A PROPOSAL OF GUIDELINES FOR DESCRIBING SAMPLING DESIGN, SAMPLING PERFORMANCE, AND STATISTICAL INFERENCE FOR IOTC FISHERIES DATA SETS

Author: IOTC Secretariat

Background

The IOTC Resolution 15/02 defines the contents of the fisheries data sets that have to be reported to the IOTC Secretariat for the monitoring of tuna and tuna-like species as well as the most common elasmobranchs caught by tuna fisheries in the IOTC area of competence. The collection of data on catch, effort, and size for both coastal and industrial fisheries relies on sampling strategies and methodologies as well as raising procedures (i.e., statistical inference) developed by the CPCs which may change over time following changes in the fisheries or need for improved methodology (e.g., Pianet 1999; Duparc et al. 2018).

Paragraph 4 of the Resolution states that "*documents describing the extrapolation procedures (including raising factors corresponding to the logbook coverage) shall be submitted routinely*" to the IOTC Secretariat to provide information on the methodology used to derive geo-referenced catch and effort data in industrial surface and longline fisheries. In addition, the resolution 15/02 also states that "*size sampling shall be run under strict and well described random sampling schemes which are necessary to provide unbiased figures of the sizes taken. Sampling coverage shall be set to at least one fish measured by ton caught, by species and type of fishery, with samples being representative of all the periods and areas fished*."

Information on sampling protocol and strategy is essential to understand some of the features of the data sets used for scientific analysis (e.g., measuring tools may differ between fleets; Hoyle et al. (2021)), assess the uncertainty of the estimates, and interpret some patterns observed in the spatio-temporal distribution of catch, effort or size data that could be due for instance to post-stratification procedure. In 2020, the WPDCS considered that detailed information on sampling schemes developed by CPCs would allow the Scientific Committee to better assess the representativeness of the data submitted to the IOTC (para 212, IOTC 2020).

Objective

The overarching objective of the document is to propose a draft of guidelines for describing sampling design, sampling performance, and statistical inference for the data sets estimated by the institutes in charge of the monitoring of the fisheries concerned by the IOTC Resolution 15/02. We argue that the use of a standard template by the CPCs would greatly facilitate the comparison of methods across data sets and fisheries and provide a useful resource to better understand the specifics of each data set.

Sampling methods & best practices

For each quantity of interest (e.g., catch composition), the sampling process steps are generally considered as follows (e.g., Taherdoost 2016):

1. Clearly define the target population;
2. Define the minimum acceptable level of precision and the confidence level needed (e.g., a targeted mean average CV, usually 20%-30%);
3. Identify the sample frame (i.e., observable population);

4. Choose the sampling technique and design (sampling type, sampling units, strata, sample selection method at each sampling stage);

5. Determine the minimum and target sample size.

We recommend to use each component of the sampling process, as defined by the ICES Working Group on Recreational Fisheries Surveys in its best practices of sampling (ICES 2013), as the different elements required to describe a sampling procedure (**Table 1**).

Table 1: Best practices of sampling (modified from ICES 2013)

Process	Best practice	Example
Target population	The target population needs to be identified and described. Access to the target population for sampling purposes need to be analysed and documented	Deep-freezing longline fishery of a CPC
Sampling units	Primary (and lower level) sampling units should be identified, justified and documented	Vessel, fishing trip, freezing well
Sampling frame	The sampling frame (or observable population) should be a complete list of non overlapping primary sampling units. The sampling frame should ideally cover the entire target population	Number of ports and landing sites, number of fishing units by vessel-gear category
Stratification	The strata of the sampling frame should be well defined, known in advance and fairly stable. Clear definitions and justifications of strata should be available	Vessel gear-type, time (e.g., month, quarter), space (e.g., fishing ground areas), landing sites (see Table 2)
Sample size	The minimum number of samples within a stratum is dependent on objective, primary sampling units, and variance and need to be calculated	Number of boats in a range of tonnage capacity, number of trips, number of wells, number of fish to be sampled for length
Distribution of sampling effort	The way sampling effort is distributed between strata needs to be described (e.g., variance, weights, expert judgment)	Sampling intensity proportional to fishing effort, Neyman allocation scheme
Sample selection procedure	The selection of PSUs to sample should be done in a controlled way allowing for estimation of sampling inclusion probabilities for the different samples	Random selection of fish on conveyor belt
Hierarchical structure in the sampling	All levels of the sampling scheme need to be documented. Sampling should ideally be random at all levels. Systematic sampling might be required in case of sorting of the catch. Sampling probabilities should be worked out at each level, and information for this needs to be collected	Hierarchy: Vessel | Trip | Well
Performance of sampling schemes	Quality indicators such as the precision of estimates (i.e., relative standard error) should be calculated, where relevant. Effective sample size (or appropriate proxy) should be calculated and recorded	150 fish per species per 5x5 grid for size frequency

It is to note that the stratification may be a full component of the sampling design (e.g., port sampling) while it may also be used *a posteriori* in the data processing with a post-stratification scheme to account for technical and spatio-temporal factors, e.g., for trip-based sampling. Some examples of strata groups that can be used in the sampling or post-stratification schemes of a sampling of fisheries is given in Appendix I (FAO 1999).

In addition, the description and availability of the sampling protocols (e.g., through open repositories such as protocols.io) is of key importance to inform on the operational aspects of the sampling operations in the field as well as on the tools used for some measurements. For instance, it provides information on the expected precision of size measurements that may differ between caliper and tape. Furthermore, it shows the transparency and reproducibility of the method and may be of interest to some CPCs for the development and implementation of similar sampling strategies.

Finally, the raising procedure should be fully documented, including: (i) how the stratification and multistage sample selection is accounted for in the raising procedures; (ii) ancillary information that is used to adjust sample weights to correct for any imbalance in samples compared to the population (e.g., national census data or license registries); (iii) methods of adjustment for missing data or non-sampled strata (e.g., substitution schemes, aggregations) (ICES 2013).

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Appendix I

Table 2: Examples of stratification for fisheries data collection (modified from FAO 1999)

Strata group	Stratification
Space	Province of country or major city
	Districts (islands, villages)
	Home port (place of registration)
	Base port of fishing
	Community of residence
	Landing place
	Fishing grounds
Time	Fishing season
	Basic time period (week, month, year)
	Day/night
Vessel/gear group	Fishing fleet
	Gear
	Vessel group (small scale, semi-industrial, industrial, joint venture, foreign)
	Fishery (métier) (defined by fleet/target species/gear)
	Geographical areas/depth zones/bottom types/habitats
Experimental fishery or research vessels	Time period/day-night
	Gear/fishing operation
Landings	Commercial species group (catch/effort, value)
	Commercial size/treatment group (catch/effort, value)
	Ecological species groups
	Landings agent
Enterprises	Companies/co-operatives
	Processing plants
	Type of support industry
Trade	Markets/auctions
	Intermediaries/companies
	Exporters/importers

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