# DOCUMENT SAC-14 INF-J

# IDENTIFYING DATA GAPS AND OPPORTUNITIES FOR UPDATING MORPHOMETRIC RELATIONSHIPS AND COLLECTING BIOLOGICAL SAMPLES FOR PRIORITY SPECIES IN EASTERN PACIFIC OCEAN TUNA FISHERIES

**CONTENTS**



## SUMMARY

Morphometric relationships (e.g., length-weight relationships) for tropical tunas are outdated and are likely no longer representative of the spatial extent of industrial fisheries. These same relationships for non-target species are either outdated, non-existent, borrowed from similar species within the region, and in some cases are based on data from other ocean basins, and do not represent populations impacted by eastern Pacific Ocean (EPO) fisheries. These data are a critical component to several research and reporting activities required to fulfill the objectives of the Antigua Convention and IATTC's Strategic Science Plan (SSP). Therefore, the staff have initiated a project (F.3.a) to address the deficiencies in these important relationships. This document summarizes the staff's internal discussions on the project during 2022. Background information, data gaps, and details on potential opportunities and considerations for implementing a proposed hierarchical sampling approach for collecting morphometric data and complementary opportunistic biological sampling (e.g., tissues, stomachs, vertebral centra, gonads, and otoliths), for tropical tunas and principal non-target species, are provided. These data are required for updating morphometric relationships and applying new methods for target and prioritized non-target species and to address data gaps identified in ecosystem-based analyses (e.g., ecosystem modeling and ecological risk assessments). The document concludes with the staff's recommendations for designing and implementing a phase-based sampling approach which includes (1) a feasibility component, (2) a pilot

study component and (3) a statistically robust sampling program covering various regions of the EPO from the coast to the high-seas and across different life stages from juvenile to adult animals. This document is complementary to SAC-12-09 and WSDAT-01-01 on improving data reporting for EPO fisheries.

## 1. BACKGROUND

Length-weight (L-W) and processed (i.e., gilled and gutted weight or headed and gutted weight) to whole weight (conversion) relationships are the foundation to a variety of research projects including stock assessments, ecological risk assessments (e.g., EASI-Fish) and catch estimations. These morphometric relationships may vary for each species by region and year depending on a suite of biological and environmental conditions. Furthermore, species and size composition of catches differ considerably between fishing gears (e.g., see SAC-14-03). This variability may influence both stock and ecological assessments and, when not accounted for, increase model uncertainty. Catch estimations are heavily influenced by L-W relationships as they are used to convert catch in numbers to weights and vice versa. Oftentimes, catch data are reported in numbers or weights and sometimes reported concurrently in both units with no explanation of the conversion methodology used. This is particularly an issue for taxa caught as bycatch in eastern Pacific Ocean (EPO) tuna fisheries (see IATTC Special Report 25). The L-W relationships for the principal tuna species are outdated by several decades (e.g., yellowfin: 1986 (Wild 1986), bigeye: 1966 (Nakamura and Uchiyama 1966) and skipjack: 1959 (Hennemuth 1959)) and remain a considerable data gap for many priority bycatch species (see SAC-13-11, SAC-09-12, IATTC Special Report 25). Use of these imprecise and/or outdated relationships can result in biased estimations of catch and may initiate inappropriate management responses. For example, tunas, billfishes, and sharks caught in industrial longline fisheries are recorded using various weight (e.g., trunk or whole weight) and length metrics (e.g., lower-jaw fork length and eye fork length for billfishes) depending on the stage of the fishing process from which data are collected. It's plausible that different stocks or sub-stocks of the same species may also have different relationships. Therefore, improvements to morphometric relationships are essential for improving the accuracy of biological and management quantity estimates.

Biological data are also critical for many of the scientific analyses conducted by the staff including stock, biological, and ecological assessments. An important example is the biological data needed to parameterize stock assessment models for the principal tuna species to characterize growth (e.g., age-at-length), reproduction (maturity ogives), longevity (maximum age), natural mortality (tagging and/or empirical biological relationships), and information on stock structure (tagging and genetic information). The IATTC's Biology Program contributes a considerable amount of information for the stock assessments of tropical tunas, which is derived from both field and laboratory research on movement (i.e., tagging), age and growth (i.e., otoliths and tagging), stock structure (tagging and genetics) and reproductive biology (i.e., through histological assessments). Similarly, the Ecosystem and Bycatch Program also rely heavily on biological data for various analyses including stomach content data and experiments on consumption rates that provide the foundation to ecosystem models, and age, growth and reproduction for the productivity component of ecological risk assessments (e.g. EASI-Fish, PSA). Future work and recommendations of the Ecosystem and Bycatch Program will also rely heavily on scientific assessments based on genetic information (e.g., to prioritize mitigation and management of a given population, estimates of abundance, movement and population structure based on Close Kin Mark Recapture).

With these concerns at the forefront, IATTC staff have initiated a project (F.3.a) for updating morphometric relationships and to opportunistically collect biological samples for tunas and other priority species captured in EPO tuna fisheries. Concurrently, the staff is working on harmonizing and improving data collection with the ultimate goal of updating the Resolution on data provision (C-03-05) to better align scientific research with the objective, rules, and relevant provisions of the Antigua Convention (see SAC-12-09, WSDAT-01-01). The Convention entered into force over a decade ago, but the provision and types of data—including size composition data essential for stock and ecological assessments—has not kept pace.

Project F.3.a aims to evaluate the feasibility of developing a sampling program, with potential upscaling to a pilot and EPO-wide sampling program, to improve morphometric relationships for the principal tuna species and other priority species and to opportunistically collect biological samples. Similar work is conducted in the western and central Pacific Ocean (SC18-ST-IP-04) and the SPC Oceanic Fisheries Programme has established observer sampling protocols for both longline (Fukofuka et al. 2021) and purse-seine (SPC-OFP 2021) fisheries, including guidelines and forms (see Form GEN-4 Conversion factors) for recording multiple measurements on the same fish. The purpose of the proposed sampling program is to build a comprehensive database of the various lengths (e.g., fork length, total length, standard length) and weights (e.g., whole weight, processed weight) collected in the field for the same individuals of principal tuna species and prioritized bycatch species to allow scientists to develop the morphometric relationships needed for stock and ecological assessments.

## 2. OBJECTIVES

The objectives of this paper are to (1) identify gaps in knowledge of key morphometric relationships and biological sampling, (2) identify potential opportunities to fill these information gaps and to evaluate the efficacy of sampling tunas, billfishes and prioritized bycatch species—using a hierarchical, phase-based approach—for collecting morphometric measurements and biological material, and (3) to offer some final considerations, which will ultimately determine the success of the proposed project.

## 3. MORPHOMETRIC RELATIONSHIPS

Obtaining morphometric data is important for many of the research tasks assigned to the staff as detailed in the themes listed in IATTC's SSP (e.g., "Life history studies for scientific support of management", "Sustainable fisheries", "Ecological impacts of fishing: assessment and mitigation"). Stock assessments rely on standard length measurements (e.g., fork length for tunas) and how these lengths relate to live weights to calculate for example, the total biomass of a population, to convert weights to the number of individuals in the total catch and to determine what proportion of the stock biomass is adult or juvenile using histologically derived maturity ogives.

Ecological assessments (e.g., EASI-Fish, Ecopath and estimations of total bycatch) require accurate length-weight relationships for (1) understanding size selectivity to reduce uncertainty in EASI-Fish vulnerability assessments (see e.g., WSDAT-01-01, BYC 11-02, SAC-13-11) and (2) to convert bycatch data—often reported in numbers—to weights for Ecopath mass-balance ecosystem models to better understand biomass flow and the internal structure and dynamics of an ecosystem (e.g., SAC-14-11 Olson and Watters, 2003) and similarly for converting bycatch numbers data to weights for annual catch estimations presented in IATTC's *Ecosystem Consideration*s report updated annually (e.g., SAC-14-11), so the relative impact of different fisheries on species are better understood.

Because at times it is not possible for fishers or observers to collect standard length measurements or whole weights (e.g., fishes may be processed, gilled and gutted, and headed and/or tailed), it is useful to collect alternative length or weight measurements (i.e., multiple lengths and weights on the same individual) to produce a standardized database of length and weight data from which specific morphometric relationships may be developed.

### 3.1. TUNA-BILLFISH

Tuna stock assessments have relied on outdated L-W relationships (yellowfin (Wild 1986), bigeye (Nakamura and Uchiyama 1966) and skipjack (Hennemuth 1959)) for decades. At times, reported weights for longline landings are not whole weight, but rather processed weight (gilled and gutted or headed and gutted), and there are currently no reliable morphometric relationships that are representative of the respective fisheries. Below the staff identify data gaps and potential opportunities specific to tunas and billfishes.

### 3.1.1. IDENTIFICATION OF DATA GAPS

Morphometric relationships, which are representative of the spatial extent of the stocks of the principal tuna species, are critical for accurate estimation of annual catch for tunas captured in both purse-seine and longline fisheries. Dating back to 1954, the IATTC has regularly conducted spatio-temporally stratified port-sampling of purse-seine catches to obtain length composition information of the tuna catch, by species. With the westward expansion of the purse-seine fishery in the mid-1990s, and to better capture changes to fishing strategies, whereby FAD fishing became a more prevalent fishing method, in 2000 IATTC modified its port-sampling protocol to include collection of data for estimation of species composition (in numbers of fish), in addition to length composition (Suter 2010). Using data from many sources such as observer records, vessel logbooks, and cannery records, as well as the port-sampling data on size and species composition, IATTC staff derive estimates of annual catch and total catch, by species (e.g., BET-02-06). However, current estimates may be biased as the morphometric relationships used to convert from fork length to weight are many decades old and are unlikely to represent the dominant fishing methods employed, nor do they reflect the spatial extents of modern fisheries. In addition to changes in fishing dynamics and effort, variability in environmental conditions have been relatively prolific since the tuna morphometric data were collected in the EPO (e.g., extreme El Niño events of 1997–1998 and 2015–2016 and strong La Niña events of 2007–2008, see SAC-14-11 section 4.1). Such dynamic ocean conditions may influence tuna growth and foraging success, which may therefore affect morphometric relationships. As a result, these relationships should be updated to account for varying environmental conditions.

The outdated relationships currently utilized were obtained from the sampling of frozen tunas at the point of unloading (Hennemuth 1959, Nakamura and Uchiyama 1966, Wild 1986). There are several issues which manifested from those methods; the first being the uncertainty of where the sampled fish were captured. In most cases, samples were derived from wells with multiple sets and therefore, the specific fishing area was unknown. Furthermore, when these samples were collected, the fishery primarily operated proximal to the coast, and its unlikely many samples were collected from offshore areas. Additional uncertainty about the reliability of these relationships is that they were collected during a time when navigation was primarily done using dead reckoning and/or from celestial methods, which are known to often be inaccurate. Reliability of these outdated L-W relationships is further exacerbated by measurement bias due to shrinkage of frozen fish (Anonymous 1974, Schaefer and Fuller 2006).

Having species-specific conversion factors (processed weight to whole weight and length to weight) derived from regional fisheries is a high priority. Longline data provided from the distant-water fishing nations, those from which historical indices of abundance are derived for stock assessments of tropical tunas, collect and report data in non-standardized ways. For example, depending on the source, data may be reported in weight (processed or whole) and/or numbers and lengths. Additionally, some weights are provided in a converted form with no indication as to how the conversion methodology was derived and subsequently applied. Furthermore, there is variability in the fish processing techniques between fleets. For example, distant-water Japanese fishers process the fish by removing the operculum and tail and then freeze the fish in ultra-low temperatures, while other local vessels land fresh fish and chill the fish with only the viscera and gills removed (Langley et al. 2006). EPO-specific conversion factors for gilled and gutted weight are non-existent. Therefore, stock assessment scientists use conversion factors for gilled and gutted fish weights for the entire Pacific Ocean developed by Langley et al. (2006) for yellowfin and bigeye tunas (SAC-07-04a). To account for variability in processing techniques, different conversion factors are needed (e.g., for chilled versus frozen at ultra-high temperatures).

Accurate representations of annual catch totals are extremely important for stock assessments for the principal tuna species, and without reliable morphometric relationships, uncertainty is compounded throughout the models. Ultimately, reliable estimates of stock status derived from assessment models are reliant on robust morphometric relationships. Data collection on morphometric relationships requires accurate measurements of lengths and weights prior to, and post, processing (e.g., weight measurements of the whole fish and of the gilled and gutted fish).

### 3.2. NON-TARGET SPECIES

Limited information on morphometric relationships is available for non-target species (e.g., elasmobranchs and teleosts) captured in industrial tuna fisheries. Many of the data on L-W relationships are either outdated, non-existent, or assumed to have the same parameters as related species that may have been studied in ocean regions other than the EPO.

#### 3.2.1. IDENTIFICATION OF GAPS

As noted above, morphometric relationships are an essential component of many of the research activities conducted by the staff of the Ecosystem and Bycatch Program. Ecological assessments of the pelagic EPO ecosystem require size and species composition data of the different fisheries operating in the region (e.g., EASI-Fish: Griffiths et al., 2019; Ecopath: Olson and Watters, 2003; and catch estimations: SAC-14-11). However, challenges arise with obtaining such data for species caught as bycatch. Collection and submission of catch by disposition (i.e., retained or discarded) and size composition data is not compulsory per IATTC Resolution C-03-05. This results in some members and cooperating non-members (CPCs) reporting catch data for taxa caught as bycatch while other CPCs do not report. Further complicating the issue is the need for reliable species identification. Without adequate training and experience in taxonomy, a fisher (e.g., captain or crew member) may not have the necessary knowledge to correctly identify an animal to species. This results in catches being reported as broad aggregations (e.g., "sharks"). Furthermore, for some fisheries and CPCs (e.g., industrial longline) bycatch is simply not recorded in logbooks. For example, data on non-tunas and non-billfishes are typically not recorded as these animals are not target species; however, some species of sharks with economic importance may be recorded (e.g., blue shark, *Prionace glauca*). Additionally, on longline vessels undesirable shark species are often released without landing the shark by cutting the leader, thus making measurements impossible. Moreover, measuring the lengths and weights of animals may be challenging due to their sheer size. For example, large sea turtles which become hooked on longline gear will likely not be landed. As a result, the IATTC relies heavily on observers and their extensive training, which includes species identification (see IATTC Special Report 25), to provide data pertaining to bycatch species. Although some observer data collected onboard longline vessels are available, analyses in BYC-10 INF-D showed that the mandated 5% observer coverage (Resolution C-19-08) is insufficient for expanding catches to fleet totals for the target tuna species, indicating catch estimates for bycatch species are likely to be even less reliable.

Conversely, 100% observer coverage on trips made by large purse-seine vessels (i.e., size class 6 vessels with a fish carrying capacity >363 mt) is mandated by the 1992 Agreement on the Conservation of Dolphins (the La Jolla Agreement). As a result, significant progress has been made in data collection of bycatch including development and implementation of dedicated identification keys and forms for specific taxa (i.e., billfishes, sea turtles, sharks, rays), which include space for observers to record size data (IATTC Special Report 25). However, multiple length measurements and weights are not obtained for each individual but rather a single length (e.g., post-orbital length for billfishes, TL for sharks, disc width for rays), is measured and/or size categories ("small", "medium" or "large") by number of individuals in each category are estimated. The sea turtle observer form is the only form that currently includes additional length measurements (e.g., shell length over the curve, shell width over the curve, head width, tail length), but no weight measurements are obtained. These size measurements and estimations are valuable for length-based analyses but are of limited use for developing morphometric relationships.

These issues described for purse-seine and longline data collections—the fisheries responsible for the largest proportion of catches—contribute to an extensive knowledge gap, not only for size composition data for non-target species, but also for fundamental species composition data (i.e., reliable species identification). Complementary to this proposed study (Project F.3.a), the staff have initiated a workshop series on data improvements for both target and non-target species following a SAC- and Commissioned-endorsed staff recommendation (SAC-12-RPT; SAC-12-16 see section B.3. "General Data Provisions"; WSDAT-01-01). Similarly, and in parallel, initiatives to improve species identification using smart tools are being explored by the staff (Project B.1.a).

More specifically related to ecosystem assessment analyses, 20 of the 32 shark bycatch species included in a recent EASI-Fish vulnerability assessment (SAC-13-11) were identified as "most vulnerable". One important component of this data-limited approach is the quality of L-W relationships used in the estimation of spawner biomass per recruit to determine vulnerability status. L-W relationships can take on various forms that use different length measurement types (e.g., fork length, standard length) reported in different measurement units (e.g., centimeters, inches) requiring the analyst to convert the relationship to a form that is appropriate for a specific analysis. For example, EASI-Fish utilizes L-W relationships in the common format of $W = aTL^b$ (TL in cm; W in kg), but shark data collected on longline vessels is frequently reported using a mixture of weight metrics (e.g., whole weight or processed weight). For these reasons, this study (Project F.3.a) aims to collect multiple length and weight measurements on individual animals to develop morphometric relationships for conversion of various measurement units of length (e.g., total length, standard length, fork length) and weight (e.g., gilled and gutted weight, whole weight). This project will ultimately greatly improve the reliability of assessment outcomes as well as catch estimations.

Another task routinely undertaken by staff is providing annual estimations of catch for species and/or species groups caught as bycatch in the annual *Ecosystem Considerations* report (e.g., see SAC-14-11). Fisheries data reports typically report data in weights, mainly because weights are used for catches of principal species. However, since 2004, bycatch data have typically been reported by observers on large purse-seiners in numbers of individuals (IATTC Special Report 25). Staff convert number data to weight data using morphometric relationships that are either outdated or non-existent for the EPO and therefore, require adoption of relationships from other oceans or related species (IATTC Special Report 25). For CPCs that report longline data on bycatch, annual data are summarized in weights only while aggregated spatiotemporal data (e.g., monthly 5°x5°) may be submitted in numbers of individuals, weights, or both units—as defined in Resolution C-03-05's corresponding data provision guidelines sent to CPCs annually by the Director (e.g., IATTC Memo Ref: 0130-410, dated March 23, 2023). Unfortunately, there is often no explanation of the methodology used to convert numbers data to weights or vice versa (SAC-12-09, WSDAT-01-01), thereby bringing into question the reliability of these submitted catch totals. These data gaps limit the staff's ability to provide reliable estimations of taxa caught as bycatch.

## 4. BIOLOGICAL SAMPLING: DATA GAPS

For exploited fish stocks, routine biological sampling is an efficient and effective way to monitor and evaluate fishing impacts on populations. For example, Schaefer and Fuller (2022) described a decrease in the size at maturity of yellowfin tuna when compared to earlier work by Schaefer (1998), which may be attributed to fishing impacts. Such changes in the population dynamics of exploited stocks can have a considerable impact on productivity and subsequent stock status and, ultimately management advice. Fishing impacts may manifest slowly, especially for long-lived species, meaning long-term monitoring and evaluation of biological processes is critical to keep stock and ecological assessments updated and reduce uncertainty in their outputs. Biological sampling of tunas has previously been limited to dedicated projects rather than through routine sampling programs, and thus have not captured possible changes in biological processes across different climatic events (e.g., El Niño, La Niña, and marine heat waves).

Additionally, biological data required for the EPO ecosystem model used to produce annual ecological indicators (e.g., mean trophic level of the catch; see SAC-10-15) is based on antiquated stomach contents analyses of samples collected three decades ago during 1992–1994 in the eastern tropical Pacific Ocean. Ecological changes observed in the ecosystem model updates of ecosystem indicators as well as substantial environmental events have occurred since that time (e.g., El Niño, La Niña and marine heat waves) (see SAC-14-11), and it is important to implement a modern sampling program to capture likely biological and ecological impacts from such events. Prioritizing and identifying potential opportunities for the collection of stomachs from the fishery, which extend beyond tropical areas, for many key species of tunas, billfishes and sharks provides the basis by which to monitor the impacts of such events. Sampling at the desired level (see potential opportunities in Tables 1 and 2) will allow IATTC staff to conduct spatiotemporal stomach contents analyses for species representing different trophic levels for development of spatially-explicit ecosystem models (e.g., Ecospace; Walters *et al.* 1999).

Finally, collection of tissue samples will be essential for conducting genetic studies on stock structure and close-kin mark-recapture (CKMR). The utility of CKMR may provide the means for staff to derive estimates of population size for species which cannot be reliably estimated by conventional stock assessment methods. With advances in genetic methods, collected tissues may also provide information on population structure, natal homing and natal origin for a range of impacted species, particularly sharks.

## 5. IDENTIFICATION OF SAMPLING OPPORTUNITIES: TUNAS, BILLFISHES, AND NON-TARGET SPECIES

The size composition of catches by different fishing gears, set type (e.g., shallow vs. deep) and fleets often differ significantly due to gear configuration and materials, operational behavior, and spatiotemporal distribution of the fishing operations. As such, this study will aim to sample across gear and fleet types to maximize both the spatial range, and size distributions for sampled fish. Collaboration with a range of stakeholders will be essential for developing and implementing sampling protocols efficiently. Therefore, staff will seek capacity building opportunities to create awareness, ascertain interest, and develop potential partnerships during the feasibility study (Phase 1, Part 1 Table 2). Efforts will also focus on identifying regions from which morphometric data may already be collected by national governments or universities. Collaborations will consider various constituents including Asian, European, Polynesian, and Latin American nations as well as SPC-WCPFC to harmonize with work already underway in the western and central Pacific Ocean. To sample the breadth of species and size classes, it will be important to include fisheries operating from the coast of the Americas to far offshore within the Convention area, which should include purse-seine fisheries, large distant-water longline fisheries, and other domestic, short-medium-range longline fleets and multi-gear/multi-species fisheries of the coastal States (Table 1; fisheries definitions adapted from those in SAC-12-09). The staff will also seek cooperation from fishing groups, vessel owners, and canneries prior to implementing any sampling, as their support is essential for a successful biological sampling program. Non-tuna and non-billfish species will be prioritized after performing a literature review and meta-analysis to determine which species should take precedence during implementation of the morphometric and biological sampling program.

To better identify how routine sampling will need to be implemented, the proposed project will occur in several stages (i.e., a hierarchical implementation approach with preliminary time frames and phases defined in Table 2). In the feasibility study (Phase 1, Part 2, Table 2), it is proposed that IATTC staff make both purse-seine and longline fishing trips to conduct morphometric measurements and opportunistically collect biological samples from tunas, billfishes, and prioritized bycatch species. During these trips, sampling by IATTC staff will be independent of any onboard observers, so that shipboard operations are not impeded. IATTC staff scientists will identify shortcomings observed or experienced during the execution of the sampling protocols and will work through alternative procedures while onboard the vessels. Results from the feasibility study will guide the revision of sampling protocols, at which time a determination can be made whether onboard observers can execute the proposed sampling, or if alternative approaches need to be considered before upscaling the project in the pilot study (Phase 2, Table 2). In this regard, it seems reasonable to think that Electronic Monitoring, if adopted and implemented in EPO tuna fisheries (e.g., EMS-01-01), could complement the information collected by observers onboard and/or relieve them to perform additional tasks to meet the scientific needs of the staff and the Commission. If the staff decide that onboard observers will be unable to execute the sampling, staff will consider alternatives, such as vessels carrying an additional sampler who will only be responsible for conducting the morphometric and biological sampling.

Should IATTC staff scientists be unable to conduct onboard sampling aboard some of the distant-water fishing fleets, collaborations will be considered with IATTC constituents. In this case, collaborators will implement the protocols designed in the feasibility study to identify potential shortcomings in the same manner outlined above, making efforts to find alternative methodologies, if needed, to efficiently conduct the morphometric and biological sampling within these fleets.

In addition to using IATTC observers, the staff will seek collaboration with coastal States, national observer programs, and other scientific entities. Where necessary, a Memorandum of Understanding will be drafted with each constituent to outline responsibilities, rights and obligations. Phase 1 of the applied feasibility study will be conducted onboard class 6 purse-seine vessels and tuna longline fishing vessels operating from coastal States (Table 2). After one year of sampling, the collected data will be reviewed and changes to the program will be considered based on findings of the staff and collaborators. These findings will guide the implementation of phase 2, the pilot study, where sampling will be upscaled to include class 1-5 purse-seine (≤363 mt fish carrying capacity) and large distant-water longline fishing vessels (Japan, Korea, Chinese-Taipei, China, and the European Union).

Logistics and practicality will likely differ among fisheries, and the impact of coastal, short-medium-range longline and multi-gear/multispecies fisheries is largely unknown. Therefore, staff will seek capacity building opportunities and possibilities for improving data collection from these fisheries, perhaps through collaboration with the current ABNJ (Areas Beyond National Jurisdiction) regional shark sampling projects (see SAC-14-01 Project C.4.c), which will be expanding from Central America to other EPO coastal States in 2023 (SAC-14 INF-M). The sampling opportunities posed by coastal States with important shark fisheries should also be considered, as they could likely be an important source of information for both morphometric relationships and biological sampling, especially for sharks. Note that the IATTC staff has already been collecting tissue samples for some elasmobranch species in recent years in certain coastal States, and experience and expertise was gained to obtain the necessary import-export permits for protected species (i.e., CITES).

Low-level, long-term biological sampling studies will be beneficial for developing knowledge of key biological process which will be utilized to improve conventional stock assessments and in ecosystem-related research, including updating parameters in ecosystem models and ecological risk assessment approaches and to monitor changes in the ecosystem, species, and populations over time. Opportunities to conduct such sampling will be considered through the collaboration and capacity building prospects outlined in Project F.3.a and this document, as well as potential discussions with participants attending the Data Improvement Workshop series (e.g., WSDAT-01, WSDAT-01-Rpt).

## 6. FINAL CONSIDERATIONS

There are several important logistical and financial issues that will ultimately determine the success of the proposed sampling program. Therefore, the staff has designed the project to have an iterative approach, starting with phase 1, the feasibility study, progressing to phase 2, a pilot study after correcting for any logistical concerns, and then implementing phase 3, a spatially explicit sampling program—covering coastal areas to high-seas throughout the EPO Convention area as well as different life stages (e.g., juveniles to adults) (Table 2). This will require input from biologists, stock assessment scientists, ecologists, and statisticians regarding outcomes of the feasibility and pilot studies to design a statistically robust sampling program that meets staff's needs.

Given the morphometrics component of this feasibility study is expected to be less complicated to implement compared to the biological sampling, as additional supplies, storage, financial and logistical constraints will affect the facilitation of biological sampling, this component is proposed to occur opportunistically, at least for the initial phases of the project. As the staff has limited on-site storage, particularly for samples requiring cold storage (e.g., stomachs, tissues), opportunities for biological sampling, supplies, and storage options will be pursued through IATTC regional offices, collaborations, and capacity building with CPCs and potentially universities within the region. Through these collaborations, discussions will need to include options for obtaining, storing, shipping and processing the samples. The success of a full EPO-wide biological sampling program is predicated on the outcome of the feasibility and pilot studies, including support from CPCs, fishing industry, and other stakeholders, as well as approval and funding from the Commission prior to implementation of the program.

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Table 1. Prospective opportunities for taking morphometric measurements and biological samples prioritized by fishery and sampling difficulty (e.g., morphometric measurements will likely be less complicated than extracting otoliths). Fisheries definitions adapted from SAC-12-09 on improving data reporting. Potential key non-target species are listed but will be defined and prioritized based on a literature review study and meta-analysis conducted by staff prior to implementing the feasibility study. YFT=yellowfin tuna, BET=bigeye tuna, SKJ=skipjack tuna, PBT=Pacific bluefin tuna, ALB=albacore tuna, SWO=swordfish.

| Fishery | Hierarchical Importance | Potential Opportunities | Target Species | Key Non-Target Species | Sampling |
|---|---|---|---|---|---|
| Large purse-seine size class-6 vessels (>363mt fish carrying capacity) | 1 | IATTC scientists, observers, collaborating scientist(s) | YFT, BET, SKJ, PBT | Silky shark, oceanic whitetip shark, hammerhead sharks, thresher sharks, dorado | (1) morphometrics, (2) tissue samples, (3) stomachs, (4) gonads, (5) otoliths (fishes); vertebrae (sharks) |
| Large longline fleets (i.e., from EPO coastal nations) | 1 | IATTC scientists, observers, collaborating scientist(s), fishing industry (e.g., US) | YFT, BET, SKJ, SWO, billfish, PBT | Silky shark, oceanic whitetip shark, hammerhead sharks, thresher sharks, dorado | (1) morphometrics, (2) tissue samples, (3) stomachs, (4) gonads, (5) otoliths (fishes); vertebrae (sharks) |
| Large longline fleets (i.e. from distant-water nations that operate mostly on the high seas) | 2 | IATTC scientist(s), observers, collaborating scientist(s), fishing industry considering multiple constituents (e.g., Asian, Polynesian, European and Latin American nations) | BET, YFT, SWO, ALB, billfish | Silky shark, blue shark, shortfin mako shark, opahs, snake mackerels | (1) morphometrics, (2) tissue samples, (3) stomachs, (4) gonads, (5) otoliths (fishes); vertebrae (sharks) |
| Small purse-seine size class 1-5 vessels (≤363mt fish carrying capacity) | 2 | IATTC scientist(s), voluntary observer programs (i.e., TunaCons), collaborating scientist(s), fishing industry considering constituents not involved in TunaCons | YFT, BET, SKJ | Silky shark, oceanic whitetip shark, hammerhead sharks, thresher sharks, dorado | (1) morphometrics, (2) tissue samples, (3) stomachs, (4) gonads, (5) otoliths (fishes); vertebrae (sharks) |
| Short-medium range longline fisheries (i.e., small-scale artisanal fisheries of the coastal States) and other gears (e.g., driftnet, gillnet) | 3 | ABNJ, OSPESCA, Mexico, Ecuador, Peru, Chile (CPPS) in collaboration with IATTC scientists; opportunities to sample shark nursery areas | Multispecies (sharks, dorado, billfish) | Silky shark, oceanic whitetip shark, hammerhead sharks, thresher sharks, dorado | (1) morphometrics, (2) tissue samples, (3) stomachs, (4) gonads, (5) otoliths (fishes); vertebrae (sharks) |

Table 2. Potential opportunities for developing a sampling design and phased implementation of morphometric and biological sampling programs for fisheries operating in the IATTC Convention area. PS: purse seine, LL: longline fisheries; L-W: length-weight.

| Phase 1 | Action | Outcome | Preliminary timeline | Collaborators |
|---|---|---|---|---|
| Feasibility study (Part 1: planning) | Identify biological samples to be collected | List of morphological measurements (e.g., FL, TL, WW, GGW); List of biological samples (e.g., tissues, stomachs) | January–May 2024 | Stock assessment, Biology and life-history, Ecosystem and bycatch, and Data Programs; CPCs, fishing industry, SPC-WCPFC |
| | Identify priority species through literature review and meta-analysis | List of priority species to sample (e.g., silky sharks, hammerhead sharks) | | |
| | Design feasibility studies with sampling protocol for both PS and LL fisheries | Development of data collection forms and data/sample storage protocols | | |
| | Identify capacity building opportunities and potential collaborators | List of vessels to be used for sampling; List of external collaborators | | |
| | Identify storage opportunities for biological samples | List of potential storage facilities | | |
| | Preliminary design of a database for morphometric measurements and biological samples | Beta database structure developed | | |
| **Phase 1** | **Action** | **Outcome** | **Preliminary timeline** | **Collaborators** |
| Feasibility study (Part 2: implementation) | IATTC staff to execute feasibility studies aboard class 6 PS and coastal tuna LL fishing vessels | Evaluation of collected data and samples; Revision of sampling protocols prior to implementing pilot phase | June 2024–May 2025 | Stock assessment, Biology and life-history, Ecosystem and bycatch, and Data Programs; CPCs, fishing industry, SPC-WCPFC |
| | Pursue capacity building opportunities with potential collaborators within distant-water LL fleets (in preparation for Phase 2, Pilot study) | List of potential distant-water fishing vessels for sampling | | |
| | Collaborate with statisticians to develop statistically robust sampling design for industrial fisheries | Development of sampling protocol for upscaling sampling to additional vessels in Phase 2, Pilot study | | |
| **Phase 2** | **Action** | **Outcome** | **Preliminary timeline** | **Collaborators** |
| Pilot study | Through collaborations, implement pilot study following lesson's learned and sampling design from Phase 1. Sample across PS Class 1-6 vessels, coastal States LL tuna fisheries, and distant-water LL fisheries. Revise the sampling design as needed. Coordinate logistics for storing samples. | Development of sampling protocols for industrial fisheries; documentation of lesson's learned from Phase 1 and Phase 2 industrial fisheries. Compilation of a dataset to derive L-W relationships for tunas and prioritized species from industrial tuna fisheries; Collection and storage of biological samples (tissues, stomachs, gonads, otoliths, vertebrae) for tunas and priority species | June 2025–May 2026 | Stock assessment, Biology and life-history, Ecosystem and bycatch, and Data Programs; CPCs, fishing industry, SPC-WCPFC |
| | Collaborate with statisticians to develop a statistically robust sampling design for small coastal, multi-gear fisheries. | Development of sampling protocols for coastal-multi-gear fisheries; documentation of lesson's learned from sampling these fisheries | | |

| | | | | |
|---|---|---|---|---|
| | Implement sampling in small coastal fisheries. Revise the sampling design as needed. Coordinate logistics for storing samples. | Compilation of a data set to derive L-W relationships for tunas and prioritized species from coastal multi-gear fisheries; Collection and storage of biological samples (tissues, stomachs, gonads, otoliths, vertebrae) for tunas and priority species | | |
| Phase 3 | Action | Outcome | Preliminary timeline | Collaborators |
| EPO-wide, statistically robust sampling | Expand sampling to additional vessels and areas across the EPO as is feasible. Continue sampling on PS class 1-6 vessels, coastal States LL tuna fisheries, distant-water LL fisheries, and coastal multi-gear fisheries | Collection of a robust data set to derive L-W relationships throughout the operational range of EPO fisheries. Store biological samples (tissues, stomachs, gonads, otoliths, vertebrae) for tunas and priority species. | January 2026–May 2030 | Stock assessment, Biology and life-history, Ecosystem and bycatch, and Data Programs; CPCs, fishing industry, SPC-WCPFC |
| Establishment of an EPO-wide morphometric and biological database for various fisheries | Analyze data; develop L-W relationships and conversion factors. Process prioritized biological samples in house and/or through collaborations | Development of EPO-wide database of morphometrics and biological data. Creation of a 'tissue bank' similar to SPC. Publications of meta-data and morphometric relationships. Project-specific analysis of biological samples (e.g., stock assessments and ecological assessments) | January 2026–2030 | Stock assessment, Ecosystem and bycatch, Biology and life-history, and Data Programs |