INTER-AMERICAN TROPICAL TUNA COMMISSION

SCIENTIFIC ADVISORY COMMITTEE

14TH MEETING

La Jolla, California (USA)
15-19 May 2023

DOCUMENT SAC-14 INF-I

ENHANCED MONITORING PROGRAM FOR BIGEYE TUNA CATCHES: LOGISTICAL ASPECTS OF DATA COLLECTION

Cristina De La Cadena, Luis Chompoy, Cleridy E. Lennert-Cody, Brad A. Wiley, Ernesto Altamirano Nieto, Jean-François Pulvenis, Nickolas W. Vogel, Alexandre Aires-da-Silva

CONTENTS

SUMMARY 1
BACKGROUND 2
A. EMP PILOT STUDY 2
A.1 EMP Pilot Study: Preliminary measures 2
A.2 EMP Pilot Study: Selecting trips and wells for sampling 4
A.3 EMP Pilot Study Phase 1: intensive sampling 5
A.4 EMP Pilot Study Phase 2: field test of designed sampling protocol 7
A.5 Quality control 9
A.6 Sampling of cargo net unloading 10
B. EMP WORKPLAN FOR 2023 11
B.1 EMP sampling protocol: logistical details of field implementation 11
B.2 Raw data management 12
B.3 Sampling in other ports with BET unloadings 12

SUMMARY

Resolution C-21-04, which established conservation measures for tropical tunas in the eastern Pacific Ocean (EPO) during the period 2022-2024, included the creation of an Enhanced Monitoring Program (EMP) to strengthen the monitoring and control system for purse-seine catches of bigeye tuna (BET; *Thunnus obesus*). One of the benefits of the EMP is that it will support vessel owners and captains in monitoring their catches, for better compliance with the objectives of Resolution C-21-04.

The implementation of the EMP was preceded by a pilot study to develop and test sampling protocols (see SAC-14-10). The pilot study, which was conducted between September 2022 and February 2023, consisted in two phases. The first phase included intensive sampling of catch from individual vessel wells for use in simulation studies of sampling designs. The second phase involved field testing of the best sampling design resulting from Phase 1.

This document provides detailed information on the logistical and operational aspects associated

with each of the two phases of the pilot study. In addition, the document provides information on the steps required to launch the EMP in March 2023. Information from the simulation studies can be found in document SAC-14-10.

BACKGROUND

Through Resolution C-21-04 adopted by the Commission in late October 2021, an Enhanced Monitoring Program (EMP) was established to support the strengthening of the monitoring and control system for bigeye tuna (BET; *Thunnus obesus*) catches made by purse-seine vessels, to address conservation concerns regarding this species. The EMP will sample the catches of purse-seine vessel trips considered likely to contain a significant amount of BET.

The EMP began with a pilot study to develop and field test sampling designs for the estimation of catch composition at the well level and at the fishing trip level. This pilot study consisted of two phases. In Phase 1, data were collected for a simulation study for development of sampling designs. Data collection during Phase 1 focused on intensive sampling of the catch from specific wells, which was necessary to identify and characterize trends in species and size composition of the catch as the wells are unloaded; Phase 2 involved field testing of the sampling designs developed during Phase 1, to identify and resolve logistical problems prior to the start of the EMP in March 2023.

The pilot study was carried out in ports located in Manta and Posorja, Ecuador. According to data from previous years, these are the ports where the largest amount of BET landings occur in the region (SAC-13 INF-L). These ports receive BET catches from Ecuadorian-flagged vessels, as well as from vessels registered to other countries, including Panama, Venezuela, United States, Spain, El Salvador and Nicaragua.

This document contains information on logistical aspects related to the implementation of the EMP pilot study (Section A) and for the EMP in 2023 (Section B). In Section A.1 the preliminary measures taken for the pilot study are described. Section A.2. describes the criteria used to select trips and wells for sampling during the pilot study. Sections A.3 and A.4 contain a description of the main aspects considered for the implementation of Phase 1 and Phase 2 of the pilot study, respectively. Section A.5 describes how technology has been used in the program to help ensure the collection of high-quality data. Section A.6 provides a detailed report on the developments arising from the pilot study related to sampling of trips that use less-common unloading methods, focusing on a description of the working environment associated with these types of unloading methods and the steps taken to mitigate sampling challenges. Section B presents details of the decisions made on the logistical aspects for the implementation of the sampling protocol for the EMP, and how efficiency in the use of resources was sought to increase the number of fishing trips that can be sampled per year.

A. EMP PILOT STUDY

The pilot study was conducted from September 2022 to February 2023, in the ports located in Manta and Posorja in Ecuador. Due to logistical and budgetary constraints, sampling in ports of other countries was not considered during the pilot study. Moreover, since a significant proportion of the EPO purse-seine catch of BET is unloaded in these ports by vessels of various flags, it was determined that collection of BET unloading data for simulation studies to obtain the best scientific estimate of catch per fishing trip could be achieved by exclusively sampling catches unloaded in Ecuadorian ports.

A.1 EMP Pilot Study: Preliminary measures

A.1.1 Determination of types of unloading methods

In order to establish the sampling protocol for Phase 1, it was important to first identify the various unloading methods employed at ports in Ecuador. Two primary categories of unloading methods used by

the tuna purse-seine fleet were identified: standard unloading and unloading with a cargo net. These methods differ in terms of when the catch first becomes available for sampling during the unloading process.

Standard unloadings are those for which catch unloaded from the well first becomes available for sampling at the wet deck of the vessel. Standard unloading can use two methods:

a) Dry unloading: Before the unloading begins, the brine is removed from the well. The unloaders begin unloading the fish from the well, one by one, until they have made enough space inside the well to work, this is known as 'opening the mouth' or, in Spanish, 'abrir boca'. Then, unloaders enter the well and use containers to remove the fish from the well. These containers can be metallic or plastic and can vary in shape and size from vessel to vessel. The full containers are hoisted to the wet deck with the help of mechanical pulleys (see VIDEO 1 - Dry unloading).

b) Floating unloading: The brine is kept in the well, and the fish, which float near the hatch of the well, are removed one by one by the unloaders, who carry out this task from the wet deck (see VIDEO 2 - Flotation unloading).

Once the fish have been removed from the well, they are transported manually or by conveyor belt to a cargo net located beneath the hatch of the main deck. Once full, the cargo net is hoisted with a crane to the main deck and later to container trucks on the dock that will transport the fish to the processing plants.

A cargo net unloading differs from a standard unloading in that the first point at which most of the catch in the well is accessible for sampling is on the main deck of the vessel; in a standard unloading, all the catch unloaded from the well is accessible for sampling on the wet deck, which is located below the main deck, in a safer working environment. The cargo net, also called 'chinguillo' in Spanish, is a large net that is filled withing the well. Once is full, the net is hoisted by crane into a dockside truck for transportation to the processing plant. If the cargo net is initially hoisted from the well by the vessel's winch, an additional maneuver will be performed on the vessel's main deck, where the cargo net is unhooked from the vessel's winch and hooked to the dock crane. Vessels will start unloading through the well located below the main deck hatch, either at the bow or stern of the vessel. At the beginning, as in dry unloading, space must be made in the well for the cargo net, so the unloaders will start removing the fish from the well one by one until there is enough space to work inside the well. Once the cargo net is placed inside the well, it is filled by the unloaders. If the vessel has wells connected by side hatches, then once the first well is emptied, the unloaders will proceed to move fish from other wells into the cargo net placed in the empty well by means of chutes connected through the side hatches of each well. This process can be repeated for all wells of a vessel, if side hatches are present in every well, allowing all wells to be connected with the use of chutes (see VIDEO 3 - Cargo net unloading).

A.1.2 Recruitment and training of personnel

The EMP is led by the program's coordinator based in La Jolla, California, USA. A local coordinator was also contracted for on-site supervision and coordination through the Commission's field office in Manta, Ecuador. In accordance with the planning outlined in SAC-13 INF-E, a call for applications was issued to procure the services of 20 samplers, with 16 samplers stationed in Manta and 4 samplers stationed in Posorja. To avoid preconceived ideas about data collection, it was decided that the candidates could not have previous experience as on-board observers, either from the IATTC, national programs, or private programs, thus ensuring uniformity among samplers at the time of implementing the protocol established for the pilot study.

The samplers participated in a training workshop where they were trained in the sampling protocol designed for the pilot study (Figure 1). The Commission's scientific staff prepared the instructions and

forms for sampling during the pilot study. An important consideration in the development of the sampling protocol for Phase 1 was that the data collection procedures should strive to have no, or only minimal, effect on the normal unloading processes and times, while still obtaining the data necessary to run simulations that would allow establishing an effective sampling protocol for estimating the catch of BET per fishing trip under the EMP. In addition, the samplers learned about purse-seine fishing operations, the main unloading methods used in Ecuadorian ports and the identification of the three tropical tuna species that were the focus of this study: BET, yellowfin tuna (YFT; *Thunnus albacares*) and skipjack tuna (SKJ; *Katsuwonus pelamis*).

The samplers were provided with personal protective equipment (boots, helmets, lumbar support belts, and gloves), work tools for counting and measuring the sampled individuals (manual counters, calipers, registration forms) and recording equipment for remote supervision (GoPro cameras).

A.1.3 Communication with authorities and the industry

Prior to the start of the pilot study, a meeting was held with representatives from the Vice Ministry of Aquaculture and Fisheries of Ecuador. The purpose of the meeting was to explain the sampling process that would be used during the pilot study, the scope of work to be conducted by the samplers in the ports of Manta and Posorja, and the communication channels that would be used to report on the selected fishing trips.

In Posorja, meetings were held with representatives of the three privately owned and managed ports, located in the area, to learn about their safety and access protocols, and to request collaboration for the implementation of the pilot program. These meetings yielded positive results, and the port representatives offered to provide meals for the samplers at no cost.

One of the main concerns expressed by the industry representatives during these meetings was the possibility of the sampling causing delays in the unloading and negatively affecting the quality of the catch. They were assured that, to the extent possible, the intervention of the samplers would have only a minimal impact on the duration and flow of the unloading process.

In addition, through the Vice Ministry of Aquaculture and Fisheries of Ecuador, the industry was informed about the pilot study activities and companies were requested to designate contact personnel. This was to ensure that staff could notify the company of fishing trips selected for sampling and to facilitate coordination prior to the vessel's arrival. The sampling procedures during the pilot phase were also shared. Finally, a meeting was held with the representative of Ecuador's national observer program (PROBECUADOR) to ensure collaborative work on the trips selected that carried observers from PROBECUADOR.

A.2 EMP Pilot Study: Selecting trips and wells for sampling

The selection of the fishing trip and wells for sampling was made based on the preliminary information from the observer. It is important to note that this information, shared by the observer prior to the vessel's arrival to port, had not been subject to the quality control processes applied to observer data prior to its uploading to the IATTC's permanent observer database. Nonetheless, updates or changes in the preliminary information on catches are very rare.

There are two sources of preliminary observer information that the EMP uses:

a) The At-sea report, also known as Informe Desde el Mar (IDM) in Spanish, is a report that observers are required to prepare periodically and provide to the vessel personnel for transmission to the IATTC staff. The IDM contains information on the estimated metric tons of the three tropical tuna species retained by the vessel, the wells where the retained tuna was stored, the fishing area, and

the cumulative totals for the entire trip up to the date the report is sent. However, the IDM information does not include a breakdown of the amounts of catch from each set that went into each well. Therefore, it only serves as a summary of the catch characteristics by fishing trip and is used only for selecting fishing trips of interest for sampling.

b) The Set Summary, also known as Resumen De Lances (RDL) in Spanish, is an auxiliary worksheet used by observers to record detailed data required for filling out specific forms such as Tuna Tracking Forms (TTF). The RDL is not uploaded to the IATTC's permanent observer database since it is a support document. However, it is the only document that provides detailed information on how the retained catch is distributed among wells and can be obtained before the vessel arrives at port.

The IDM is received periodically by the IATTC staff as part of the observer program protocol and shared automatically with the EMP through a dynamic table placed on the IATTC's intranet which shows information in near real-time (Figure 2). In the case of the RDL, the information is usually provided to the staff after the arrival of the vessel in port, as part of the observer's package of forms for the trip. However, for the purposes of the EMP, it was necessary to receive the RDL prior to the vessel's arrival. Internal coordination was carried out with the IATTC's observer program, in addition to communications with the representatives of the national programs, to request their collaboration in sending the scanned RDL by electronic means of communication prior to the vessel's arrival in port.

A.3 EMP Pilot Study Phase 1: intensive sampling

A.3.1 Selection of trips and wells for sampling

For Phase 1, the wells of trips to be sampled were selected opportunistically, with priority given to trips where the observer reported catches of BET and to IATTC Class 4 to 6 vessels with high historical annual catches of BET. Parameters were defined to ensure that the trips selected were representative of those that would be of primary interest during the implementation of the EMP.

Trip selection: To establish sampling priorities, IATTC Class 4 to 6 purse-seine vessels (the vessels to which the EMP will apply per Resolution C-21-04) were classified according to the following categories, ranked from highest to lowest priority for sampling:

a) Vessels that, during the implementation of the pilot study, caught BET.
b) Vessels with high historical catches of BET.
c) Vessels not included in the first two categories that made few to no sets on tunas associated with dolphins (DEL).
d) Vessels that mainly made DEL sets.

Well selection: Wells were selected according to the characteristics of the catch they contained, based on the following categories, ranked within each characteristic from highest to lowest priority for sampling:

Set types:

a) Sets on tunas associated with floating objects (OBJ).
b) Sets on unassociated schools of tuna (NOA).
c) Mixed set types not involving DEL (i.e., OBJ-NOA).
d) Sets on tunas associated with dolphins (DEL).

Wells with mixed set types that include DEL sets were not considered as a priority for this stage of the study.

Fishing areas:

In order to incorporate the inshore - offshore gradient in the BET catch within the EPO (e.g., SAC-10 INF-D), a boundary was defined at longitude 110°W, based on the spatial fishery definitions used in the last BET tuna assessment (SAC-11-06 REV). Two fishing areas were established: a) west of 110°W, referred to as offshore, or OFF; and b) east of 110°W, referred to as inshore, or IN, where the first, OFF, takes precedence over the second, IN, because annual BET catches tend to be greater, on average, for the area west of about 110°W than the area to the east (SAC-14-10).

Presence of tuna species:

a) Wells reported to contain at least two tropical tuna species, one of which was BET.
b) Wells reported to contain two tropical tuna species, neither of which was BET.
c) Wells reported to contain only one tropical tuna species.

The amount of BET contained in the well was also considered since sampling too many wells with little presence of BET could result in many samples with few or no individuals of this species, which would not produce the best data set for testing sampling designs for BET catch estimation.

A.3.2 Sampling process

During Phase 1 of the pilot study, a sampling coverage of 10% was primarily used. This involved sampling every 10th 'unit' of fish that was unloaded from the well, using a "1-out-of-10" protocol. The sampling process began with a randomly selected unit from the first 10 that were unloaded and continued until the end of the unloading process. A unit of fish was defined as either a physical container filled with fish or a fixed number of fish that were individually unloaded from the well. In cases where fish were individually unloaded, such as during flotation unloading or at the beginning of a dry unloading, virtual units were used. These virtual units were essentially a fixed number of fish that were treated as if they were in a container. The number of fish used to define a virtual unit remained constant throughout the unloading process and was determined by the samplers at the start of unloading. This was done by filling the type of container that would be used during unloading with fish, as outlined in Appendix I.

The sampling sequence of unit of fish for a particular well is determined by two parameters: the desired sampling percentage and the random number used to select the first unit for sampling. For example, if the random number was 4, the samplers would count the unloaded units until they reach the fourth unit, process all the fish from this unit for species identification and measurement (tropical tunas only), and then continue counting the unloaded units until they reach the next unit to sample, which would be unit 14. This process was repeated for every tenth unit (unit 24, unit 34, unit 44, etc.) until the well was emptied.

In November 2022, intensive sampling was tested where one out of every eight units was sampled (coverage percentage of 12.5% of units). However, the time between units to sample was too short, increasing the risk of errors in data collection due to the speed with which the samplers had to operate. To ensure the collection of high-quality data, it was concluded that it was not prudent to continue sampling at a coverage level higher than 10%.

The sampling of a well was performed by a team of four samplers with the following roles:

a) One sampler counted the units of fish and selected the unit to be sampled.
b) Two samplers measured and identified each tropical tuna in the unit selected for sampling. Any fish in the unit that were not tropical tunas were counted but not measured.
c) One sampler collected the information on paper forms.

A total of 5 teams of samplers were formed, four based in Manta and one based in Posorja. A lead sampler

was designated in each team. Due to the dynamic nature of the unloading process, it was determined that the best means of communication between the samplers and the coordinators would be a group chat on WhatsApp, which allows quick interaction. Through the group chat the local coordinator would give information for the selected trip, including the trip number, vessel name, port and time of unloading, the desired sampling percentage, the random number to initiate the sampling sequence; and a list of wells from which they could choose to sample. These wells in the list were defined by the local coordinator based on the selection parameters described above. The list included more wells than could actually be sampled by the team because sometimes logistical constraints precluded sampling certain wells, and thus it was necessary to have alternates (see VIDEO 4 - EMP Phase 1 sampling protocol).

A.3.3 Summary of data collected

During Phase 1 of the pilot study, between September and December 2022, sampling of 58 fishing trips and 93 wells was achieved; with 1 well sampled for 30 trips, 2 wells sampled for 21 trips, and 3 wells sampled for 7 trips (Table 1). On 13 occasions, 100% of the unloading could not be sampled due to several factors described below:

a) During the course of the study, there were three instances of prolonged unloading times that hindered the implementation of the sampling protocol for the complete unloading. These extended times were attributed to unforeseeable events that were beyond the control of the unloaders and the sampling team. For instance, in one case, despite 12 hours of sampling, only 27% of the well unloading was completed due to delays in the unloading process. Such delays may arise from mechanical breakdowns on the vessel or delays in the handling of the catch at the processing plant. Unfortunately, due to the unavailability of a replacement team to continue with the tasks, sampling had to be terminated at this point in the process.

b) On one occasion, after a possible leak of ammonia was identified in the well, the unloading was stopped at 90% progress due to safety concerns.

c) The remaining occasions corresponded to sampling on the main deck of the vessel during unloading with a cargo net. The interruption of the sampling was due to the transport of the cargo net directly from the well to the truck on the dock, without first pausing on the main deck. In Section A.6 more details can be found regarding the challenges encountered when sampling cargo net unloadings during Phase 1 of the pilot study.

A.4 EMP Pilot Study Phase 2: field test of designed sampling protocol

Data analysis during Phase 1 of the pilot study led to the design of a sampling protocol for standard unloadings, which was tested during Phase 2, carried out between January and February 2023. The protocol for the sampling of cargo net unloadings has not been finalized; further analysis of Phase 1 data will need to be carried out to determine the sampling parameters that will provide quality data under the logistical challenges encountered during this type of unloading, including the few special cases of cargo net unloading by vessels with cold chambers.

The standard unloading sampling protocol requires a minimum of six wells to be sampled per fishing trip, with one systematic sample of units obtained from each well with a sampling coverage of 3.33% of unloaded units. This systematic sample is achieved by selecting one unit out of every 30 units, starting from a randomly selected unit from the first 30 units unloaded from the well. The wells to be sampled are chosen randomly from those with catch from the primary catch stratum (or strata) of interest for the trip, as described in Section A.4.1.

This protocol has been determined to produce reliable estimates of BET catch with a reasonable margin of error for the trip or for the primary catch stratum of the trip (SAC-14-10). It can be executed by samplers

over the long-term without unduly interfering with the normal catch unloading process.

A.4.1 Selection of trip and wells for sampling

Catch strata, which were defined for the trip-level catch estimation (SAC-14-10), were used to select fishing trips and wells for sampling. These strata are based on the set type and fishing area associated with the catch in the wells of a trip. The set types of highest priority for sampling were OBJ and NOA sets. Three fishing areas were defined: west of longitude 110°W (OFF); between 110°W and 95°W (IN-west); and east of 95°W (IN-east). Because the vessel strategies for filling wells do not consider partitioning according to these strata, some flexibility was permitted when assigning wells to spatial strata by considering a buffer of 2° for the strata described. That is, if part of the catch contained in a well was 2° or less outside the dominant fishing area of the catch in the well, then the well is assigned to this dominant fishing area for the spatial component of the stratification (i.e., for the purposes of sampling and catch estimation, the catch in the well is considered to come from a single spatial stratum). If a portion of the catch in the well was caught outside of this 2° spatial buffer zone, then the well is considered to have catch associated with two spatial strata and it would, therefore, be considered a mixed-stratum well. With these definitions of set type and fishing area, the following catch strata were defined for the selection of wells to be sampled, listed in order of priority, from highest to lowest:

- OBJ OFF: catch OBJ sets made west of 110°W
- OBJ IN-west: catch OBJ sets made between 110°W and 95°W
- OBJ IN-east: catch OBJ sets made east of 95°W
- NOA OFF: catch from NOA sets made west of 110°W
- NOA IN-west: catch from NOA sets made between 110°W and 95°W
- NOA IN-east: catch from NOA sets made east of 95°W

Wells with catch from DEL sets are presently considered a low priority for sampling, unless the accuracy of the set type determination is in question, because DEL sets produce effectively no catch of BET (e.g. SAC-13-03).

A.4.2 Sampling process

The sampling protocol that was established from analysis of the Phase 1 data (SAC-14-10) was the two-stage protocol tested during Phase 2 of the pilot study. Specifically, the first stage consisted of the random selection of wells from a trip based on the catch stratum; and the second stage involved the collection of one systematic sample from each of the selected wells, where the within-well sampling consisted of selecting units of fish according to a percentage of coverage and a designated random number. During the protocol testing in Phase 2, for a fishing trip, 6 wells were randomly selected from the catch stratum considered most likely to contain an appreciable amount of BET, the first option being OBJ OFF. Then, one unit from the well is taken for sampling from every 30 units unloaded, starting from a randomly selected unit from among the first 30 units unloaded, until the end of the unloading.

This protocol represents an increase in the minimum number of wells to sample per fishing trip, over the number sampled per fishing trip in Phase 1, which is necessary to achieve an estimate of BET catch with a coefficient of variation below 0.4 (SAC-14-10). This increase in the number of wells to sample, made it necessary to restructure the teams of samplers because 5 teams were insufficient to cover 6 wells per trip. Therefore, the samplers were placed in groups of 3, resulting in 6 teams of samplers, and 2 backup samplers who assisted with the testing of new data collection tools (voice recorders and scales; see Section A.4.3).

The possibility of working in smaller teams during Phase 2 was due to the change in the sampling protocol. While more wells needed to be sampled per fishing trip, the number of units to be sampled per well

decreased from 1 out of 10 to 1 out of 30. This change allowed for an increase in the available time to sample a unit, from 6-10 minutes in Phase 1 to 20-30 minutes in Phase 2. As a result, smaller teams could handle the workload more efficiently, without compromising the quality of the data collected.

A.4.3 Summary of data collected

Between January and February 2023, a total of 16 fishing trips and 72 wells were sampled. Of the 11 fishing trips sampled in Manta, 6 wells were sampled in each trip (Table 2).

In Posorja, two samplers conducted tests on the use of voice recorders and portable electronic scales. The use of a voice recorder allows the sampler who is identifying and measuring fish to also collect the data, this way the role of a sampler solely dedicated to taking information in written form is eliminated, allowing the possibility of two-sampler teams. Several tests were carried out simulating problematic situations that could affect the quality and reliability of the data recorded, such as noisy environment on the wet deck or the possibility that the information would not be recorded at all, either due to human error or to device failure. As a result of these tests, a set of guidelines for the use of voice recorders was developed and included in the EMP protocol (see Appendix I)

The use of scales to weight fish instead of measuring them for length was considered and tested during Phase 2. After analyzing the GoPro imagery collected in Phase 1, it was observed that fish with broken caudal fins or curved bodies may bias the length measurements. High-quality length data were considered necessary because length measurements were being used to estimate the weight of each fish sampled so that the proportion of each species in the well, in terms of weight, could be obtained. Species composition in weight is required for the catch estimation (SAC-14-10). The scale selected for testing needed to be portable, resistant to the unloading environment related to humidity, temperature and salinity, and capable of measuring with a sensitivity to the thousandths of a millimeter. The tests identified additional problematic situations that may influence the performance of the scale and solutions to these problems were found. For example, on vessels with a conveyor belt on the wet deck, the scale reading was affected by the vibration caused by this machinery. A solution was found by placing the scale on a base that could absorb the vibration. Additionally, positioning larger fish on the scale's tray proved to be a challenge. To solve this problem, a special stainless-steel tray with supports to hold the fish in place was designed by the local coordinator. The tray attaches directly onto the scale plate, providing stability when weighing (Figure 4).

A.5 Quality control

Supervision of the samplers was of utmost importance to ensure the quality of the data collected and the proper implementation of the sampling protocol.

The use of GoPro cameras for remote monitoring was tested in Phase 1 of the pilot study. Samplers would wear the cameras on a chest mount and record the sampling process. The videos were reviewed by the coordinators and experienced samplers from the IATTC's regular port sampling program to verify if species identification and measurements were done properly; these recordings also helped identify problematic situations like the presence of broken or curved fish, as explained in A.4.3. On-site supervision was also carried out.

Several remote meetings were conducted between the EMP samplers and La Jolla staff to discuss the challenges encountered during sampling and to explain the analysis of the data collected and preliminary results obtained. The purpose of these meetings was to emphasize the importance of properly collected information during the sampling. It was explained how the raw data were being used in developing an EMP sampling protocol and how the fieldwork performed by the samplers flows into the analyses conducted by the staff in La Jolla. The meeting highlighted the fact that high-quality data collection and

good science are inextricably linked.

A.6 Sampling of cargo net unloading

Sampling of wells unloaded with cargo nets has logistical challenges that were identified and addressed to some extent during Phase 1 of the pilot study. According to information collected in the field, about 21 vessels unloading in the Ecuadorian ports of Manta and Posorja use cargo nets, either for unloading all or part of their wells.

During Phase 1 of the pilot study, a total of 18 wells that had been unloaded with cargo nets were sampled either partially or entirely. In some instances, the purpose of the sampling was to obtain data collected with different sampling sequences and coverage percentages for analysis. On other occasions, the purpose of the sampling was to test the viability of different field techniques for selecting a sample of fish from the cargo net in a manner that would prevent sampler selection bias. Given that cargo nets can contain over 600 fish at a time, the concept of a unit used for sampling standard dry unloadings, where the content of one container represented one unit of fish that could be completely sampled, was not applicable. It would not be possible to identify and measure all the fish contained in a cargo net with the available human resources, the working space conditions on the main deck and still comply with the mandate to have only minimal impact on unloading times and product quality. In this sense, protocols for partial sampling of a cargo net were tested, considering the following guidelines:

- The samplers had to find a safe place on the main deck to work, avoiding being beneath the cargo net unloading route, too close to the primary hatch of the main deck, and in areas where there were trip hazards (e.g., cables lying on the main deck).
- Samplers had to wait for the cargo net to be placed on deck, and the tension taken off the cables holding the net, before approaching the net to sample.
- To try to minimize sampler selection bias at the time of sampling, the contents of the cargo net were divided into four quadrants and a random number between 1 and 4, previously provided by the local coordinator, was used by the samplers to select the quadrant from which the sample would be taken.
- The samplers had to take all the fish in the quadrant for identification and measurement.

These early guidelines proved impractical to implement. For example, the randomly selected quadrant might be located in an area that was difficult for the samplers to access; even if this was not a problem, the time needed to take all the fish contained in a quadrant would result in a delay of the unloading. Climatic factors were also an important consideration because of their effect on the working conditions and the quality of the fish. Taking the above into consideration, a modification was made where the selected quadrants were always in the safe working area for the samplers and a fixed number of fish[1] were to be selected from the cargo net for species identification and measurements. To try to minimize sampler selection bias, the selection of fish was to begin at the edge of the cargo net closest to the samplers and proceed to the center of the selected quadrant until the fixed number of fish to sample were obtained (see VIDEO 5 Cargo net sampling).

Although these adjustments made to the cargo net sampling protocol resulted in an improved methodology, there are aspects of the cargo net unloading process that are vessel-specific, and thus make

[1] During Phase 1 of the pilot study, several options were tested on the number of fish to collect as a group to be sampled from a cargo net. At first, an estimate of how much fish was held on a cargo net was made and 10% of the fish were selected from the cargo net for sampling; later on in the pilot study a fixed number of 30 or 40 fish were determined as a more practical number of fish to be sampled from the cargo net.

it difficult to develop a standard sampling protocol applicable to all vessels, or at least one that would require only minor variations. Thus, it seems clear that further collaboration from the industry would be required to arrive at a final protocol for sampling cargo net unloadings, including those from vessels with cold chambers.

B. EMP WORKPLAN FOR 2023

B.1 EMP Sampling protocol: logistical details of field implementation

Sampling logistics have evolved as the analysis of the data collected determined new requirements. The greatest impact has been in terms of the number of samplers required per well and per fishing trip in order to achieve the level of sampling coverage required to estimate BET catch per fishing trip. Before the pilot study, the general sampling plan involved forming a total of five teams of four samplers each (see SAC-13 INF-E), which was the resource configuration used during the pilot study, where the priority was intensive sampling of the catch in a well, sampling one unit out of every 10 units unloaded. However, a maximum of three wells per trip were sampled, with only one well being sampled for about half of the trips.

The sampling protocol designed with the analyses of the data collected in Phase 1 that was tested during Phase 2 of the pilot study, and is currently being used in the EMP, involved a reduction in the Phase 1 within-well sampling frequency, from sampling 1 out of every 10 units unloaded to sampling 1 out of every 30 units unloaded; which extended the time between sampled units from an average of 6 minutes to 30 minutes. This extra time between sampled units allowed for the sampling of a well to be done by a team of 3 instead of 4 samplers. Therefore, the 16 samplers based in Manta were redistributed into 5 teams of 3 samplers each, and a sixth team was created by adding 2 samplers from Posorja. Further revision of the configuration of sampling teams was made possible following the important results obtained from tests carried out during Phase 2 on the use of voice recorders for data collection, making it possible to eliminate the role of a sampler dedicated exclusively to the written collection of data.

With the tests carried out during Phase 2 of the pilot study, the logistical feasibility of implementing the sampling protocol developed during Phase 1 within the approved budget for the EMP in 2023 was verified. It was determined that the minimum number of samplers needed to both collect high-quality data for a sufficient number of wells per trip and allow for sampling of a reasonable number of fishing trips, all within the approved budget, would be 14 teams of two samplers each, 8 teams based in Manta and 6 teams based in Posorja. This requires existing IATTC staff assume some tasks that had been planned for new hires (e.g., data entry), and the hiring of 8 additional samplers for Posorja, which was done in February. Thus, the EMP will be able to sample up to 8 wells per fishing trip, and an estimated 100 trips per year within Ecuadorian ports (Table 2)

Each team of samplers will follow these guidelines (see VIDEO 6 - EMP sampling):

- For a two-person sampling team, one sampler will be stationed at the well head to count the units as they are unloaded and assist the second sampler with the fish within the unit selected for sampling. The second sampler will be responsible for the identification of all fish and measurement of all tunas in each unit selected for sampling. In the case of flotation unloadings, since the fish must be counted one by one as they are taken out of the well to determine the 'virtual units', which means the counting is constant, a third sampler will be required solely for this task.
- The samplers in a team will rotate among functions to help reduce fatigue and monotony during sampling. In addition, the members of individual teams will not be fixed, the samplers will rotate among teams to promote sharing of knowledge.

- The samplers will be able to keep a careful count of the units unloaded for the well with the help of a manual counter and a counting template. The units may be physical containers or groups of fish removed one by one from the well that form a virtual unit.
- Each team of samplers shall be equipped with a calibrated and fully charged portable scale. The scale will include a base capable of absorbing vibration and a custom tray with a support specifically designed to keep the fish to be measured centered over the scale (Figure 4).
- The samplers will also have a caliper for measuring the fork length, which will be necessary in cases where the fish exceeds the weight limit of the scale, set at 28 kg (set below the manufacturer's weight limit to account for the weight of the custom tray).
- The sampler responsible for identification and measurement will have a voice recorder to collect information in real time (Figure 3).
- At all times, the samplers are to follow the instructions established in the EMP sampling protocol, which includes guidelines for the correct use of the voice recorder and scale (Appendix I).

B.2 Raw data management

The transcription of the information recorded in audio to physical format (i.e., data sheets) will be performed by a local assistant based in the IATTC Manta field office. The assistant is also responsible for managing digital and physical EMP files, which consist of set summaries, sampling forms, voice recordings, video recordings from GoPro cameras, and photographic records.

The information transcribed onto paper forms is then transferred to IATTC data entry staff located in the Manta field office. These staff members are responsible for data entry and data editing from sampled fishing trips (RDL data and sampling forms). These data are then uploaded into databases created by the staff of the Data Collection and Database group in La Jolla. The information digitized in Manta is shared with the scientific staff in La Jolla on a weekly basis and will be used to obtain the best scientific estimate (BSE) of the catch of BET per fishing trip for sampled trips. It is estimated that the first BSE results will be shared starting mid-August of 2023 through a dynamic table that each CPC will have access to for the visualization of the information of its flag fleet.

B.3 Sampling in other ports with BET unloadings

During the pilot study, information was collected on the logistical and budgetary aspects associated with sampling in other ports, outside of Manta and Posorja, where BET catch is unloaded. Based on historical catch information, it was determined that the port of La Union, El Salvador, would be the next most important for the EMP sampling (SAC-13 INF-L; Figure 5). However, it is noted that the magnitude of BET catch unloaded in La Union has historically been considerably less than that unloaded in Manta and Posorja (80% of BET catch unloaded in Manta and Posorja, compared to 6% in La Union).

Since the program is based in Ecuador, sampling in other countries is costly due to travel expenses. Considering that a fishing trip requires the sampling of at least 6 wells, a total of 12 samplers will need to travel. It is estimated that the operational costs for sampling one fishing trip in La Unión will be between US$ 20,000 and US$ 25,000. Costs of this magnitude were not anticipated in the original EMP budged because it was assumed that only a few wells per trip would need to be sampled.

On average, 86% of the BET catch has been landed in Manta, Posorja, and La Unión. Therefore, to optimally utilize the resources allocated for the EMP, it would seem best to concentrate sampling efforts in these ports. However, the potential to expand sampling to other ports and countries should be taken into account and will be addressed during the discussion of the proposed budget for 2024.

B.4 Sampling at processing plants

Another expansion of the EMP might result from a recommendation that was adopted by the SAC at its 13th meeting in July 2022 "*That, within the framework of the pilot program, the staff consider whether the enhanced sampling program can be carried out at the processing plants, and report back to the SAC on this matter in 2023*". In addition to the considerable increase in costs of such an expansion and the need therefore for new resources, there are a number of issues that should be addressed even prior to developing a feasibility study, which the staff has identified as follows:

- The variability in catch composition within and among wells, even for wells with catch from the same set type and area (SAC-14-10), suggests that sampling containers could be at least as involved as sampling individual wells aboard the vessel;
- If catch from different areas and set types is loaded into the same container, catch estimation cannot be done by strata, requiring additional sampling to estimate the trip catch (i.e., sampling more containers);
- During the EMP pilot study it was observed that some BET catch may be diverted during unloading for sale elsewhere (not at the cannery), requiring more resources to monitor the unloading of a trip; and,
- Comparison of observer and EMP catch estimates and observer and cannery catch estimates (SAC-14-10), suggests that cannery data presently provided to IATTC may underestimate BET catches, and thus, any sampling at canneries might require modification to the current catch sorting procedures conducted at canneries.

B.5. Additional tasks

The EMP will be implemented during 2023 following the protocol designed and tested in the pilot study, and with the logistical guidelines established and detailed in B.1 and B.2. Other aspects to be addressed are listed below:

- The protocol for sampling cargo net unloadings will be completed and implemented, including the unloading of vessels with cold chambers;
- Sampling will be carried out at the port of La Unión and efforts will be made to find more efficient ways of meeting cost and logistical requirements, without affecting the quality of the data collected, when sampling in ports outside of Ecuador;
- Efforts will be made to continue to improve the use of the working tools: scales, voice recorders and GoPro cameras, as well as in the office activities related to handling the data collected;
- Communication with the various stakeholders will continue to be strengthened by seeking support in sending RDLs prior to vessel arrival and in the coordination for port sampling.

ACKNOWLEDGMENTS

The authors extend a special thank you to the samplers Jennifer Aguilar, Grace Álvarez, Carlos Bravo, Pablo Delgado, Jonathan Gaibor, Juan Galarza, José Guillén, Javier Mejía, James Méndez, Diego Montehermoso, Marcos Muñoz, Darío Quimi, Alex Santana, Diego Ureta, Wellington Vásquez, Víctor Vinces, Ledin Vizueta, Robinson Zambrano, Tommy Zamora, and Alisson Zúñiga; the Field Office staff of Manta, Erick D. Largacha Delgado, Daniel E. Cevallos-Alarcón, Carlos de la A Florencia, Glenthon Macías Pita, Nilo Pérez, and Alex Urdiales; the Field Office staff of Playas, William E. Paladines Proaño and Felix F. Cruz Vargas; the national observer programs of Ecuador and Panama, and, to Dan W. Fuller, for their effort to help ensure the success of the EMP pilot study and to the fishing industry and Ecuadorian authorities for their collaboration on all aspects of this project.

TABLE 1. Detail of trips and wells sampled by vessel flag, for each phase of the EMP pilot study.
TABLA 1. Detalle de los viajes y las bodegas muestreadas por pabellón del buque, para cada fase del estudio piloto del PRM.

Vessel Flag	Trips			Wells		
	Phase 1	Phase 2	Total	Phase 1	Phase 2	Total
Ecuador	40	11	51	63	42	105
Spain	1	-	1	2	-	2
Nicaragua	3	-	3	6	-	6
Panama	9	3	12	15	18	33
USA	4	1	5	6	6	12
Venezuela	1	-	1	1	-	1
El Salvador	-	1	1	-	6	6
TOTAL	58	16	74	93	72	165

TABLE 2. Evolution of the various logistical aspects related to sampling, from Phase 1 of the pilot study in September 2022 to the implementation of the EMP in March 2023.
TABLA 2. Evolución de los diversos aspectos logísticos relacionados con el muestreo, desde la Fase 1 del estudio piloto en septiembre de 2022 hasta la implementación del PRM en marzo de 2023.

Pilot study Phase 1 Intensive sampling	**Pilot study Phase 2 Test of designed protocol**	**EMP 2023**
Samplers		
4 samplers per team, periodically rotating amongst the following tasks: - Counting units as they are unloaded from the well - Identify all fish and measure all tunas in the unit selected for sampling. - Write the collected data on physical forms.	3 samplers per team, periodically rotating amongst the following tasks: Counting units as they are unloaded from the well Identify all fish and measure all tunas in the unit selected for sampling. - Write the collected data on physical forms.	2 samplers per team, periodically rotating amongst the following tasks: Counting units as they are unloaded from the well Identify all fish, measure all tunas and voice record data from the unit selected for sampling.
Sampling sequence		
Selection of 1 out of 10 units for sampling from a random starting unit in the first 10 units unloaded from the well.	Selection of 1 out of 30 units for sampling from a random starting unit in the first 30 units unloaded from the well.	Selection of 1 out of 30 units for sampling from a random starting unit in the first 30 units unloaded from the well.
Average time between units selected for sampling		
6 minutes	30 minutes	30 minutes
Data Collection		
On paper forms	On paper forms	With a digital voice recorder
Type of measurement		
Fork length in millimeters	Fork length in millimeters	Weight in kilograms. Measurement with the use of electronic scales.
Trips sampled		
A total of 58, with 1 to 3 wells sampled per trips.	A total of 11, with 6 wells sampled per trip.	It is estimated that the EMP will be able to sample around 100 trips per year.

FIGURE 1. Samplers workshop held in September 2022. Samplers were trained in the sampling protocol designed for the pilot study and in the identification of the three tropical tuna species: BET, SKJ and YFT.
FIGURA 1. Taller de muestreadores celebrado en septiembre de 2022. Se capacitó a los muestreadores en el protocolo de muestreo diseñado para el estudio piloto y en la identificación de las tres especies de atunes tropicales: BET, SKJ y YFT.

Trip: [redacted] - [redacted] with 1286MT of capacity and 68% of fullness [redacted]

Left from Posorja - No arrival date

WELL ID	BET-E	YFT-E	SKJ-E	BET-W	YFT-W	SKJ-W	OBJ-E	NOA-E	DEL-E	OBJ-W	NOA-W	DEL-W
C01	0	0	0	0	0	67	0	0	0	0	1	0
P02	0	0	0	14	10	29	0	0	0	2	0	0
P03	0	0	0	11	62	22	0	0	0	2	0	0
P05	0	0	0	21	30	64	0	0	0	4	0	0
P06	0	0	0	21	28	46	0	0	0	3	0	0
P07	0	0	0	82	31	62	0	0	0	1	0	0
P08	0	0	0	85	36	74	0	0	0	2	0	0
P09	0	0	0	26	1	24	0	0	0	2	0	0
S02	0	0	0	17	44	34	0	0	0	3	0	0
S03	0	0	0	14	46	40	0	0	0	2	0	0
S05	0	0	0	19	21	60	0	0	0	3	0	0
S06	0	0	0	15	38	47	0	0	0	2	0	0
S07	0	0	0	20	11	44	0	0	0	3	0	0
S08	0	0	0	82	31	62	0	0	0	1	0	0
S09	0	0	0	47	2	101	0	0	0	4	1	0
Total	**0**	**0**	**0**	**231**	**214**	**431**	**0**	**0**	**0**	**25**	**2**	**0**

FIGURE 2. An example of the information shown in the IDM dynamic table developed for the EMP. BET-E is retained catch east of 110°W and BET-W corresponds to retained catch between 110°W and 150°W. Retained catch means loaded into the vessel.
FIGURA 2. Un ejemplo de la información que aparece en la tabla dinámica del IDM desarrollada para el PRM. BET-E corresponde a la captura retenida al este de 110°O y BET-W corresponde a la captura retenida entre 110°O y 150°O. Captura retenida significa captura cargada en el buque.

FIGURE 3. Sampler equipment: A) scale, B) caliper, C) voice recorder, D) GoPro camera, E) counting sheet.
FIGURA 3. Equipo de muestreo: A) balanza, B) calibrador, C) grabadora de voz, D) cámara GoPro, E) hoja de conteo.

FIGURE 4. Portable scale with custom tray and anti-vibration base.
FIGURA 4. Balanza portátil con bandeja modificada y base antivibraciones.

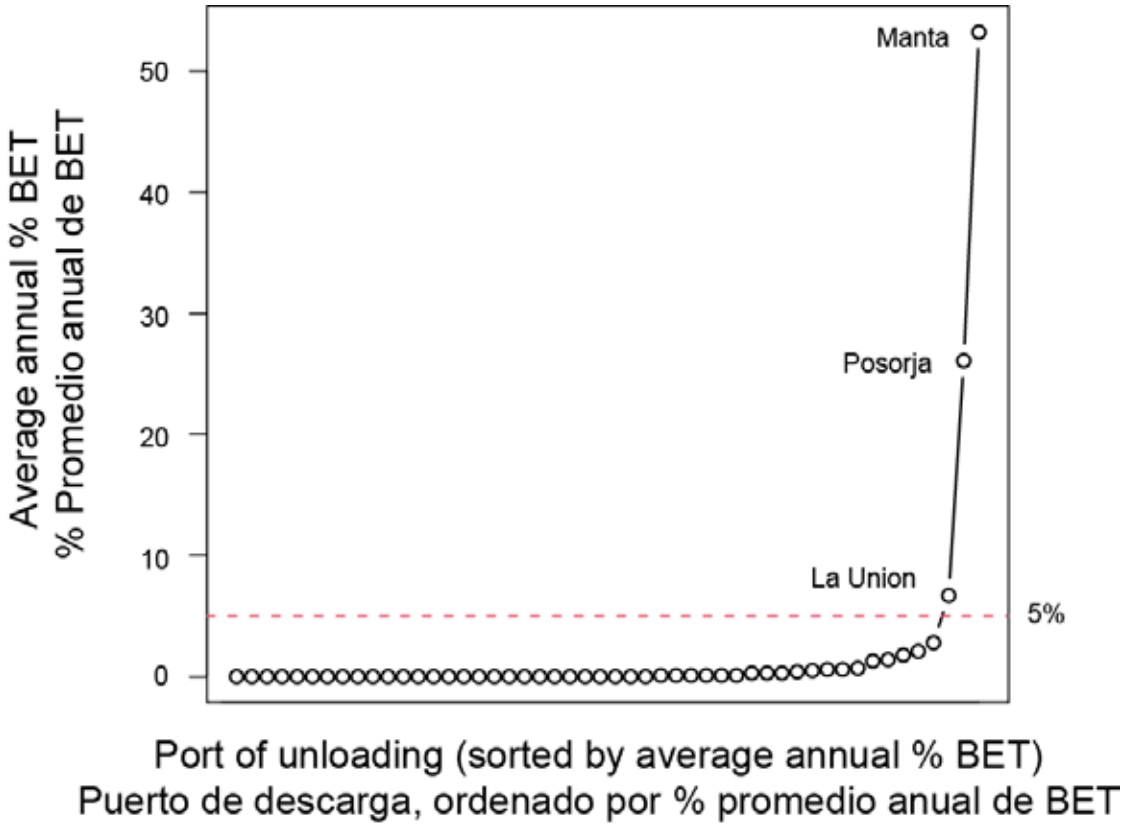

FIGURE 5. Average annual percent of retained BET catch, by port of unloading, sorted from lowest to highest values. The retained BET catch is obtained from observer and logbook data (Class 1-6 vessels; all three set types), for years 2010 - 2022. The average percentages are computed as follows: a) for each year, the retained BET catch per trip is summed across trips according to the port of unloading; b) these annual sums are converted to percent by dividing by the total across ports; and, c) by port, the annual percentage values are averaged over the 13-year period. The red dashed line is at a value of 5%.

FIGURA 5. Porcentaje promedio anual de captura retenida de BET, por puerto de descarga, ordenado de menor a mayor. La captura retenida de BET se obtienen a partir de los datos de observadores y de bitácora (buques de clases 1-6; los tres tipos de lance), para el periodo 2010-2022. Los porcentajes promedio se calculan del siguiente modo: a) para cada año, la captura de BET retenida por viaje se suma en todos los viajes según el puerto de descarga; b) estas sumas anuales se convierten en porcentajes dividiéndolas por el total de todos los puertos; y c) por puerto, los valores porcentuales anuales se promedian a lo largo del periodo de 13 años. La línea punteada roja está en un valor del 5 %.

Appendix 1 -EMP Protocol – (Translation pending)