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UPDATE ON OPERATIONAL LONGLINE OBSERVER DATA REQUIRED UNDER RESOLUTION C-19-08 AND A PRELIMINARY ASSESSMENT OF DATA RELIABILITY FOR ESTIMATING TOTAL CATCH FOR BYCATCH SPECIES IN THE EASTERN PACIFIC OCEAN

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1. INTRODUCTION

Over the past 3 years, the IATTC staff have worked together with CPCs to incrementally refine the data reporting requirements for large-scale tuna longline fishing vessels (LSTLFVs) to enable IATTC scientific staff to enhance the reporting of non-target species (i.e. "bycatch") for the *Ecosystem Considerations* report and the Fishery Status Report. However, these improved data are also intended to be used to improve the quality of scientific research and assessments involving the fishery, in particular ecological risk assessment, and to improve the transparency of data for compliance under relevant IATTC Resolutions.

In 2017, the IATTC staff proposed the establishment of minimum data standards for longline observer programs under Resolution C-11-08 (SAC-08-07e). At the eighth meeting of the Scientific Advisory Committee, the proposal was adopted, and CPCs agreed to provide those data for 2013–2017, and for subsequent years. The measures were subsequently incorporated into Resolution C-19-08 that entered into force in July 2019.

There have been positive advances in longline data reporting over the past two years. The most notable improvement in data reporting has been the agreement by IATTC Members to submit operational-level observer data using an expanded set of data fields, which have been required of IATTC CPCs by the WCPFC since 2016 (WCPFC, 2016; Attachment F) when reporting observer data for sets made in the WCPO. Further data reporting improvements include the adoption of number of hooks as the metric by which longline fishing effort is to be measured in the EPO, as well as the use of a standardized reporting template that summarizes key elements of observer activities that is transparent in demonstrating compliance under Resolution C-19-08. In particular, this relates to the mandates of a minimum of 5% observer coverage of the total annual effort by each CPC's fleet of longline vessels greater than 20 m length overall (LOA), and that the coverage is "*…representative of the activities of its fleet, including in terms of gear* *configuration, target species and fishing areas representing of the activities of the fleet*".

The current requirement of 5% observer coverage of the longline fleet has been a concern for IATTC research staff for several years given the results of studies conducted as far back as 1996 that recommended a minimum observer coverage of 20% for the Hawaii-based longline fleet (Skillman et al. 1996). Since this time, the recommended minimum coverage levels have been increased to be 40% and 80% to sufficiently monitor the catch rates for bycatch species that have a low incidence of capture in the American Samoa longline fishery (McCracken 2006) and the Hawaiian shallow-set longline fishery (McCracken 2012), respectively. Consequently, since 2017 the staff has annually recommended to the SAC that observer coverage for the longline fleet should be increased to 20% (IATTC-92-04c; p. 4), which has not been supported by the Members.

Considering growing evidence of the potential inadequacy of current observer coverage in the EPO, the objectives of this paper were to:

i) fulfil the recommendation by the SAC at its tenth meeting to provide a summary of the operational-level longline observer data for LSTLFVs >20m LOA received to date by the IATTC, and reporting of the percent observer coverage for 2020 as required under Resolution C-19-08 (see Annex A),

ii) determine whether the current requirement of 5% observer coverage of LSLFVs under Resolution C-19-08 is sufficient to characterize the activities of LSTLFVs in the EPO and facilitate the reliable estimation of total annual catches for bycatch species for inclusion in the IATTC's annual *Ecosystem Considerations* report and Fishery Status Report.

2. DESCRIPTION OF THE DATA AND ANALYSES

2.1. Operational-level observer data submissions

In 2017, SAC-08 established minimum data standards for the reporting of operational longline observer data to the Commission, which was subsequently adopted in Resolution C-19-08. Under C-19-08, submissions of longline observer data for the previous year are due by June 30 of the following year, including submission of Annex 1 that provides an overview of observer coverage and catch of bycatch species (Appendix 1).

Because the requirement for a minimum of 5% observer coverage has been in force since 2013, CPCs should possess the operational observer data for 2013–2017 that is required to be reported to the Commission. However, some CPCs have not submitted longline observer data for these all relevant years, or in some cases have never submitted operational longline observer data. To gain clarity on these situations, the Director circulated letters to all relevant CPCs in February 2020, seeking further clarification as to whether the CPC: 1) did not have a qualifying longline vessel operating during the fishing year, 2) did not have a longline observer program to collect data, 3) observed some portion the effort, but the data have not yet been submitted to the Commission, or 4) Other.

2.2. Assessing the representativeness of operational level data submissions

To assess the representativeness of the observer data submitted by CPCs, four CPCs were selected as case studies. The data provided by these CPCs span multiple years, and the fleets of these CPCs represent a significant portion of the longline catch of tropical tunas and swordfish in the EPO. To maintain anonymity of the CPCs, the name of each CPC was replaced with an arbitrary code, CPC1, CPC2, CPC3, and CPC4. Data provided to the IATTC for 2016–2018 for each CPC were used in the analyses.

Representativeness of the observer data was primarily evaluated by comparisons with the Task 2 (i.e.

“gridded”) data, which is the only fleet-wide dataset available to IATTC staff. However, Task 2 data provide only limited information; primarily numbers of hooks and catches of retained target tuna species and some non-target species (*e.g*., billfish and sharks), at 5° x 5° resolution, by month and year. We assumed that the Task 2 data represented all, or the vast majority, of the fleet activity for each CPC. Three types of comparisons were made in our analyses.

First, an important comparison that can be made between the observer data and the Task 2 data is the spatial (5° grid cells) and temporal (monthly) distribution of effort (as proportion of total hooks). Here, the number of hooks per set was used for the observer data, instead of the number of hooks observed. Comparison of the Task 2 and observer effort distribution maps and monthly time series allowed an evaluation of whether the distribution of the observer data in space and time was similar to that of the fleet, for each CPC, for each year.

Second, the level of observer coverage, which can be evaluated by comparing to the Task 2 data, is another important indicator of data reliability (McCracken 2006; 2012). Two coverage estimates were computed for each CPC. The first estimate of observer coverage, hereafter referred to as “effective coverage”, is the sum of all hooks in observed sets divided by the total number of hooks reported in the Task 2 data. By measuring observer coverage in this way, we assumed all hooks in any observed set were “observed”. The second estimate of observer coverage, hereafter referred to “actual coverage”, is the sum of all hooks that were actually observed divided by the total number of hooks reported in the Task 2 data.

Finally, we compared estimates of total catch of two primary target species (bigeye tuna (BET) and yellowfin tuna (YFT)), based on observer data, with totals reported in the Task 2 data. At very low levels of observer coverage in longline fisheries, catch rates obtained from observer data have been shown to be highly variable and unreliable for estimating fleet totals (e.g., Skillman et al. 1996; McCracken 2006; 2012). It was therefore assumed that if the observer data could not be used to reliably estimate the known total catch of relatively data-rich target species, then they would be even less likely to provide reliable estimates of the total catch for bycatch species, which are generally less frequently encountered. Also, given that the IATTC conducts stock assessments for BET and YFT, it seems reasonable to assume that the Task 2 data for the two species have been thoroughly vetted.

Because Task 2 data provide little to no operational-level information with which to develop optimal catch estimators, especially for bycatch species, a simple ratio estimator (*e.g.* Thompson 2012)—represented as the product of the overall catch-per-unit effort (CPUE) from the observer data and the total effort from the Task 2 data—was used to estimate the total catch for BET and YFT in the Task 2 data. The CPUE from the observer data was computed as the ratio of the sum of the retained number of individuals of the species of interest divided by the sum of the number of observed hooks from all sets containing catch of any species—to ensure that any zero-catch sets were included. It was assumed that the catch reported in the observer data corresponded to the hooks observed, which may not be all hooks deployed in a set. For BET, a second estimate of “retained” catch was used to compute CPUE because it was unclear exactly how the Task 2 retained catch related to the various catch “fates” recorded in the observer data. This second version of retained catch included any BET that was used as bait, consumed onboard, retained as a scientific sample, of other, unknown or unrecorded fate, in addition to the catch that was expressly recorded as “retained as catch”.

Approximate 95% confidence intervals were computed for the estimated total catch using the bootstrap percentile method (Efron 1982), where trips, the primary sampling unit, were resampled with replacement. The approximate confidence intervals were based on 5000 bootstrap estimates of total species catch. The reported Task 2 total catch—assumed to be “truth”—was compared to the point estimate and these confidence bounds, estimated separately for each year, by CPC.

3. RESULTS

3.1. Operational observer data submissions

After the minimum standards for reporting operational-level longline observer data were adopted in 2017, the IATTC has received data from nine CPCs for 1131 fishing trips, 30,415 sets and 1,248,478 catch records, as of 1 May 2021. The data from each CPC span various periods from 1 to 8 years (Table 1). The highest number of years of complete data reported were submitted by the USA (2013–2020) and TWN (2012–2019), while the fewest years were reported by CHN and PER (2019 only).

Some CPCs submitted operational-level data, but the data are either incomplete or in inconsistent formats. PER and the EU (PRT) submitted data for 2019, and 2016 and 2019–2020, respectively, but from only one vessel in each case. The EU (ESP) submitted complete data for 2017–2020 in various data and file formats (e.g. PDF) that require substantial database development by IATTC staff to automate database import processes. As a result, data from these three CPCs are not considered further in this paper.

Where the Director had not received any clarifying information from a CPC for a given year, the cells in **Table 1** remain red, indicating that the longline observer requirements are presumed to have applied and that no operational observer data for that year has been received.

Coverage rates—in number of hooks or effective fishing days—for the most recent year for which annual observer data was expected to be received (*i.e*. 2020) are shown in Table 2. Eight CPCs submitted data for 2020, with reported coverage ranging between 2.87–16.31%. Four CPCs (CHN, EU, KOR, and TWN) did not reach the minimum observer coverage of 5% (Table 2).

3.2. Comparisons of observer and Task 2 data for four CPC case studies

The annual level of effective and actual coverage for 2016–2018 varied considerably by CPC (Table 3). Effective coverage was 4–6% for CPC1, 7–9% for CPC2, 20% for all three years for CPC3, and 14–19% for CPC 4. Actual coverage was lower than the effective coverage for 3 of the 4 CPC being 5% or less for CPC1, 5–7% for CPC2, 20% for CPC3, and 8–11% for CPC4 (Table 3).

3.3. Spatial distribution of fishing effort

The extent to which the spatial distribution of observed effort was similar to that of the Task 2 data varied by CPC (Figure 1). To comply with the 3-vessel rule, 5° grid cells containing observer data from less than 3 vessels could not be shown—although analyses were undertaken on the full dataset. The two datasets showed the closest alignment for CPC3, both in terms of the extent of the region covered and the location of effort hotspots, which is not surprising given that CPC3 had the highest level of observer coverage (Table 2).

The effort hotspots in the Task 2 data for CPC1, CPC2 and CPC4 were generally represented in the observer data in most years, with the most notable exceptions being CPC1 and CPC4 in 2018 (Figure 2). However, the spatial distribution of the observer data for CPC1, CPC2 and CPC4 did not always cover the full area of their fleet operations, even without application of the 3-vessel rule (not shown). The spatial extent of the observed effort, relative to that of the fleet, was most contracted for CPC2.

3.4. Temporal distribution of fishing effort

The monthly number of hooks in observed sets relative to the annual total number of hooks in observed sets for the year(Figure 2) was closest to the monthly number of hooks in the Task 2 data relative to the annual total number of hooks in the Task 2 data for CPC3 and CPC4, and most disparate for CPC1 and CPC2, which reflected their respective levels of observer coverage (Table 2). The monthly proportion of hooks relative to the annual total for CPC3 was reasonably similar between the observer and Task 2 datasets for each of the 3 years, with the highest proportions being in quarter three (Figure 2). Similar to CPC3, the monthly proportion of hooks relative to the annual total for CPC4 was reasonably similar between observer and Task 2 data. However, for CPC1 and CPC2, the monthly proportion of hooks in the observer data was often below that of the Task 2 data at the beginning of the year (not shown) and above that of the Task 2 data in the latter half of the year (Figure 2). The months having a low proportion of hooks in the observer data for these two CPCs typically corresponded to months for which three or fewer vessels were sampled (Table 2).

3.5. Estimates of Task 2 BET and YFT catch totals from observer data

Overall, for most CPCs in most years, the estimates of total BET catch from the observer data were less than that of the reported Task 2 data (Table 3). The estimated Task 2 total BET catch was closest to the actual Task 2 BET catch for CPC3—the fleet with the highest level of observer coverage—and most disparate for CPC4 (Table 3). The ratio of estimated BET catch to Task 2 BET catch was 0.79–1.27 for CPC1, 0.76–0.87 for CPC2, 0.91–1.06 for CPC3, and 0.31–0.46 for CPC4. The Task 2 total BET catch typically fell outside the approximate 95% confidence intervals for the estimated catch, except 2017 for CPC1, and 2017 and 2018 for CPC3. With the exception of 2016 for CPC2, using the expanded definition of retained catch for BET had a negligible impact on the results.

For YFT, the estimates from the observer data relative to the Task 2 totals were variable (Table 3). The ratio of estimated total YFT catch to Task 2 total YFT catch was 0.78–1.26 for CPC1, 0.90–1.17 for CPC2, 1.15–1.24 for CPC3, and 0.56–0.72 for CPC4. The Task 2 total YFT catch total typically fell outside the approximate 95% confidence intervals for the estimated catch, except 2017 for CPC2 and 2016 for CPC3.

4. DISCUSSION

The IATTC Member's adoption of the IATTC staff's recommendations to improve the level and quality of data reporting pertaining to the EPO longline fishery shows a clear commitment by CPCs to honor their responsibilities under the Antigua Convention to ensure their fishing activities are ecologically sustainable. Since Resolution C-19-08 entered into force in 2019, the submission of over 1 million catch records to the IATTC is a testament to the CPC's commitment to improving data provision for the longline fleet. However, this study has identified numerous instances where the quality and quantity of reported data needs to be improved to allow IATTC scientists to increase the accuracy and precision of total catch estimates for bycatch species for routine reporting and conducting research, such as ecological risk assessment.

4.1. Spatial and temporal distribution of observed and reported fishing effort

For the four CPCs included as case studies in this paper, the proportion of observed hooks relative to the total number of observed hooks in high effort regions identified from Task 2 data for corresponding years was often substantially lower than the proportion of hooks in these areas in the Task 2 data; or not observed at all. For example, sets made by CPC2 and CPC4 below 20° S were either simply not observed for 2016–2018 (Figure 1), or in cases where sets were observed below 20° S, they were represented by less than 3 vessels (data not shown due to <3 vessel data confidentiality rule). In a review of historical longline catches in the EPO, Griffiths and Duffy (2017) showed that this region is particularly important for catches of swordfish, bigeye and albacore tunas, which are often targeted using different set types (Lennert-Cody et al. 2012). For example, swordfish are generally targeted with gear configured to have a small number (2–12) of HPB that is set shallow (<150 m maximum hook depth) during the night (Ward and Myers 2005) when many pelagic predators follow vertically-migrating prey (*e.g.*, myctophids) into the mixed layer (Abascal et al. 2010). In contrast, bigeye and albacore tunas are targeted using a large number (20–32) of HPB in deep sets—typically 200–400 m depth—made during the day (Bigelow et al. 2006) when the target species generally reside below the thermocline.

These two very different set types also have very different catch compositions. For example, shallow sets catch vertically mesopelagic predators (*e.g.*, swordfish, opah, thresher sharks), as well as epipelagic species that reside almost exclusively in the mixed layer (*e.g.*, dorado, wahoo, carcharhinid sharks, turtles). As a result, shallow sets made at night often catch a diverse suite of species. By contrast, species richness of catches from deep sets made during the day is generally much lower as mesopelagic species (*e.g*., opah, escolar) are dispersed across a broader depth spectrum that may extend beyond the depth of the deepest longline hook (Kerstetter et al. 2008; Polovina et al. 2008), while epipelagic species (*e.g*., wahoo) reside in depths above the shallowest hook (Sepulveda et al. 2011).

These large differences in catch composition between the two commonly utilized longline set types have the potential to bias total catch estimates if both set types do not receive sufficient observer coverage that is proportional to their contribution to the total effort by the fleet. In the cases of CPC2 and CP4, the undercoverage of sets made below 20°S may result in an underestimation of epipelagic species and mesopelagic species if the majority of sets in the region were deep sets and shallow sets, respectively.

With respect to temporal coverage of longline fleets, CPC1 and CPC2 failed to observe sets for up to 6 months of the year (*e.g*. CPC1 in 2018), with unobserved sets for these CPCs mostly occurring during the first half of the year. During other months when actual coverage reached up to 7%, this was achieved by observations from only a few vessels. Therefore, both the low level of temporal coverage and small number of vessels, call into question how representative the observer data are for CPCs, especially during the first half of the year, that theoretically meet the minimum observer coverage of 5% annually (Table 3). A study aiming to determine adequate levels of observer coverage for Hawaiian longline fleets (Skillman et al. 1996; McCracken 2006; 2012) indicated that low observer coverage of less than about 20% cannot produce data that can be used to derive reliable estimates of total catch for a specific fleet, due to high variation in estimates and potential bias due to the small number of vessels for which the data represents.

For CPC2 and CPC4 where effort was most widely dispersed, catch estimates were generally significantly underestimated for both species for each year. In the case of CPC4, estimated catches for BET and YFT were only 31–46 % and 56–72 % of the Task 2 catch totals, respectively, even despite CPC4 having 14–18% effective coverage. This underestimate in catch may be attributed to 0–2 vessels with observers in some months (*e.g*., March–June in 2018 for CPC4) that may have been unable to adequately represent the spatially diffuse sets. For CPC1 and CPC3 where the spatial distribution of effort was far more restricted, catch estimates for BET and YFT were 84–127 % and 78–126 % of Task 2 catch totals, respectively—but Task 2 catch totals were still outside the approximate 95 % CIs. Although this better alignment between estimated catch and Task 2 catch might be expected for CPC3 since it had the highest effective (and actual) coverage of any CPC (20 % per year), CPC1 had the lowest coverage (4–6 %) and the highest number of months each year (6) where no sets were observed (Table 2).

4.2. Estimating total catch from observer data

The ultimate aim of the current paper was to determine how well estimates of total catch for individual species using observer data aligned with those from reported Task 2 catch data. The relatively data-rich BET and YFT were used for these analyses simply because if observer data could not be used to produce reliable estimates of total catch for these species, it would be unlikely that estimates would improve for less frequently caught bycatch species. The results were conclusive for both species in that total reported catches from Task 2 data were either higher or lower than the approximate 95 % CIs for the total catches estimated from the operational-level observer data for almost every year for each of the four CPCs. These results may be due to several factors, including low observer coverage, imbalanced distribution of observed effort in space and time, relative to that of the fleet, and partial coverage of all hooks in a set, presumably due to observer work hour limits. Some of these factors are discussed below.

An important issue to consider is that details of the sampling design used to collect the observer data have not been provided to the IATTC staff, which makes use of more sophisticated estimation methods impossible. Were information on the sampling design provided (assuming the sampling is not purely voluntary and thus opportunistic), this information could possibly be used to select more appropriate estimators for fleet totals. In principle, a sampling design, including the level of observer coverage, should be based on results from simulations that indicate which estimators and sampling strategies will perform best for estimating fleet totals. Such simulations could be conducted using operational-level logbook data if logbook coverage is high. These sorts of simulation studies are critical to ensuring that limited resources are used appropriately.

Another potential issue that may have resulted in discrepancies between estimates of total catch from the observer data and the Task 2 data is that observers of some CPCs do not monitor all hooks in the set. In the present study, we reported "effective" coverage, where it was assumed that every hook was observed in an observed set, and "actual" coverage, when information was available regarding the proportion of hooks that were observed in an observed set. For some CPCs, such as CPC4, the effective coverage was higher than the actual coverage (1.72–1.8 times higher in the case of CPC4). The extent to which such partial reporting could lead to bias will depend on whether CPUE varies systematically over the course of the recovery of the longline, something which is not possible to investigate with the data provided.

This disagreement between the estimated catch and the reported Task 2 catch for BET and YFT may not solely be attributed to the level of observer coverage, but a number of inter-related factors. The first issue may be uncertainty in how the Task 2 catch and effort are reported to the IATTC. Although Task 2 data should theoretically be the total catch and effort by grid cell by month, there is no requirement for CPCs to explicitly describe how the data were collected (*e.g*. by logbook, observer, etc.) and analysed to raise the data to represent the total fleet (if required), which is currently a requirement for longline vessels by the WCPFC (WCPFC, 2016; Attachment F). Therefore, it was not possible to make adjustments to the Task 2 data in the present study to account for CPCs collecting or analyzing data in different ways, which may have affected interpretations as to what extent the observer data are representative of the fleet. This is an important consideration for improving data provision for the longline fleet, which is addressed in detail in SAC-12-09.

4.3. The need to improve data provision

During this study two aspects of data provision were identified that, if addressed, would improve the staff's ability to use the operational-level observer data for the purposes for which it was intended; to provide a representative account of the longline fishing activities in the EPO from which to produce annual total catch estimates for bycatch species. First, some of the data fields, such as haul direction, that are required to be completed under C-19-08 were not completed by some CPCs Such data fields pertaining to fishery operations and gear characteristics are useful for investigating any potential for bias caused by partial catch reporting, standardizing CPUE and facilitating more precise estimates of species-specific total catch.

Second, in order to obtain accurate estimates of total bycatch from observer data, the total effort from the fleet is required at the finest resolution possible. This allows the analysis to properly account for spatial and temporal variability in operational characteristics that might otherwise introduce bias into the estimated fleet totals. This is particularly important when sampling coverage is very low, as is presently the case for large-scale tuna longline vessels operating in the EPO. Unfortunately, however, the Task 2 data submitted by CPCs to characterize the effort by the entire fleet are often submitted at the lowest permissible resolution of 5° x 5° by month, and for most CPCs, without any information on gear and other operational characteristics. One potential cost-effective solution to overcome this issue is for CPCs to submit operational-level logbook data. Complemented with observer data to estimate catch rates (e.g., for bycatch species), the effort data can be used to raise these catch rates to the entire fleet. Many CPCs that have longline fleets in the EPO also fish in the Convention Area of the WCPFC, which adopted a measure for the submission of logbook data for longlines in 2016 (WCPFC, 2016; Attachment F). It is likely that these vessels also collect equivalent logbook information for sets made in the EPO and may already be required to submit these data to their CPC. Therefore, it may not be a significant burden for fishers and CPCs to collect and submit these data to the IATTC, which may greatly reduce the current shortcomings in the available effort data. A current IATTC paper (SAC-12-09) also discussed for the need to improve the quality of data for other IATTC scientific and reporting objectives.

4.4. The need for increased observer coverage

In a spatial context, achieving adequate observer coverage may be logistically easier and less expensive for fleets where the effort is distributed across a relatively small spatial scale. For example, fishing effort for CPC1 and CPC 3 was distributed over 25° of latitude, but for CPC2 and CPC 4 fishing effort spanned 65° and 80° of latitude, respectively. In a temporal context, the proximity of the EPO fishing grounds to the country of the fleet may also play an important role in the potential for a fleet to achieve sufficient observer coverage. For example, longline vessels from coastal CPCs in the EPO may undertake relatively short trips (e.g., several weeks) that allow for a frequent exchange of observers. This may concomitantly result in less 'burn-out' of observers and thus allow for maximum coverage of sets during the year. In contrast, CPCs that have their home country outside of the EPO tend to undertake much longer trips (e.g., many months) and therefore may find difficulty in recruiting an observer willing to be at sea for long periods. This may result in low, or completely absent, coverage of particular regions or periods of the year when an observer may not be available.

It is clear from the results of the analyses that the current mandate of 5% observer coverage for CPCs in insufficient for estimating the total catch of even the most data-rich target species, bigeye and yellowfin tunas. Published studies from as far back as 1996 fleet (Skillman et al. 1996; McCracken 2006) present strong evidence that the current level of coverage is insufficient for most species caught by tuna longline fleets. This has been the driver behind the recommendations by IATTC staff since 2017 to increase observer coverage to at least 20%. Coincidentally, recent studies by Chinese scientists evaluated the efficacy of the current 5% observer coverage of the Chinese longline fleet in the Pacific Ocean for estimating total catch (Wang et al. 2021) and length-frequency distributions (Wang et al. 2020) of commonly-caught species. They concluded that at least 20% coverage is required to reliably estimate the total catch and representative length-frequency distributions of target tuna species, but much higher coverage rates were required to estimate the total catch of species caught less frequently.

Unfortunately, cost is a major impediment for many CPCs to increase observer coverage since their national observer programs are solely responsible for managing and funding longline observers. This contrasts heavily with the 100% observer coverage for the fleet of large (>363 mt) purse-seine vessels in the EPO, where IATTC observers are mandated to observe 50% of trips—pursuant to the Agreement on the International Dolphin Conservation Program (Annex II, Section 2). One potential cost-effective option to increase observer coverage is the use of electronic monitoring (EM), which has been shown to be up to 98.3% as effective as human observers for identifying the catch of commonly-retained species caught in tuna longline fisheries in the Indian, Atlantic and western Pacific Oceans (Ruiz et al. 2014; Emery et al. 2018). A similar outcome was achieved in a recent trial of an EM program conducted by IATTC staff on tuna purse-seine vessels in the EPO, with a recommendation to apply the same methodology to longline vessels (Román et al. 2020). Although EM may rapidly and cost-effectively increase observer coverage on longline vessels if the methodology is supported by CPCs, some level of human observer coverage will still be required to monitor species that may not be well covered by EM (e.g. those that are difficult to identify, species that are released before reaching the vessel), collection of biological material, and aspects of compliance.

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Table 1. Status of reporting of operational observer data by CPCs, by year, for 2013–2020. Cell color denotes whether a CPC reported operational observer data (green), intends to submit data in the near future (orange), nominated not to report or were exempt from reporting (black), or have not reported (red).

CPC	2013	2014	2015	2016	2017	2018	2019	2020
BLZ	NR[2]	NR[2]	P	P	P	P	NR[3]	
CHL							NA[1]	NA[1]
CHN								
CRI							NR[2]	
ECU								
EU (Portugal)	NR	NR	NR		NR	NR		
EU (Spain)	NR	NR	NR	NR				
FRA								
GTM	NR[2]	NR[2]	NR[2]	NR[2]	NA	NA	NA	
JPN	NR[1]	NR[1]						
KOR								
MEX								
NIC					NA[1]			
PAN								
PER	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]		
SLV	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	
TWN								
USA								
VEN					NA[1]	NA[1]	NA[1]	NA[1]
VUT								

NR- Not reporting

NR[1] - CPC stated they will not be reporting data because they cannot report against the IATTC standards for these years

NR[2] - CPC reports that they had qualifying vessels, but did not have a longline observer program in this fishing year

NR[3] - CPC reports that relevant vessel was only active during the last quarter of the fishing year and an observer could not be assigned

NA- CPC reports that the observer requirements were not applicable

NA[1]- CPC reports that the observer requirements were not applicable because relevant vessels listed on the RVR were not active or did not fish for IATTC species in this year

P- CPC has indicated that data will be submitted soon

Table 2. Summary of reporting by CPC showing whether Annex A for C-19-08 was submitted for 2020, including the percent observer coverage reported, and the fishing effort metric used to calculate observer coverage. Cell color denotes whether a CPC correctly completed and submitted Annex A (green). Red cells denote that a CPC had longline vessels >20 LOA on the IATTC Regional Vessel Register (RVR) (or longline vessels without registered LOAs) but did not report. Black cells indicate that although the CPC had qualifying vessels on the RVR, C-19-08 did not apply in 2020 because the relevant vessels were not active or did not fish for IATTC species. Orange cells denote incomplete, preliminary data or other issues.

CPC	Annex A Summary submitted?	% Observer coverage reported 2020
BLZ		
CHL	NA	
CHN	Y	4.86% preliminary(# hooks)
CRI		
ECU	Y	5.66% (effective days fishing)
EU	Y	3.80% (effective days fishing)
FRA		
GTM		
JPN	Y	5.97% (effective days fishing)
KOR	Y	2.87% preliminary (effective days fishing)
MEX	Y	6.17% (effective days fishing)
NIC		
PAN		
PER		
SLV		
TWN	Y	0.6% preliminary, 10.6% projected
USA	Y	16.31% (# hooks)
VEN	NA	
VUT		

Table 3. Number of longline vessels sampled per month during 2016–2018 by national observer programs and two measures of annual observer coverage. “Effective coverage” is based on the ratio of total hooks in observed sets to total hooks in the Task 2 data. “Annual coverage” is based on the ratio of total observed hooks to total hooks in the Task 2 data. Both Effective and Annual coverage are rounded to the nearest whole percentage point.

CPC	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Effective Coverage	Actual coverage
CPC1														
2016	2	2	1	0	0	1	2	4	3	4	6	3	6%	5%
2017	3	3	2	0	0	0	0	2	3	5	3	5	4%	3%
2018	0	0	1	0	0	0	0	1	1	2	7	10	4%	3%
CPC2														
2016	3	2	1	1	1	1	2	5	8	9	4	2	7%	6%
2017	2	1	1	2	1	2	5	5	6	6	6	7	9%	7%
2018	5	4	2	1	0	2	4	3	3	4	5	3	7%	5%
CPC3														
2016	7	9	10	9	3	3	16	26	17	13	9	4	20%	20%
2017	5	6	13	13	14	18	11	12	27	20	8	14	20%	20%
2018	12	11	12	16	14	10	12	21	10	8	6	2	20%	20%
CPC4														
2016	5	4	4	1	2	4	4	5	5	5	7	9	14%	8%
2017	5	5	4	1	4	5	7	8	8	11	13	13	18%	10%
2018	12	8	2	1	1	1	3	4	9	13	12	10	19%	11%

Table 4. Comparison of Task 2 catch (in numbers of fish) of bigeye tuna (BET) and yellowfin tuna (YFT) to that estimated from observer data, by CPC for 2016–2018, with approximate 95% confidence intervals (CI) in parentheses. Bold text show values where the approximate 95% confidence intervals on the estimated catch from observer data do not contain the Task 2 catch. Ratio is the estimated catch from the observer data divided by the reported Task 2 total catch. The version 2 estimate for BET and the ratio are only provided if the estimate differed from the estimate shown in column 3.

CPC	Task 2 catch	Estimated catch (95% CI)	Ratio	Estimated catch, version 2	Ratio for version 2
CPC1					
2016					
BET	**149,553**	**132,543 (125,498; 139,819)**	**0.89**		
YFT	**36,007**	**27,635 (24,652; 30,691)**	**0.78**		
2017					
BET	149,349	142,226 (133,089; 151,825)	0.95		
YFT	**38,199**	**30,205 (25,886; 34,652)**	**0.79**		
2018					
BET	**116,225**	**97,465 (91,072; 103,957)**	**0.84**		
YFT	**37,179**	**32,420 (28,628; 36,542)**	**0.87**		
CPC2					
2016					
BET	**179,843**	**154,717 (146,816; 162,591)**	**0.79**	**160,087**	**0.89**
YFT	**38,684**	**34,964 (31,472; 38,626)**	**0.90**		
2017					
BET	**135,212**	**117,904 (112,975; 122,839)**	**0.87**	**119,929**	**0.89**
YFT	34,909	34,442 (31,760; 37,244)	0.99		
2018					
BET	**113,373**	**85,685 (80,295; 91,173)**	**0.76**	**88,115**	**0.78**
YFT	**34,754**	**40,312 (35,477; 45,554)**	**1.17**		
CPC3					
2016					
BET	**51,240**	**46,630 (43,826; 49,509)**	**0.91**		
YFT	6,085	7,022 (6,040; 8,061)	1.15		
2017					
BET	64,752	64,075 (61,147; 67,164)	0.99		
YFT	**13,305**	**15,962 (14,769; 17,200)**	**1.20**		
2018					
BET	56,121	56,779 (54,137; 59,589)	1.01		
YFT	**8,738**	**10,389 (9,516; 11,265)**	**1.19**		
CPC4					
2016					
BET	**106,402**	**48,542 (44,231; 53,035)**	**0.46**	**48,535**	**0.46**
YFT	**25,426**	**14,120 (12,390; 15,954)**	**0.56**		
2017					
BET	**107,526**	**49,799 (46,055; 53,630)**	**0.46**	**49,869**	**0.46**
YFT	**23,121**	**16,606 (14,735; 18,534)**	**0.72**		

2018					
BET	**88,652**	**27,393 (25,013; 29,974)**	**0.31**	**27,977**	**0.32**
YFT	**22,035**	**12,365 (11,052; 13,742)**	**0.56**		

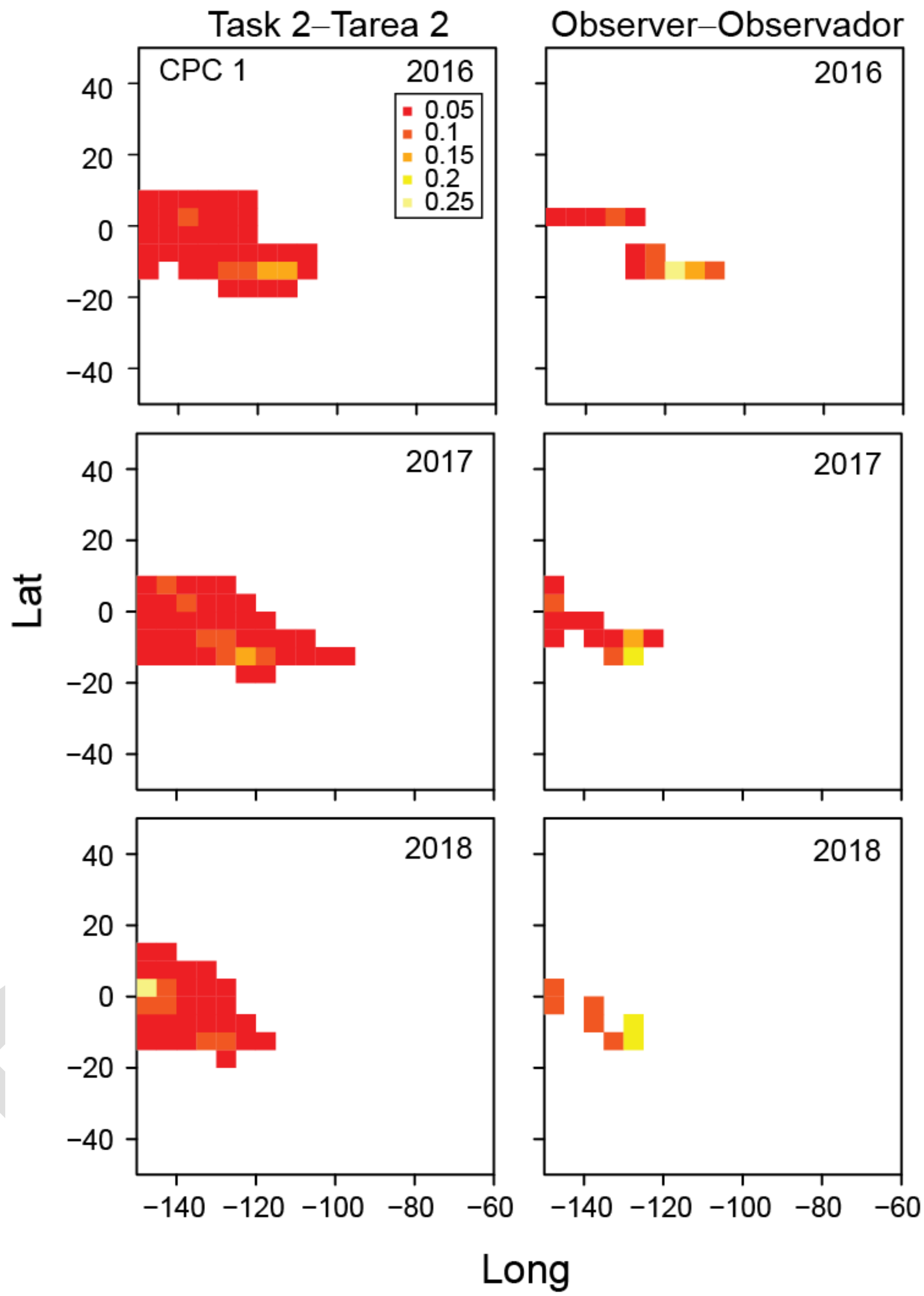


Figure 1. Spatial representativeness of observer data reported by CPC 1, CPC2, CPC3 and CPC4, as shown by the proportion of hooks set in each 5° x 5° grid cell, within each year, for Task 2 and observer datasets. The number of hooks used for the observer data is the number of hooks deployed in each set as opposed to the number of hooks observed per set. Whilst statistical analyses were performed on data available at the finest resolution available, due to data confidentiality rules, the data are presented at 5° x 5° resolution only where greater than 3 vessels contributed to the data in each grid cell per year.

Figure 1 continued.

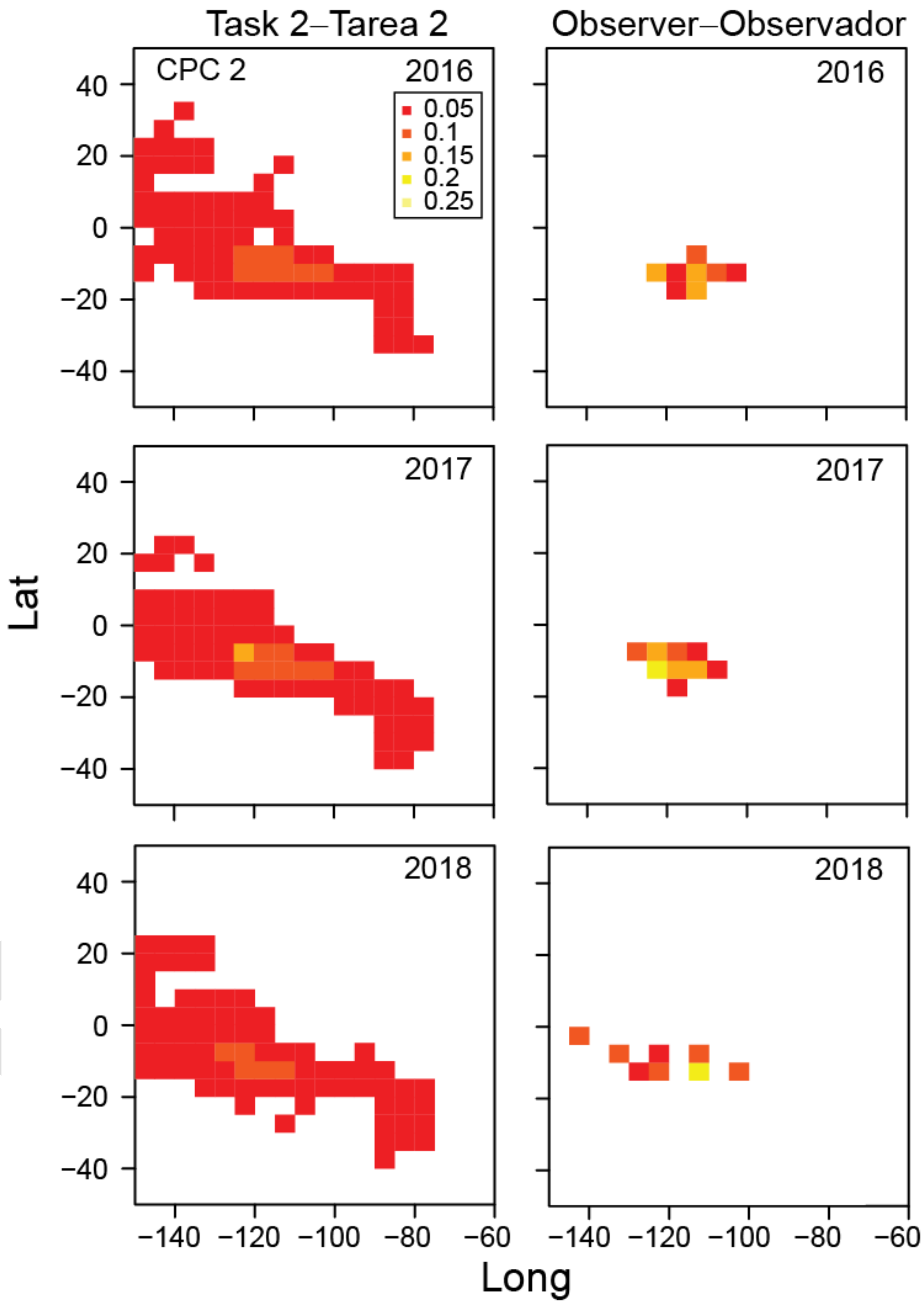


Figure 1 continued.

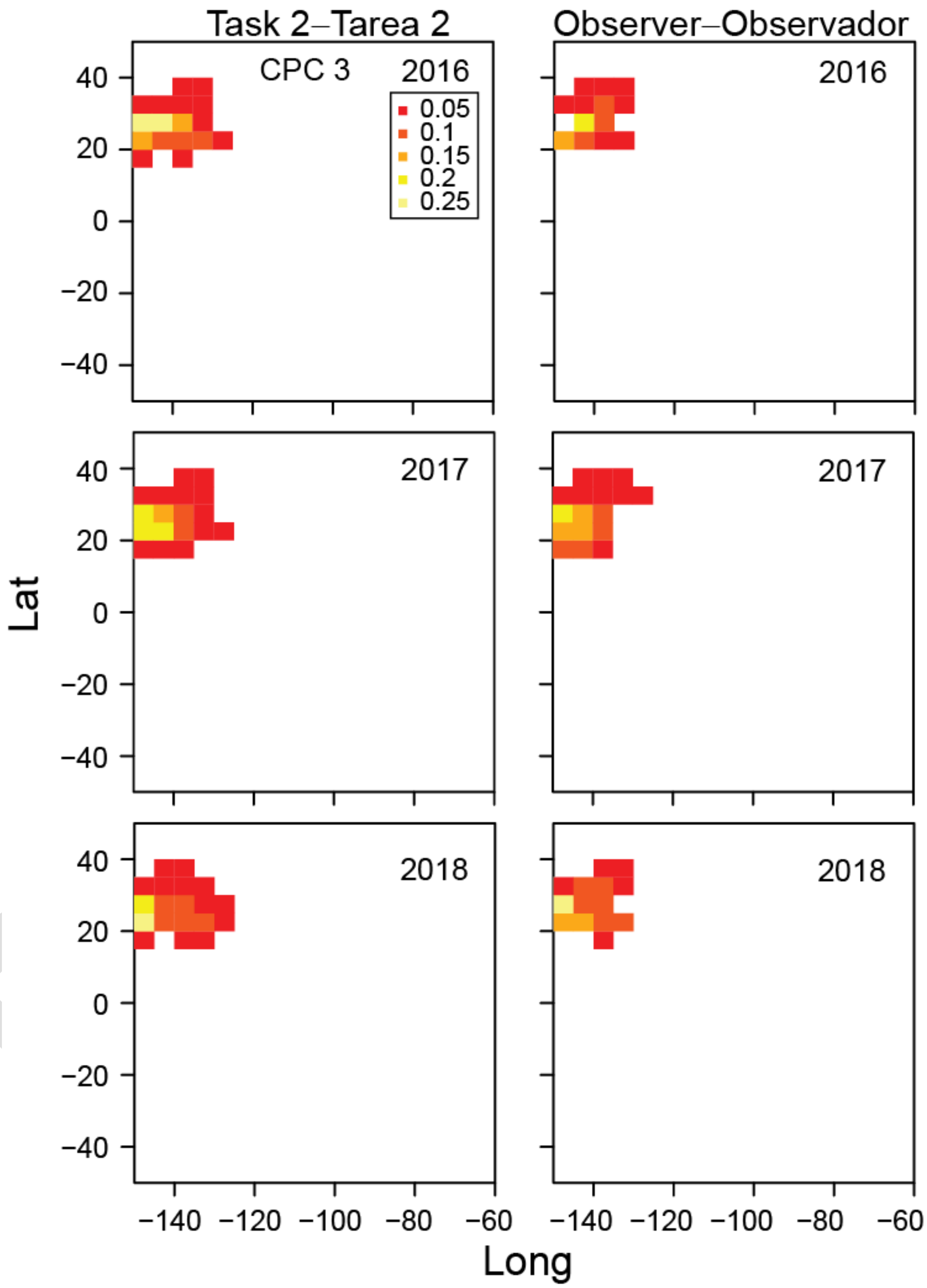
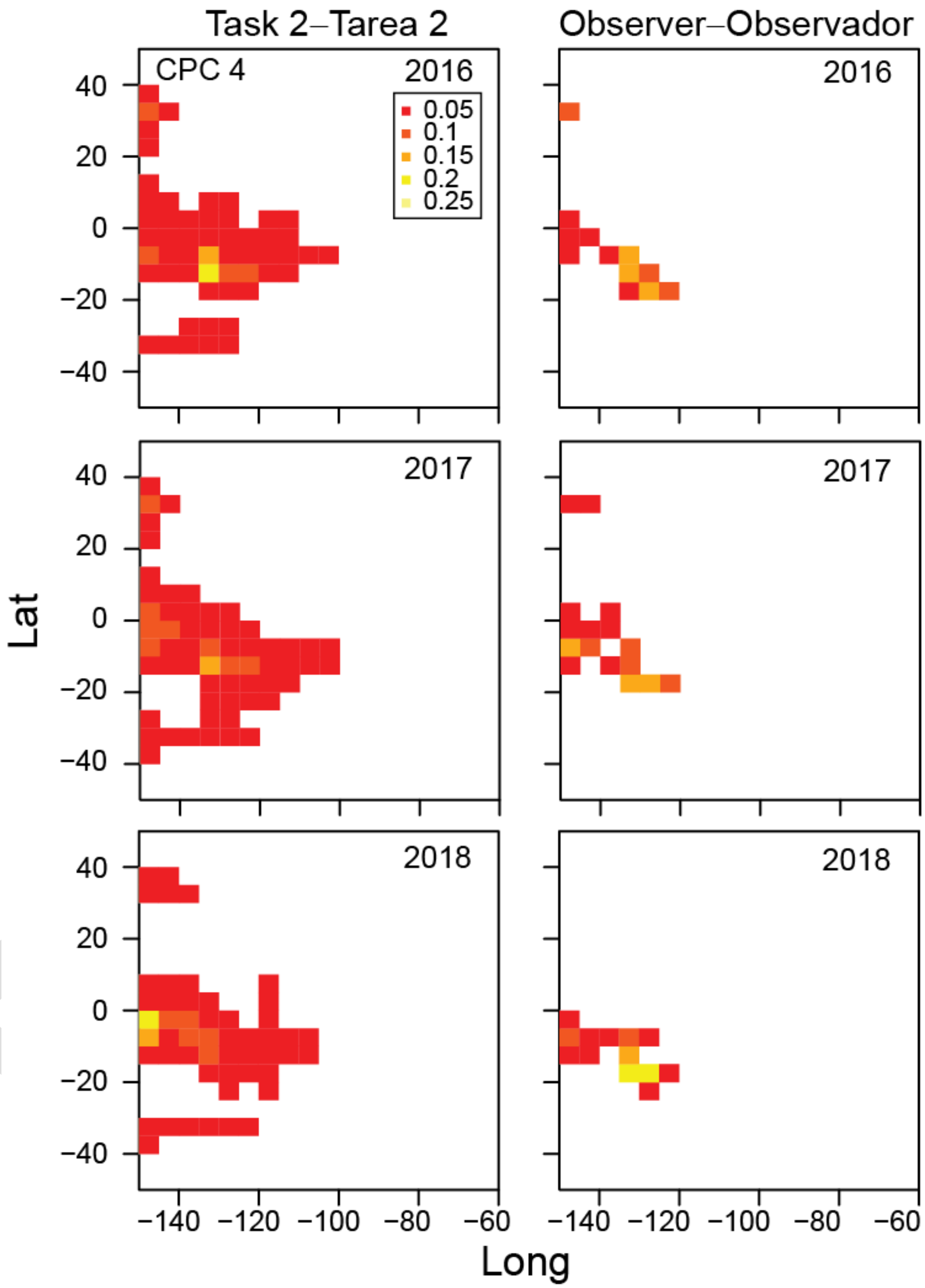


Figure 1 continued.



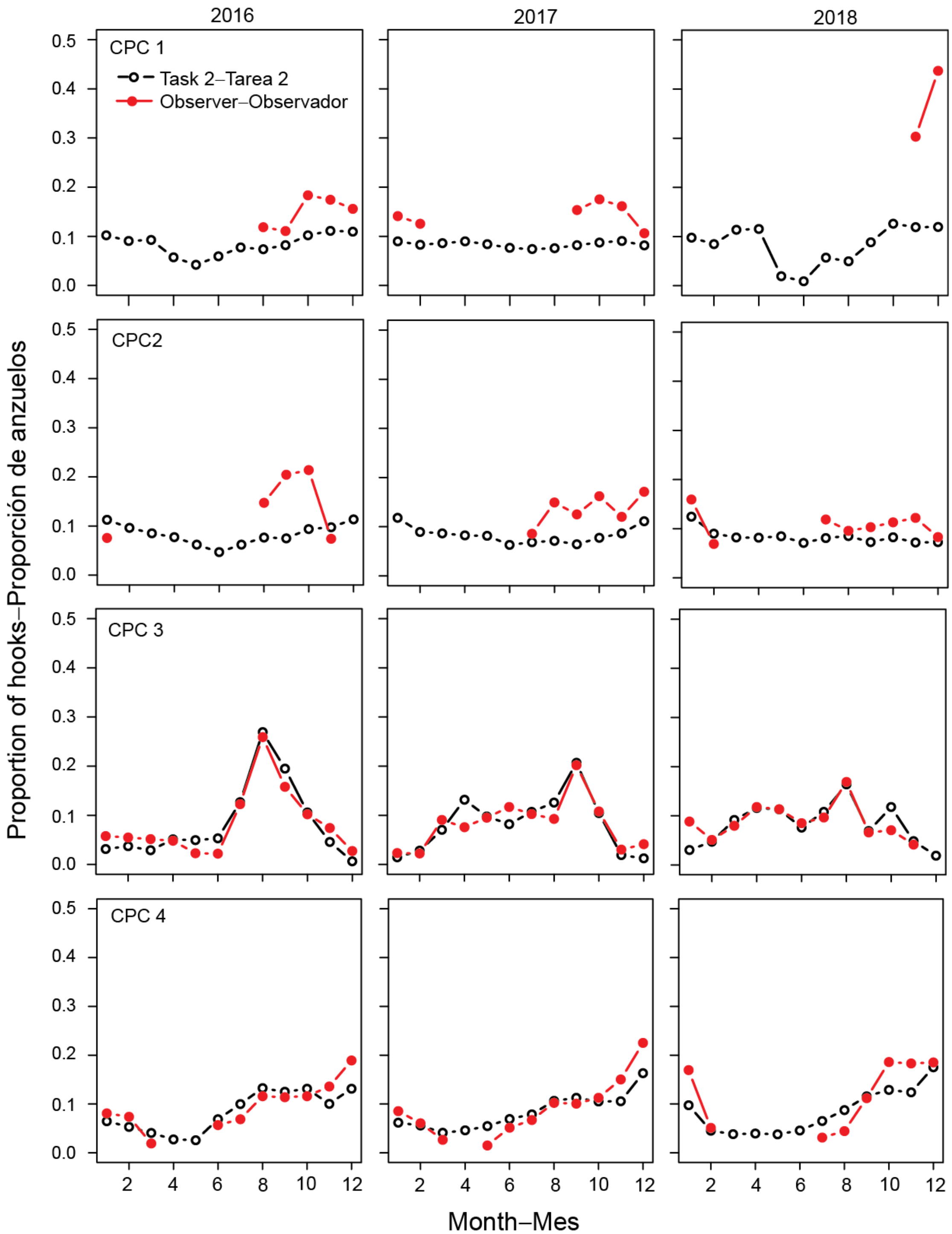


Figure 2. Temporal representativeness of observer data reported by CPC1, CPC2, CPC3 and CPC4 for 2016–2018, as shown by the proportion of hooks set by month in each year, for Task 2 (black open circles) and observer (red filled circles) datasets. The number of hooks used for the observer data is the number of hooks deployed in each set as opposed to the number of hooks observed per set. Whilst statistical analyses were performed on data available at the finest resolution available, due to data confidentiality rules, only months where greater than 3 vessels contributed to the data for each year are shown.

Appendix 1. Template for annual summary reports on fleet information and observer data for longline vessels >20m operating in the EPO, for use from 2020.

Member, or cooperating non-member	Country name

FLEET INFORMATION (vessels >20m)									
	All sets types combined			**Shallow sets** (<15 HPB/HBF[1] or <100m max hook depth)			**Deep sets** (≥15 HPB/HBF or ≥100m max hook depth)		
Period covered	date range mm/dd/yyyy–mm/dd/yyyy			date range mm/dd/yyyy–mm/dd/yyyy			date range mm/dd/yyyy–mm/dd/yyyy		
Area fished	from (XXX)°W to (XXX)°W and from (XXX)°S/N to (XXX)°S/N			from (XXX)°W to (XXX)°W and from (XXX)°S/N to (XXX)°S/N			from (XXX)°W to (XXX)°W and from (XXX)°S/N to (XXX)°S/N		
	Total Fleet	**Observed**	**% observed**	**Total Fleet**	**Observed**	**% observed**	**Total Fleet**	**Observed**	**% observed**
No. of vessels that fished	100	9	9	60	3	5	90	8	8.9
No. of trips	300	19	6.3	150	15	10	300	10	3.3
No. of effective days fishing	4500	260	5.8	3700	238	6.4	800	22	2.8
No. of sets	5000	320	6.4	4000	800	20	1000	25	2.5
No. of hooks (in thousands) *If unknown, approx.. no. of hooks/set, using a *)*	1000	60	6	700	120	17	300	12	4
Predominant[2] hook type/size ([IATTC code](#))	C-40	C-40		C-40	J-02		C-33	C-33	
Predominant bait type[3]	SQ	SQ		SQ	SQ		M	M	

NON-RETAINED SPECIES (vessels >20m)									
	No. of Individuals Observed								
	All sets types combined			**Shallow sets** (<15 HPB/HBF[4] or <100m max hook depth)			**Deep sets** (≥15 HPB/HBF or ≥100m max hook depth)		
	Released Alive	**Released Dead**	**Released Condition Unknown**	**Released Alive**	**Released Dead**	**Released Condition Unknown**	**Released Alive**	**Released Dead**	**Released Condition Unknown**

[1] Hooks per Basket / Hooks Between Float
[2] Predominant indicates most common, e.g. >50%
[3] Bait code: SQ – squid (e.g. Cephalopods), M – mackerel (e.g. Scomber spp.), A – artificial lure (e.g. plastic jig)
[4] Hooks per Basket / Hooks Between Float

Taxa - Sea turtles									
leatherback (*Dermochelys coriacea*)									
loggerhead (*Caretta caretta*)									
green (*Chelonia mydas*)									
olive ridley *(Lepidochelys olivacea*)									
Add more rows for each additional species									
Taxa – Sharks and Rays									
silky (*Carcharhinus falciformis*)									
oceanic whitetip (*Carcharhinus longimanus*)									
blue shark (*Prionace glauca*)									
shortfin mako (*Isurus oxyrinchus*)									
scalloped hammerhead (*Sphyrna lewini*)									
smooth hammerhead (*Sphyrna zygaena*)									
great hammerhead (*Sphyrna mokarran*)									
giant manta ray (*Manta birostris*)									
Add more rows for each additional species									
Taxa – Marine Mammals									
false killer whale (*Pseudorca crassidens*)									
Risso’s dolphin (*Grampus griseus*)									
Guadalupe fur seal (*Arctocephalus townsendi*)									
Add more rows for each additional species									
Taxa – Seabirds									
Antipodean albatross (*Diomedea antipodensis*)									
waved albatross (*Phoebastria irrorata*)									
Laysan albatross (*Phoebastria immutabilis*)									
short-tailed albatross (*Phoebastria albatrus*)									
Add more rows for each additional species									
Taxa – Billfish									
striped marlin (*Kajikia audax*)									
shortbill spearfish (*Tetrapturus angustirostris*)									
blue marlin (*Makaira nigricans*)									
Add more rows for each additional species									