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PILOT STUDY FOR THE INDIVIDUAL VESSEL LIMIT PROGRAM TO MONITOR BIGEYE TUNA CATCHES: UPDATE

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SUMMARY

In late October 2021, the Commission, at its 98th Meeting of the IATTC, established an Individual Vessel Limit (IVL) program for bigeye tuna catches. Beginning in 2023, this program will include additional port-sampling of the wells of trips that are considered to have caught a substantial amount of bigeye tuna. In order to prepare for this enhanced port-sampling component of the IVL program, an IVL pilot study was funded by the Commission, to take place in July – December 2022. In this document, the planned first phase (Phase 1) of the IVL pilot study is described in detail. This phase will focus on collection of extensive well sampling data to be used in simulations to test sampling designs for estimation of well-level and trip-level catch composition. This will be followed by a second phase that will focus on field testing of the best sampling design from Phase 1, to identify and resolve any potential logistical issues. This document includes a description of the sampling protocol for Phase 1, the cooperation from vessel crew and unloaders that will be necessary to implement this protocol, and the anticipated numbers of wells that will be sampled. A brief description of the use of the extensive well sampling data in the simulations is also presented.

BACKGROUND

Resolution C-21-04, adopted by the Commission at the 98th Meeting of the IATTC in late October 2021, established an IVL program to address conservation concerns related to bigeye tuna (BET). The compliance monitoring aspect of the IVL program has two components. The first component, which began in January 2022, is to use existing data sources (i.e., observer/logbook, cannery) to monitor compliance for all trips. The second component, which is to begin in January 2023, will monitor compliance for trips considered to have caught a significant amount of BET through a special port-sampling program (IVL enhanced port-sampling program). The Resolution also established a pilot study, to take place between July – December 2022, for the purpose of developing and field-testing sampling designs that will be used to estimate well-level and trip-level catch composition during the IVL enhanced port-sampling program.

The IVL pilot study will serve two main purposes, and for this reason it can be viewed as occurring in two phases. In Phase 1, data will be collected for a simulation study to test sampling designs. It is anticipated that Phase 1 will occur during July – October 2022. To generate the data necessary for the simulation

study, the sampling conducted during Phase 1 will focus on extensive sampling of catch from specific wells. Extensive well-sampling is necessary to identify and characterize any trends in the species and size composition of the catch as it is unloaded from the well. In Phase 2, which will take place during November – December 2022, sampling designs developed in Phase 1 will be field-tested to identify and resolve any logistical problems prior to initiation of the IVL enhanced port-sampling program in January 2023. The field-testing of Phase 2 will involve sampling of multiple wells of the same trip, in the same manner as would be done in 2023, and generating estimates of the catch composition. An added benefit of Phase 2 is that the trip-level estimates of catch composition can be compared statistically to cannery and observer (logbook) estimates for the same trip to assist the IATTC staff in its determination of the preferred data source for the Best Scientific Estimate (BSE) of catch composition for trips that will not be sampled by the IVL enhanced port-sampling program.

The extensive sampling of purse-seine catch at the time of unloading that will be conducted during Phase 1 of the IVL pilot study builds on studies conducted previously by IATTC staff. In the late 1980s, a study was undertaken to evaluate sampling design options for estimating the length composition of yellowfin tuna caught in sets on dolphin-associated schools (DEL) and on unassociated schools (NOA) (Wild 1994). The study protocol involved measuring the length of every n^{th} fish in the unloading, in the order in which it was unloaded. Wild's results indicated that both short-term and long-term trends in length were present in the sequence of unloaded fish (Figure 1), due to factors such as size selection by unloaders and stratification of the catch within the well. The sequential length data collected during the study were used to generate synthetic length-composition data for individual wells and test via simulation the performance of various sampling designs. Results of this study informed the port-sampling data collection protocol for length composition in the 1990s and the species composition sampling protocol (e.g., appendix in Suter 2010) that began in 2000. In particular, there was the recommendation to conduct 'protracted' sampling so as to obtain a sample from a greater fraction of the unloading, thereby helping to mitigate bias that could be caused by stratification of the catch, either species or size, within the well.

Since the study of Wild (1994), the purse-seine fishery on floating objects (OBJ) has evolved from a more coastal fishery on both natural objects and fish-aggregating devices (FADs) to a fishery that extends across the eastern Pacific Ocean (EPO) and primarily uses FADs (SAC-13-03). Likely to investigate the applicability of the Wild (1994) results for sampling wells with catch from FAD sets, a study was initiated by IATTC staff in 1999 that included exhaustive sampling of several wells with catch from OBJ sets, recording the species and weight category[1] of every fish in each unloading, in the order in which it was unloaded. A preliminary inspection of those data suggests the potential for variability in species composition over the course of the unloading, particularly for BET (Figure 2).

Both of these previous studies identified changes in catch composition that occurred over the course of the unloading of a well that will be important to confirm for the current fishery catching BET, and if present, account for in the sampling design for the IVL enhanced port-sampling program. Within-unloading changes in species and/or size composition of the catch from a single well could lead to bias in the estimates of catch composition for a trip, if not taken into consideration when developing the sampling design. Data collected during Phase 1 of the pilot study will be used to evaluate: a) whether there are within-unloading changes in catch composition; and b) through simulation studies, the ability of different sampling designs to mitigate any bias that might otherwise arise in well-level and trip-level catch estimates. Simulation studies using data from the current port-sampling program would be ineffectual in this regard for several reasons. First, the data from each sampled well represent a single 'snapshot' from the unloading. Second, how any within-unloading changes in catch composition may differ among vessels

[1] There are three weight categories for tunas used by IATTC observers and staff (e.g., Fuller et al. 2022): 'small': < 2.5 kg; 'medium': 2.5 – 15 kg; 'large': > 15 kg.

is not known. It is noted that this is not necessarily problematic with respect to estimation of the catch composition of the fleet, as long as trips are selected at random for sampling and the starting point of the sampling of individual wells is selected at random.

The sampling protocol used in the IVL enhanced port-sampling program must necessarily be different from that used by the regular IATTC sampling program because the IVL program is expressly structured to promote vessel-specific modifications to normal fishing practices. The nature and effect of any such modifications may vary through time for an individual vessel as it approaches its BET catch limit. The sampling protocol used by the regular port-sampling program stratifies the data collection by type of purse-seine set, area and month of fishing, and vessel size class category, but not by vessel or trip. This would not allow for estimation of the catch composition of individual trips without assuming that fishing behavior has little effect on catch composition at the trip level, within a vessel or among vessels. On the other hand, the IVL program expressly seeks to encourage changes in vessel-specific behavior over time, i.e., from one trip to the next, to achieve a reduction in BET catches for the fleet, and therefore the IVL enhanced port-sampling protocol must focus on collection of data appropriate for estimating well-level and trip-level catch composition, as well as their variances.

This document summarizes the current sampling plans for Phase 1 of the IVL pilot study. In as much as the protocol described in this document will be tested in July before data collection begins in earnest, it can be expected the protocol may evolve to some extent to improve its implementation.

PHASE 1 SAMPLING PROTOCOL

The purpose of Phase 1 of the IVL pilot study is to collect data that can be used in a simulation to test sampling protocols, as well as estimation methods, for the IVL enhanced port-sampling program. Ideally, the data collected for each well sampled during Phase 1 would be the identification of the species and length of every fish unloaded from the well, in the order they were unloaded. Such data would fully capture any trends in the species and size composition characteristics of the unloading. However, IATTC staff are concerned that collection of such data would cause substantial delays to the unloading of the well that was being sampled, in addition to the unloading of other wells of the same trip, and would yield too few well samples, given the time and resources available for the pilot study. Therefore, a practical approach to extensive well sampling will be adopted, with the intention of minimizing impact on the normal unloading process of the vessel yet yielding adequate, high-quality data with which to conduct a simulation study.

This practical approach will entail sampling every n^{th} "group of fish" (defined below) that is unloaded from the well, instead of every fish, or even every n^{th} fish. For each n^{th} group of fish, the species and length of every fish in the group will be recorded. To minimize the impact of sampling on the unloading operations of the vessel, the teams of samplers will be larger than those currently used by the regular IATTC port-sampling program. Nonetheless, the sampling will require cooperation from vessel crew and unloaders. The details of the sampling protocol are as follows:

- A well of a particular trip will be selected for sampling depending on the operational characteristics of the trip, as well as those of previous trips of the vessel. (More than one well may be selected for sampling from the same trip.)
- A team of 4 samplers will be required to extensively sample the catch of a well.
- The four members of the sampling team will have the following tasks:
    - one person will be positioned at the well head counting the "groups of fish" as they are unloaded, and selecting every n^{th} group for sampling. How a group of fish is defined will depend on the unloading method, but in general it will be defined as either a container

of fish, when the catch of the well is unloaded using containers, or a collection of individual fish (e.g., 100 or 150 fish), when containers are not used to unload the catch in the well. (Unloading methods are discussed below.)

  - two people will measure, and identify to species, each fish in every n^{th} group of fish;
  - one person will record the species identifications and length measurements for every n^{th} group of fish.

- A four-person team will sample one well per day.

Different values of *n* will be tested in July. At this point, it is anticipated that *n* = 10, i.e., sampling every 10^{th} group of fish, will be possible, while still keeping pace with the normal unloading process. The goal will be to use an *n* that is as small as possible to provide the finest within-well resolution of the sample data as possible while still keeping the sampling protocol practical. This will likely require the team of samplers to identify to species and measure several thousand fish per unloading. Frequency distributions of the estimated number of fish per well for IATTC Class-6 vessel wells with catch from OBJ and NOA sets (Figure 3) have a mode at about 15,000 fish per well for OBJ-set catch and at about 20,000 fish per well for NOA-set catch.

This sampling protocol is intended to try to minimize delays on the normal unloading of the sampled well, but it will not be without any impact and will be more time consuming than the current IATTC well sampling protocol that facilities and unloaders are used to. In particular, it will be essential that the vessel crew and unloaders:

- Provide space for the three samplers collecting the species identification and length data near the well head area, and space for the one sampler at the well head counting the groups of fish.
- Assist the team of samplers in moving the group of fish away from the immediate unloading area at the well head to a nearby location where data collection can safely take place, without delaying the unloading of the well.
- Return the sampled group of fish to the next step in the unloading process, once the sampling team has collected the species and length composition data;
- Delay unloading briefly if the sampling team falls behind the normal unloading pace and is not immediately ready to process the n^{th} group of fish at the time it is unloaded from the well.

Although it is anticipated that the sampling conducted during the IVL enhanced port-sampling program will be less extensive than that conducted during the Phase 1 of the IVL pilot study, it is expected that the same space requirements for the sampling team and cooperation from the vessel crew and unloaders will be required. As the pilot project nears completion, it is essential to have more certainty in this respect.

To facilitate identification of trips and wells to sample before vessels arrive to port, so as not to further delay the unloading, well information will be provided by observers as part of their required, at-sea weekly reports (for trips carrying an observer). This added information will not only benefit both phases of the IVL pilot study, but will be essential to implementation of the IVL enhanced port-sampling program. Thus, the pilot study will provide a "test run" for collection and processes of this new information. Although the emphasis of Phase 1 of the pilot study will be on sampling trips of Class-6 vessels, sampling of wells of smaller purse-seine vessels (e.g., Class-5 vessels) may also be conducted.

The sampling during Phase 1 of the IVL pilot study will be concentrated in Ecuador, in the ports of Manta and Posorja. Manta and Posorja are two of the principal ports at which BET catch is unloaded (SAC-13 INF-L). However, if time and resources permit, sampling may also be conducted in a few other countries and

ports where vessels catching BET unload, such as Mazatlan or Manzanillo, Mexico, to collect data from wells that are unloaded with methods not commonly used in Manta and Posorja (see below).

An important part of Phase 1 of the IVL pilot study will be to sample wells with fish caught using different operational characteristics (e.g., set types, areas of fishing) and unloaded using different unloading methods (see below). Given the range in the number of wells per vessel for Class-6 vessels (Figure 4), it is anticipated that during the IVL enhanced port-sampling program it will not be possible to sample every well of a trip, and therefore it will be important to establish how to select wells, and optimize sampling, to best estimate the well-level and trip-level catch composition and their variances. Because the focus of the IVL program is on BET catch, it will be important to sample wells loaded with catch from OBJ sets, as this set type generates the majority of the BET catch, as well as NOA sets, and mixed set types, in particular catch from OBJ and NOA sets, which have historically represented about 10% of the wells of Class-6 vessels unloading in Manta and Posorja (Figure 5). (DEL sets catch effectively no BET (SAC-13-03).) Spatial strata will be defined for sampling to capture the inshore-offshore gradient in bigeye catch within the EPO (e.g., SAC-10 INF-D; FAD-05 INF-A and INF-C). The exact inshore-offshore boundary has yet to be chosen, but may follow the spatial fishery definitions used in the latest BET stock assessment (SAC-11-06 REV), which would suggest an inshore/offshore boundary at 110°W.

There are two primary well unloading methods used in Manta and Posorja. The first is referred to as a "dry" unloading. At the beginning of a dry unloading, the unloaders remain outside the well, removing the fish at the well head, until sufficient space has been created that they may enter the well. The unloaders then enter the well, break the fish free, in cases where they are frozen together, and load the fish into containers inside the well. When these containers are full, they are removed from the well and the fish emptied onto a conveyor belt or into chutes or other containers for off-loading from the vessel. The empty containers are then returned to the well to be loaded with more fish. Dry unloadings are common in Posorja. The second type of unloading, which is common in Manta, is a mix of flotation and dry unloading methods. The flotation method is used to unload the top portion of the well (as much as the upper 50%), followed by dry unloading of the rest of the well. With the flotation method, the cooling system for the brine is turned off, allowing the fish to break loose and float freely within the well. The freely-floating fish are unloaded at the well head onto a conveyor belt, chutes or into containers. Wells unloaded using one of these two methods will be the focus of sampling during Phase 1 because of the prevalence of their use in the two main ports where BET catch is presently unloaded. However, if resources and time permit, wells unloaded using only the flotation method, such as occurs in Mazatlan, Mexico, or wells unloaded by the dry method but through other wells, such as occurs occasionally in Posorja, will also be sampled.

The number of wells that can be sampled during Phase 1 of the IVL pilot study will depend on several factors, including available resources, the number of trips unloading during the months of July – October, and vessel cooperation. The budget for the IVL pilot study agreed upon at the 98th Meeting of the IATTC in October 2021 included funding for 8 samplers for 6 months, plus an additional 4 samplers that are to be provided "in-kind' by the government of Ecuador, for a total of 12 samplers or three 4-person sampling teams. Following careful review of the other positions funded for the pilot study, the IATTC staff have subsequently concluded that the tasks to have been covered by the scientific programmer position will be more efficiently completed by existing staff, which will make available funding to hire additional samplers for Phase 1 of the pilot study. It is anticipated that as many as 8 additional samplers will be hired, for a total of 5 four-person sampling teams. Given the physically-demanding and time-consuming nature of the sampling work, it is expected that each four-person team will sample three wells per week. Assuming availability of trips and vessel cooperation, between 9 wells (with 3 teams) and 15 wells (with 5 teams) will be sampled per week. At these rates, it is anticipated that between early August and late-October, it may be possible to sample between 100 and 165 wells. This level of sampling would equate to

roughly 12-20 wells sampled for each the 8 combinations of important factors described above: four set type - spatial categories (OBJ offshore; OBJ inshore; OBJ-NOA mixed; NOA) x two unloading method categories (dry only; mixed flotation and dry). With 5 sampling teams, sampling of less common unloading methods, and in Mazatlan in the latter part of October and early November 2022, will hopefully be possible.

PHASE 1 DATA ANALYSES

Estimates of the species and length composition of the n^{th} section of each unloading will be obtained from the sample data for the n^{th} group of fish of the unloading. The estimates can be used to investigate whether species and/or length composition varies over the course of the unloading, at a resolution of sections of size 1/*n* (or coarser). These estimates can also be used to construct synthetic unloading data for the simulations, with a section resolution of 1/*n*. In addition, given estimated amounts of fish unloaded in every n^{th} section of the unloading, either in weight from numbers of containers, or in numbers of fish from counts of groups of fish, the length composition of the catch of each species in the well can be estimated by raising the estimated length composition of each n^{th} section to the section catch and then summing over the *n* sections.

The purpose of the simulations will be to test different sampling designs and estimators of catch composition. Systematic sampling designs will be the focus of the simulation study because sampling designs based on simple random sampling have been found to be impractical (Wild 1994). The details of the candidate sampling designs have yet to be determined. However, with a section resolution in the synthetic unloadings for each well of 1/*n*, characteristics of systematic sampling designs that can be tested will include: a) designs with a coarser resolution than 1/*n*; and, b) trade-offs between increasing the number of fish sampled per group (section) and the number of sections sampled per well, which is related to the level of variability within *versus* among the *n* sections and the overall prevalence of the species of interest in the unloadings. This simulation work will be similar to a sampling design study recently conducted by the IATTC staff (Lennert-Cody *et al*. 2022) as part of the pilot study for a shark fishery sampling program in Central America (SAC-11-13). In that study, sampling designs were developed for estimating size composition of sharks and other species caught in artisanal longline fisheries. The unloadings of Costa Rican longline vessels were exhaustively sampled for species and weight category composition. Using the catch unloading sequences of 99 unloadings, systematic sampling designs and various estimators of size composition were tested to evaluate the error associated with the estimated size composition over a range of sampling frequencies. Design-based estimators of catch composition, similar to those used for the Best Scientific Estimate (Tomlinson 2002) will be considered. However, other types of estimators may also be explored.

Although the primary purpose of Phase 1 of the IVL pilot study is to develop practical and robust sampling designs to be used during the IVL enhanced port-sampling program, the data collected in Phase 1 will also be invaluable for exploring options for improving sampling designs used by the regular port-sampling program for estimating the catch composition of the purse-seine fleet. In particular, the data collected during Phase 1 will allow for an evaluation of the performance of the current port-sampling protocol for estimation of the catch composition from OBJ sets. Not only will this work potentially lead to improvements for the IATTC port-sampling program, but the result may also benefit sampling programs of other tuna Regional Fisheries Management Organizations.

QUESTIONS TO BE ADDRESSED IN PHASE 1

The questions that Phase 1 will attempt to answer through simulation include the following:

1) Are there significant changes in the species and/or length composition of the catch over the course of the unloading processes at the point where the catch first becomes available to

samplers? If so, do the magnitude of the changes differ by set type or area associated with the catch, or by unloading method? Is there a greater tendency for changes in species and/or length composition with unloadings of mixed-set type wells (e.g., OBJ-NOA mixed), as compared to single set type wells?

2) How many samples per well should be collected (and of how many fish) to best estimate the catch composition of a well and its variance? Should these sampling parameters differ depending on the set type(s) and area of the catch or the unloading method?

3) Is the variance associated with the estimated catch composition from the same trip and set type/area - but different wells - smaller or greater than the variance among samples within a well? In other words, if more than one well of a trip contains catch from the same set type(s)/area (i.e., "stratum"), should sampling be focused on obtaining at least one sample from each well or on obtaining multiple samples from one of the wells?

POTENTIAL CHALLENGES

There are several factors that may affect the number of wells that can be sampled during Phase 1 of the IVL pilot study, including:

- Continued presence of the COVID pandemic may limit the ability to sample at the desired level of intensity.
- The first closure period for purse-seine vessels (July 29 – October 8) may have some impact on the availability of trips to sample during Phase 1. Roughly, 50% of the vessels that typically unload in Manta and Posorja observe the first closure period. To a limited extent, this may be mitigated by sampling multiple wells of some trips.
- A lack of cooperation with the extensive sampling plan of Phase 1 would negatively impact data quality. Cooperation of vessels with the sampling will be essential to the success of the IVL pilot study and the IVL enhanced port-sampling program.

Should any of these challenges be encountered, Phase 1 will be extended to allow for collection of an adequate number of well samples.

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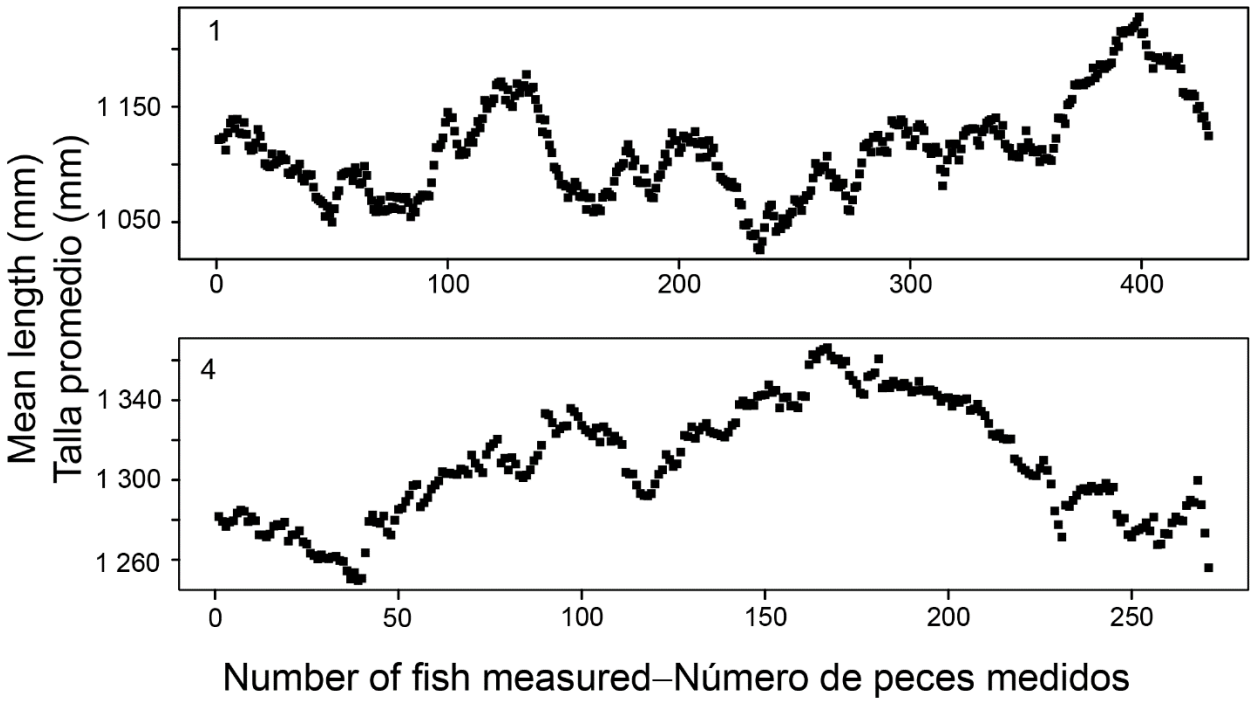

FIGURE 1. Mean length (moving average of 50-fish samples) for yellowfin tuna, from the data of Wild (1994), for two of the extensively sampled wells (Test Well 1 and Test Well 4, both containing catch from DEL sets).

FIGURA 1. Talla promedio (promedio móvil de muestras de 50 peces) para el atún aleta amarilla, a partir de los datos de Wild (1994), para dos de las bodegas muestreadas exhaustivamente (Bodega de prueba 1 y Bodega de prueba 4, ambas con capturas de lances DEL).

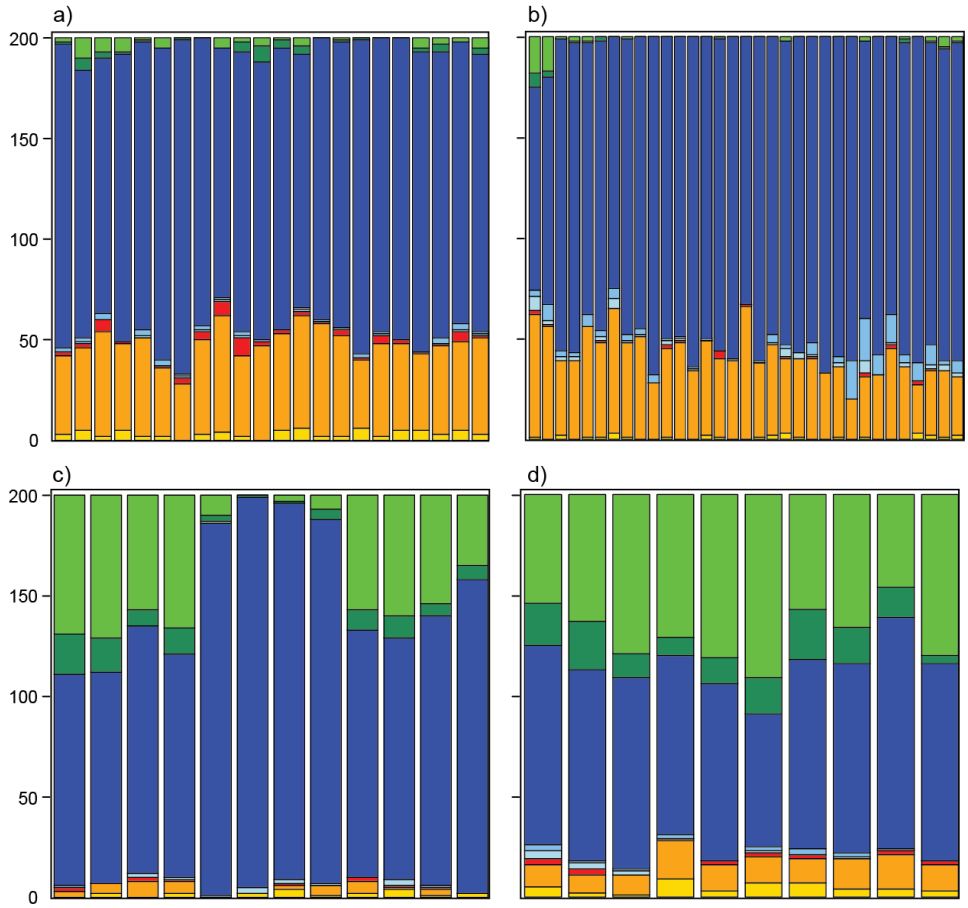

FIGURE 2. Data from exhaustive port-sampling of 4 wells, each well from a different vessel, that was conducted in 1999 by IATTC staff. Each panel is a separate well sample, and each vertical bar represents 200 consecutive fish (a block size of 200 fish was selected because this is the number of fish that might typically be counted for species composition under the current sampling protocol (appendix of Suter 2010)). All sampled wells contained catch exclusively from OBJ sets. Yellowfin tuna: small (yellow), medium (gold), large (red). Skipjack tuna: small (light blue), medium (blue), large (dark blue). Bigeye tuna: medium (dark green), large (medium green). Small: < 2.5kg; Medium: 2.5 – 15kg; Large: > 15kg. Total BET and tropical tuna catch – in numbers of fish – for each unloading were: (a) 75 BET, 6637 tropical tunas; (b) 112 BET, 4567 tropical tunas; (c) 615 BET, 2471 tropical tunas; (d) 849 BET, 2005 tropical tunas.

FIGURA 2. Datos de muestreo en puerto exhaustivo de 4 bodegas, cada bodega de un buque diferente, realizado en 1999 por personal de la CIAT. Cada panel es una muestra de bodega separada, y cada barra vertical representa 200 peces consecutivos (se seleccionó un tamaño de bloque de 200 peces porque éste es el número de peces que típicamente se contaría para la composición por especie bajo el protocolo de muestreo actual (anexo de Suter 2010)). Todas las bodegas muestreadas contenían capturas exclusivamente de lances OBJ. Aleta amarilla: pequeño (amarillo), mediano (dorado), y grande (rojo). Barrilete: pequeño (azul claro), mediano (azul medio) y grande (azul oscuro). Patudo: mediano (verde oscuro) y grande (verde medio). Pequeño: < 2.5 kg; Mediano: 2.5–15 kg; Grande: > 15 kg. El total de capturas de BET y de atunes tropicales, en número de peces, para cada descarga fue: (a) 75 BET, 6637 atunes tropicales; (b) 112 BET, 4567 atunes tropicales; (c) 615 BET, 2471 atunes tropicales; (d) 849 BET, 2005 atunes tropicales.

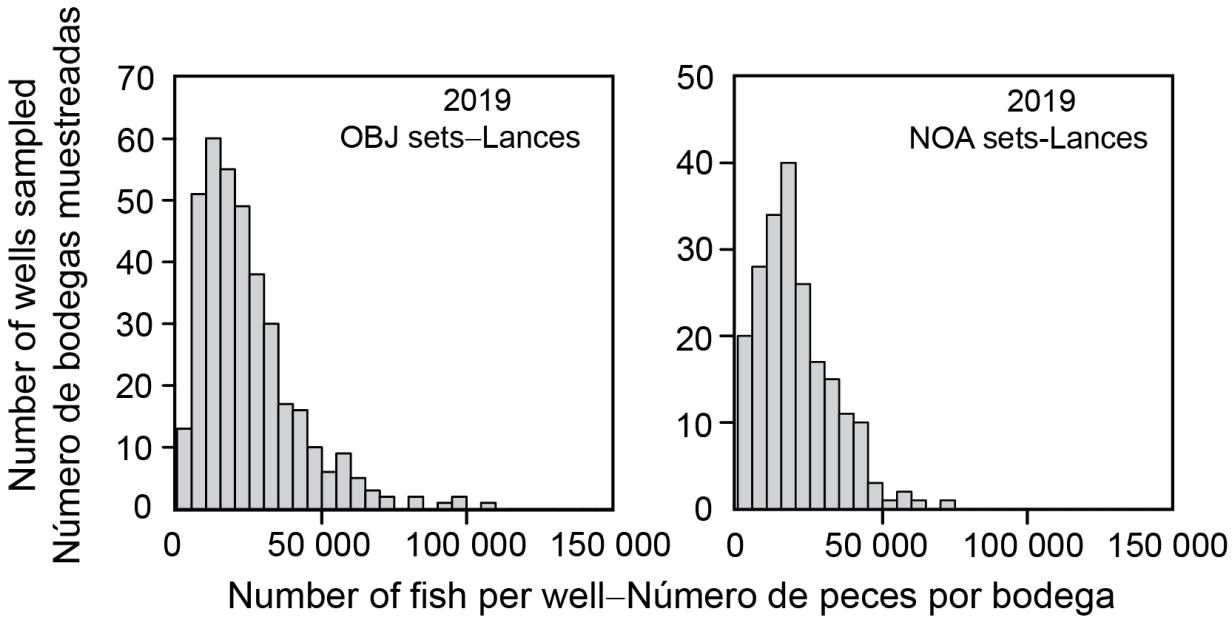

FIGURE 3. Frequency distributions of the estimated number of fish (yellowfin + bigeye + skipjack) per well for 2019 Class-6 vessels sampled by the regular port-sampling program, for wells with OBJ-set catch (left panel) and NOA-set catch (right panel).

FIGURA 3. Distribuciones de frecuencia del número estimado de peces (aleta amarilla + patudo + barrilete) por bodega para buques cerqueros de clase 6 muestreados en 2019 por el programa de muestreo en puerto habitual, para bodegas con captura de lances OBJ (panel izquierdo) y captura de lances NOA (panel derecho).

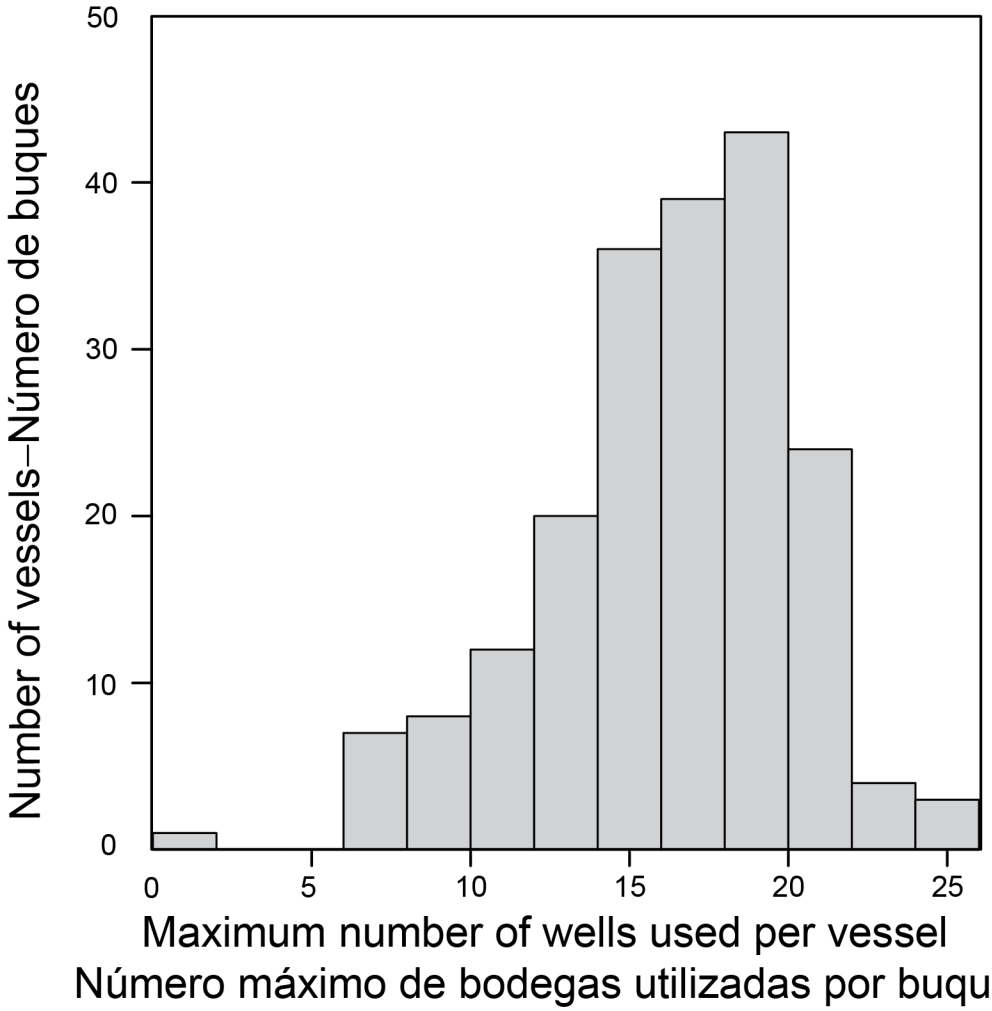

FIGURE 4. Frequency distribution of the maximum number of wells used per vessel for IATTC Class-6 vessels during 2017 - 2021.

FIGURA 4. Distribución de frecuencia del número máximo de bodegas utilizadas por buque, para buques cerqueros de clase 6 de la CIAT durante 2017-2021.

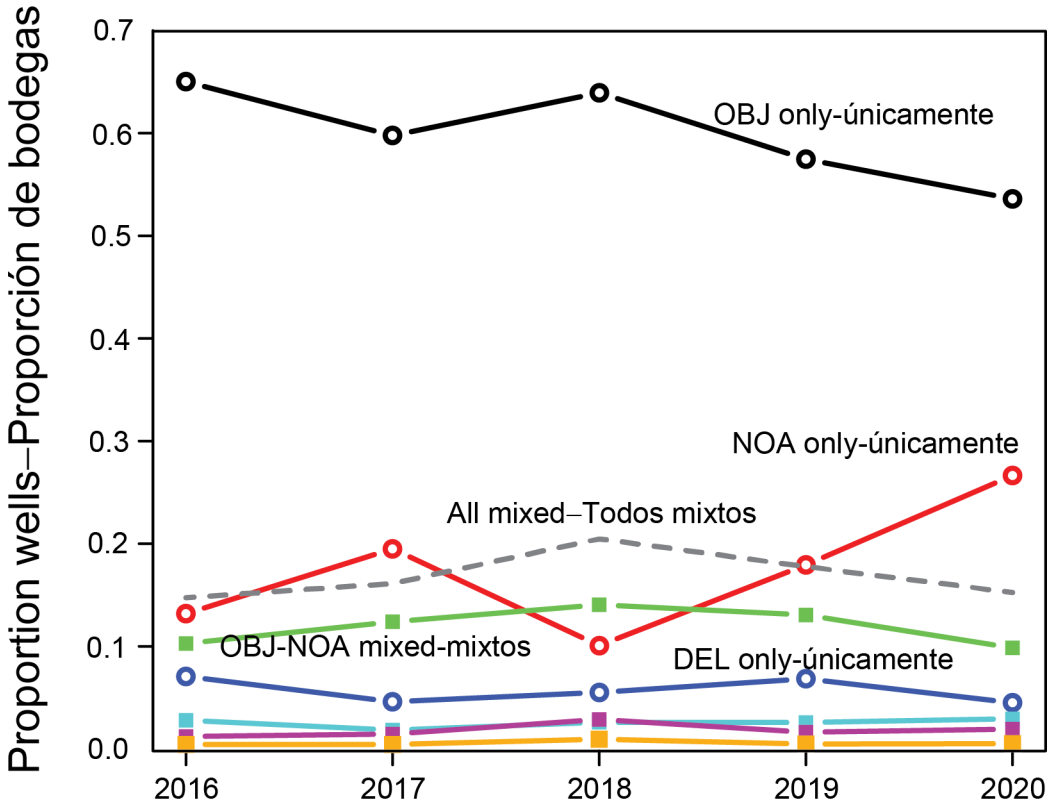

FIGURE 5. Proportion, by year, of wells unloaded, according to the set types associated with their catch, in Manta and Posorja, 2016-2020. Open circles indicate wells loaded with catch from only one set type and filled squares indicate wells with catch from more than one set type. The dashed gray line ("All mixed") indicates the proportion of wells with any mix of set types. Black: OBJ sets only; red: NOA sets only; dark blue: DEL sets only; green: OBJ and NOA sets; light blue: DEL and OBJ sets; pink: DEL and NOA sets; gold: DEL, NOA and OBJ sets.

FIGURA 5. Proporción, por año, de bodegas descargadas, según los tipos de lance asociados a su captura, en Manta y Posorja, 2016-2020. Los círculos sin relleno indican bodegas cargadas con capturas de un solo tipo de lance y los cuadrados rellenos indican bodegas con capturas de más de un tipo de lance. La línea gris discontinua ("Todos mezclados") indica la proporción de bodegas con cualquier mezcla de tipos de lance. Negro: lances OBJ únicamente; rojo: lances NOA únicamente; azul oscuro: lances DEL únicamente; verde: lances OBJ y NOA; azul claro: lances OBJ y DEL; rosa: lances DEL y NOA; dorado: lances DEL, NOA y OBJ.