | 1442 | 2674 |
| | 6 | MEX | 0 | 1 | | | |
| | 6 | PAN | 2 | 51 | 0 | 7 | 58 |
| | 6 | PER | 0 | 10 | | | |
| | 6 | USA | 0 | 22 | | | |
| | 6 | ESP | 0 | 6 | | | |
| | 6 | VEN | 0 | 9 | | | |
| | 6 | NIC | 0 | 8 | | | |
| | 6 | SLV | 0 | 21 | | | |
| Total | | | 193 | 255 | 87 | 1449 | 2732 |
| PROBECUADOR data | 4 | ECU | 0 | 5 | | | |
| | 5 | ECU | 0 | 15 | | | |
| | 6 | ECU | 922 | 737 | 323 | 5517 | 16621 |
| Total | | | 922 | 757 | 323 | 5517 | 16621 |
| Total general | | | **1482** | **1076** | **508** | **9657** | **25561** |

## 8. FIGURES

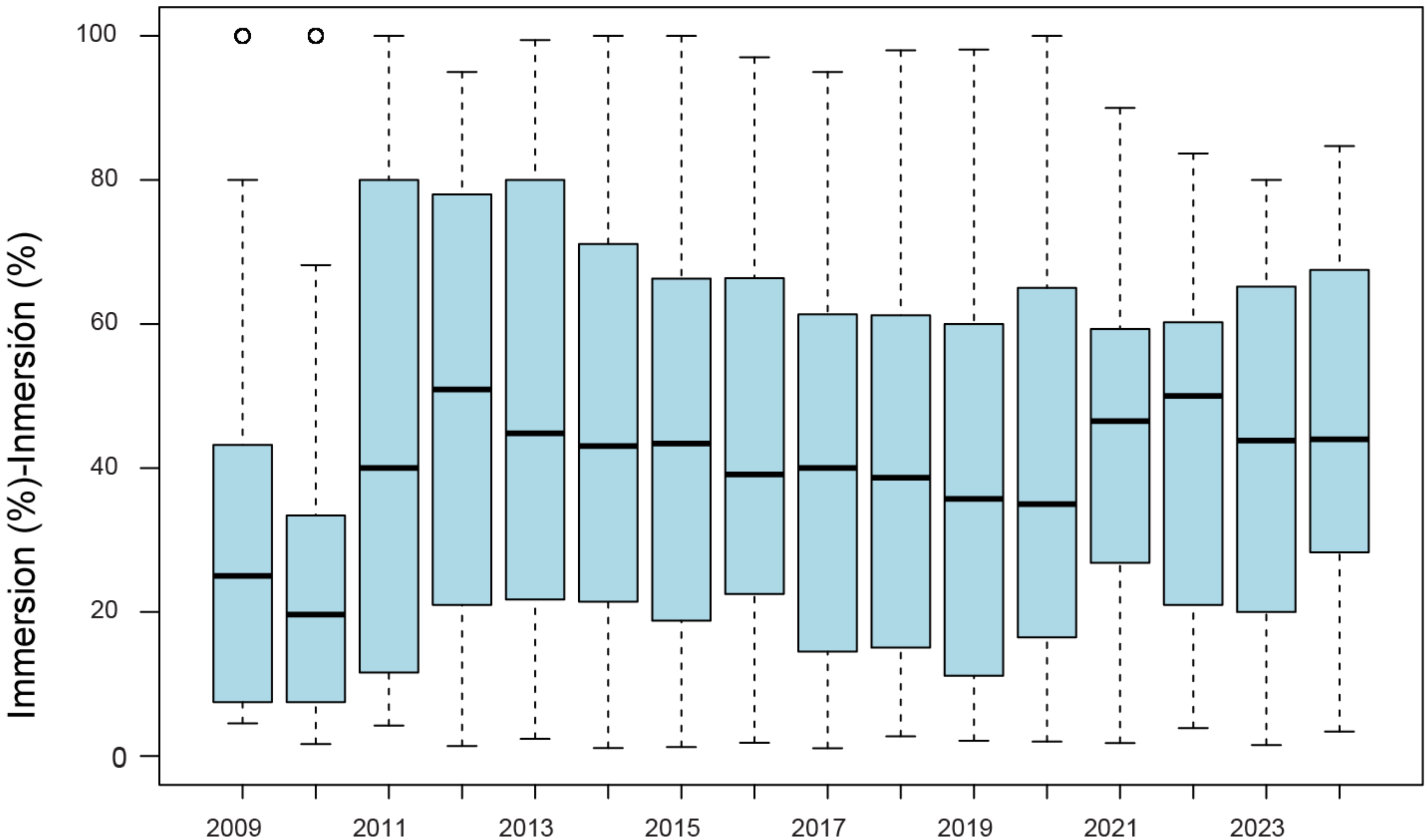


**FIGURE 1.** PROBECUADOR data: Percentage of grid immersion level by year.
**FIGURA 1.** Datos de PROBECUADOR: Porcentaje de nivel de inmersión en la red por año.

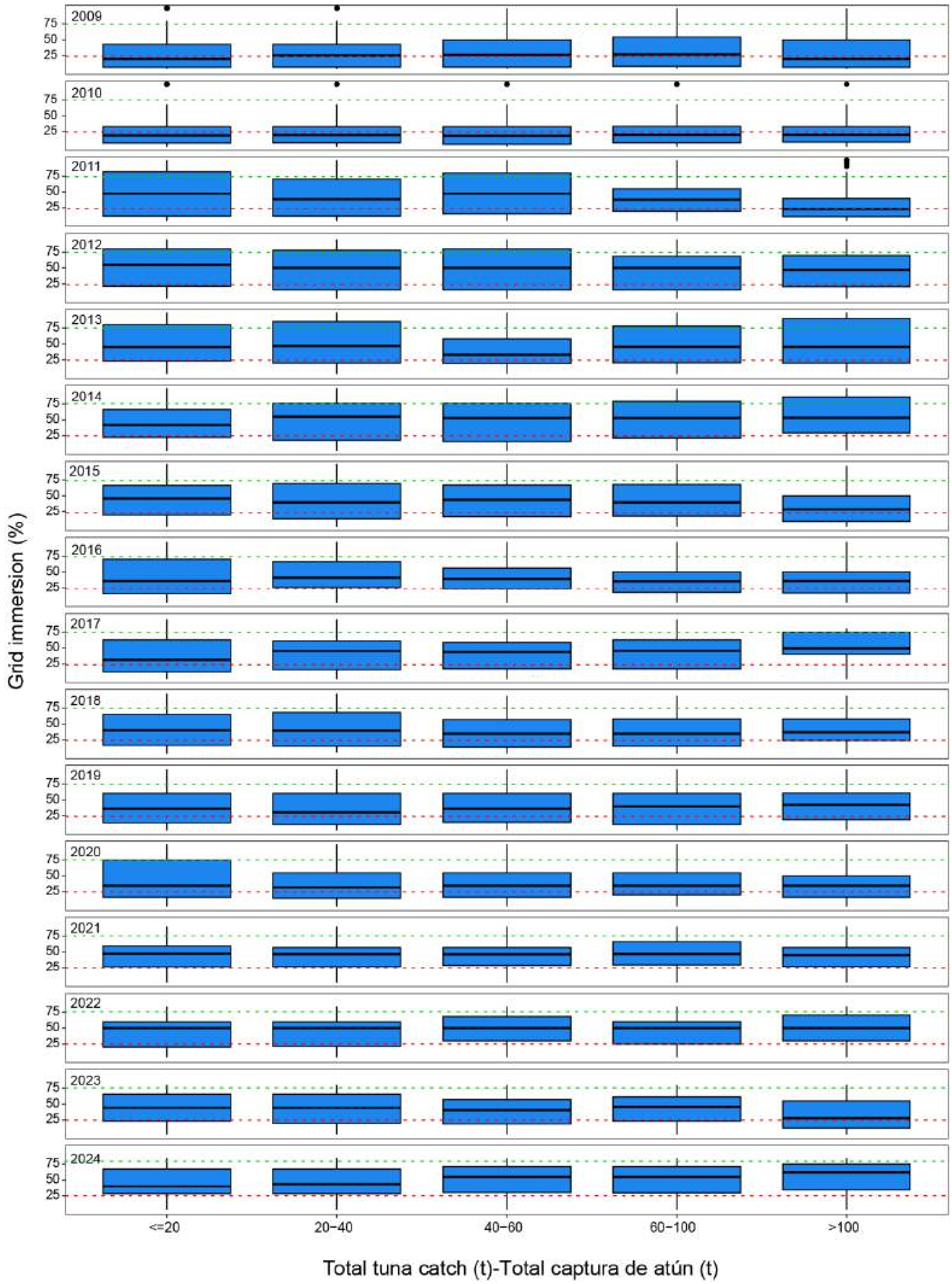


**FIGURE 2**. PROBECUADOR data: Percentage of grid immersion level relative to total tuna catch by year.
**FIGURA 2**. Datos de PROBECUADOR: Porcentaje del nivel de inmersión en la red en relación con la captura total de atún por año.

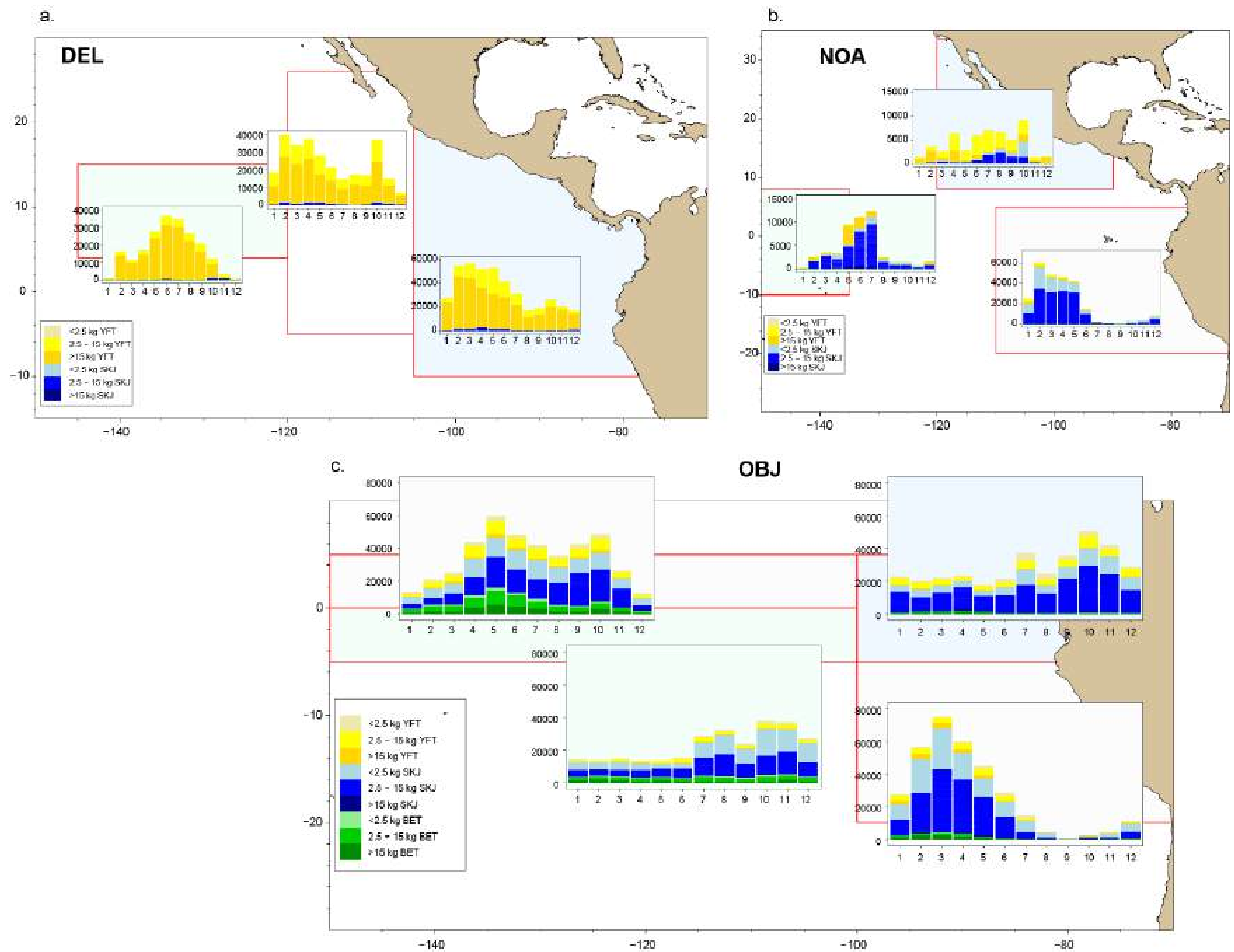


**FIGURE 3.** Spatial distribution and size composition of YFT, SKJ and BET in: a) sets on tunas associated with dolphins (DEL), b) in sets on tunas not associated (NOA), c) and sets on tunas associated with floating objects (OBJ).

**FIGURA 3**. Distribución espacial y composición por tallas de YFT, SKJ y BET en: a) lances sobre atunes asociados con delfines (DEL), b) en lances sobre atunes no asociados (NOA), y c) en lances sobre atunes asociados con objetos flotantes (OBJ).

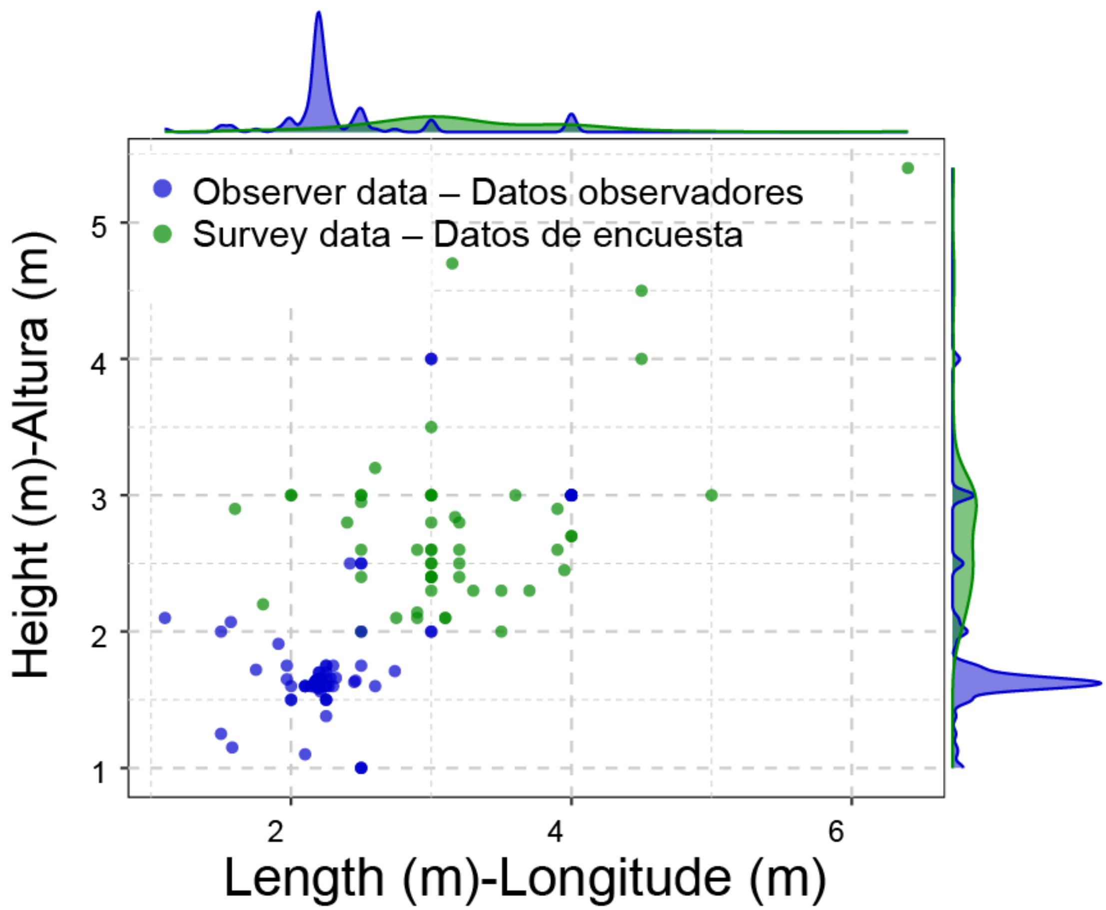


**FIGURE 4.** Dimension of the sorting grid (in meters, m) across time periods, with data from 2008-2009 (Observer data), and 2024-2025 (Survey data).

**FIGURA 4.** Dimensión de la rejilla excluidora (en metros, m) a lo largo de los periodos de tiempo, con datos de 2008-2009 (datos de Observadores), y 2024-2025 (datos de Encuesta).

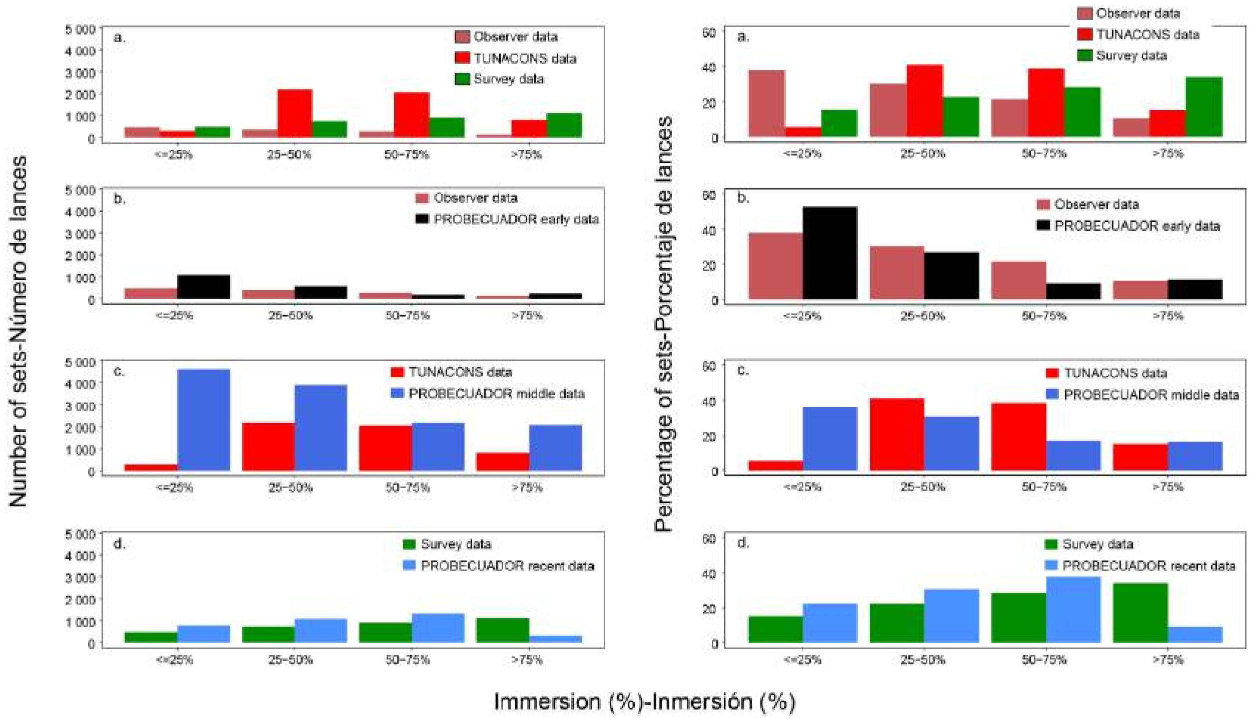


**FIGURE 5.** Number and percentage of sets relative to percentage of grid immersion depth: a) Data from 2008-2009 (Observer data), 2018-2020 (TUNACONS data), and 2024-2025 (Survey data); b) 2008-2009 (Observer data) and 2009 (PROBECUADOR data); c) 2018-2020 (TUNACONS and PROBECUADOR data); and d) 2024-2025 (Survey data) and PROBECUADOR 2024 data.

**FIGURA 5.** Número y porcentaje de lances en relación con el porcentaje de profundidad de inmersión en la rejilla: a) Datos de 2008-2009 (datos de Observadores), 2018-2020 (datos de TUNACONS), y 2024-2025 (datos de Encuesta); b) 2008-2009 (datos de Observadores) y 2009 (datos de PROBECUADOR); c) 2018-2020 (datos de TUNACONS y PROBECUADOR); y d) 2024-2025 (datos de Encuesta) y datos de PROBECUADOR 2024.

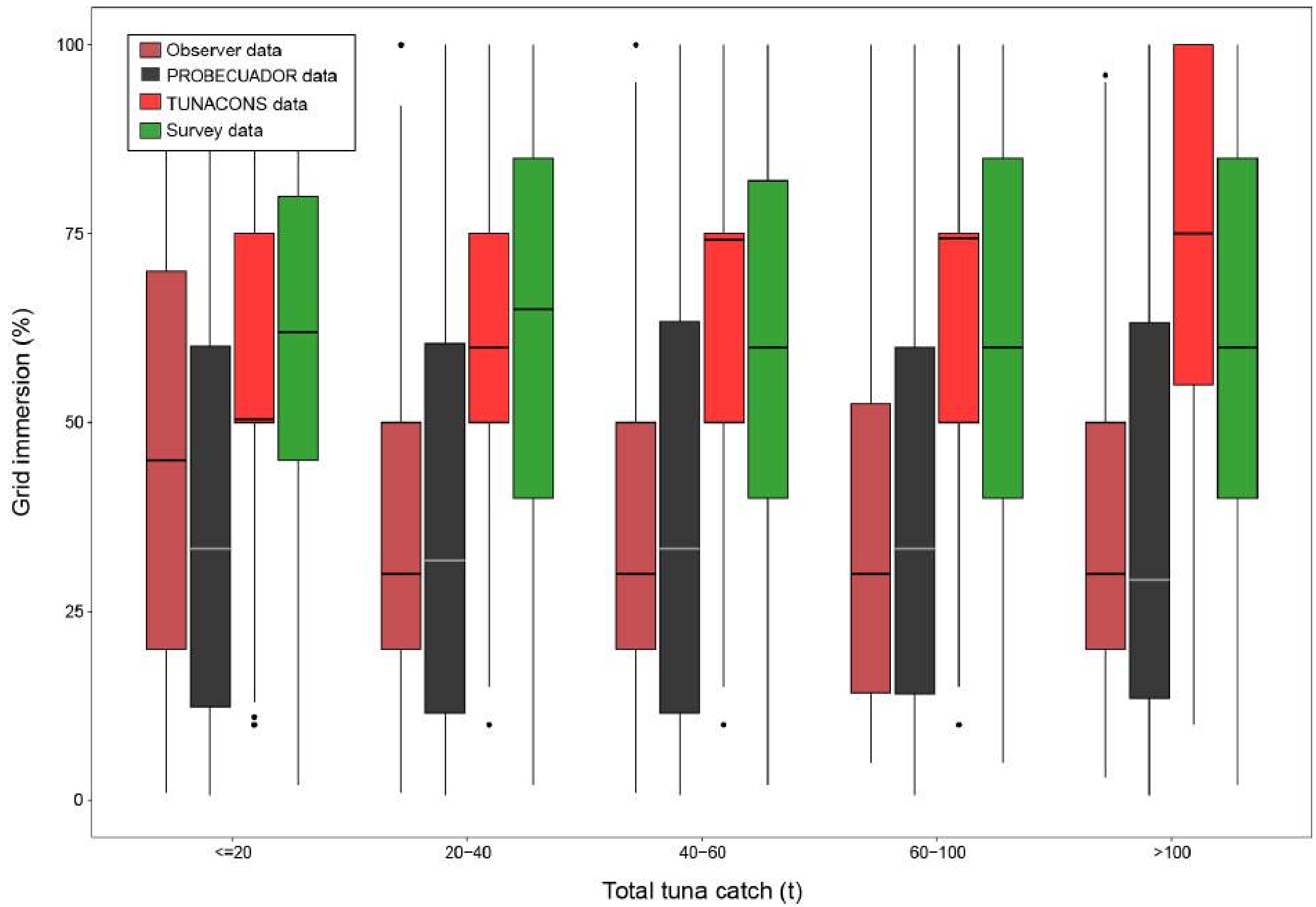


**FIGURE 6.** Percentage of grid immersion level relative to total tuna catch. Data from 2008-2009 (Observer data); 2010-2015 (PROBECUADOR data); 2018-2020 (TUNACONS data), and 2024-2025 (Survey data).

**FIGURA 6.** Porcentaje del nivel de profundidad de inmersión de la rejilla relativo a la captura total de atún. Datos de 2008-2009 (datos de Observadores); 2010-2015 (datos de PROBECUADOR); 2018-2020 (datos de TUNACONS), y 2024-2025 (datos de Encuesta).

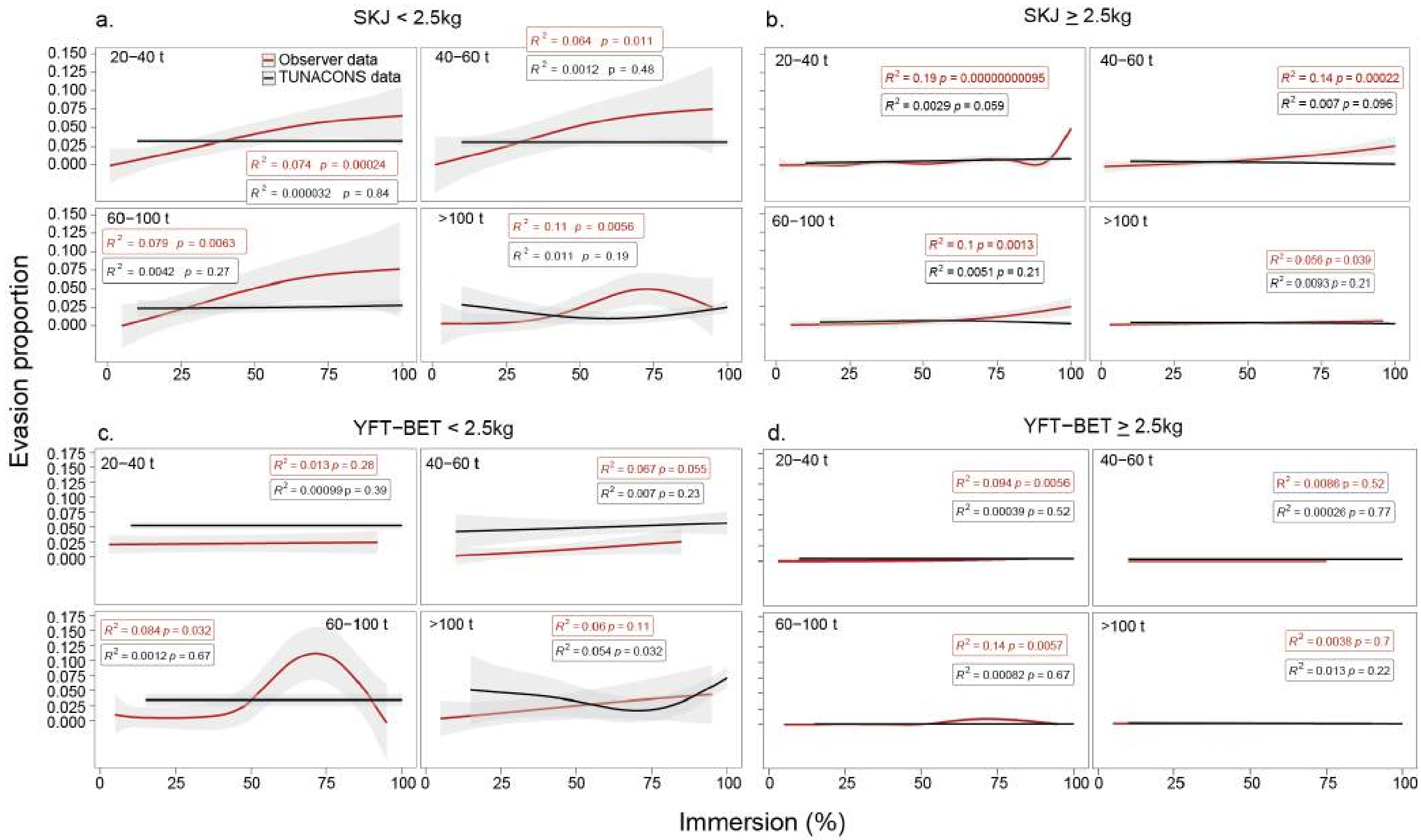


**FIGURE 7.** Evasion proportions of small and medium-large sized SKJ (a, b) and BET-YFT (c, d) tunas relative to grid immersion levels, and by total tuna catch. Data from 2008-2009 (Observer data), and 2018-2020 (TUNACONS data). The solid line is the GAM fit, and the shaded lines are 95% confidence bands.

**FIGURA 7.** Proporciones de evasión de atunes SKJ (a, b) y BET-YFT (c, d) de tamaño pequeño y mediano-grande en relación con los niveles de profundidad de inmersión en la rejilla, y por captura total de atún. Datos de 2008-2009 (datos de Observadores), y 2018-2020 (datos de TUNACONS). La línea sólida es el ajuste GAM, y las líneas sombreadas son bandas de confianza del 95%.

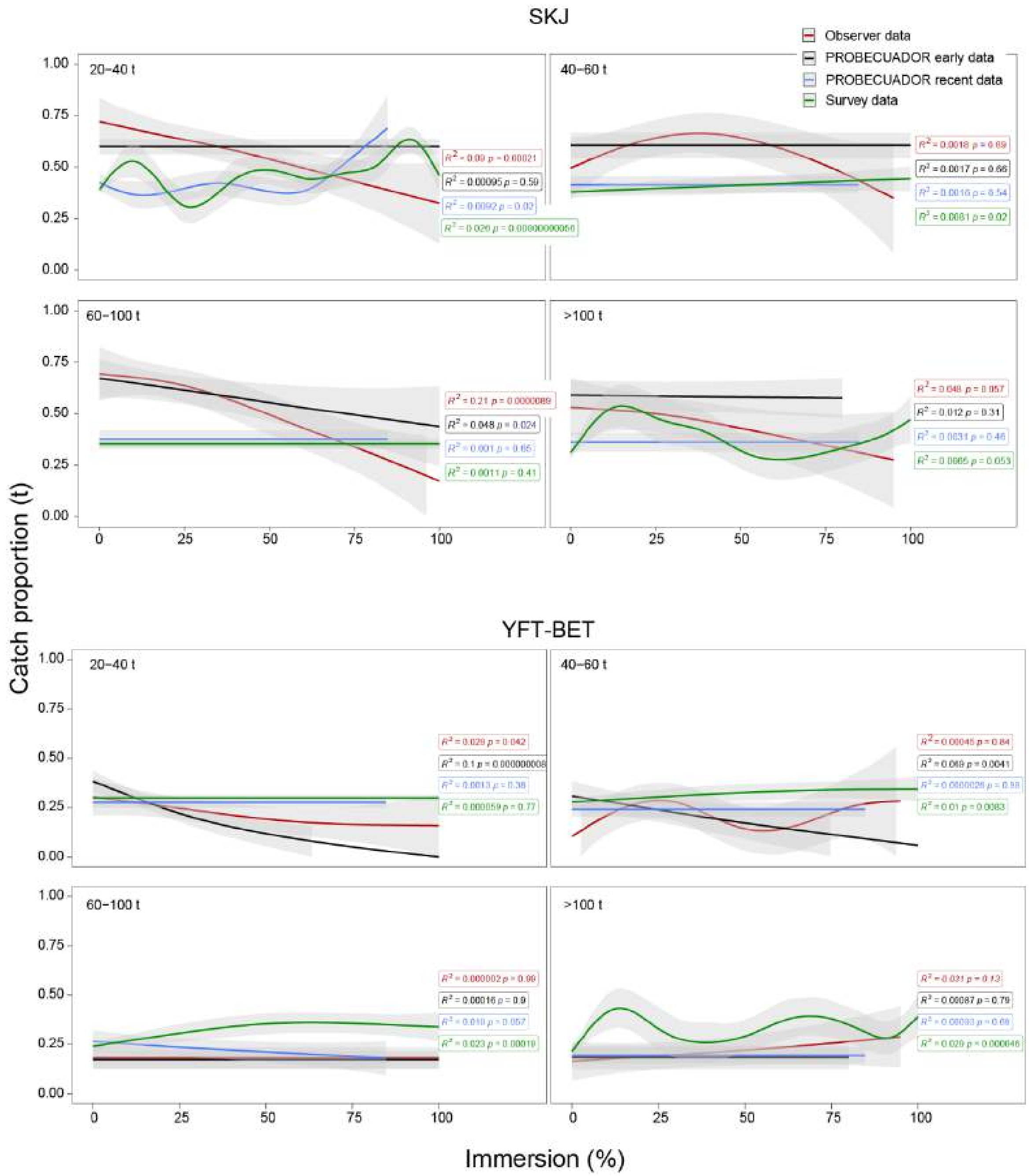


**FIGURE 8.** Proportion of small tuna catch relative to tuna catch by species, by grid utilization, and by total tuna catch (OBJ sets). Data from 2008-2009 (Observer data) and 2009 (PROBECUADOR early data), and 2024-2025 (Survey data) and 2024 (PROBECUADOR contemporary data). The solid line is the GAM fit, and the shaded lines are 95% confidence bands. Note: Immersion = 0% means the grid was not used.

**FIGURA 8.** Proporción de la captura de atún pequeño en relación con la captura de atún por especie, por utilización de la rejilla y por captura total de atún (lances OBJ). Datos de 2008-2009 (datos de Observadores) y 2009 (datos tempranos de PROBECUADOR), y 2024-2025 (datos de Encuesta) y 2024 (datos PROBECUADOR). La línea continua es el ajuste GAM, y las líneas sombreadas son bandas de confianza del 95%. Nota: Inmersión= 0% significa que no se utilizó la rejilla.