PRELIMINARY GUIDE TO MEASUREMENTS AND SAMPLING

- WORK IN PROGRESS -

Author: IOTC Secretariat

Guidelines for the Sampling and Measurement of Fish Size in the IOTC Convention Area

"In order to ensure sustainable management of fisheries and to enable social and economic objectives to be achieved, sufficient knowledge of social, economic and institutional factors be developed through data gathering, analysis and research." (CCRF 7.4.5)

1. Introduction

Reliable biological information is fundamental to fisheries science and management. Size measurements are used to estimate growth, mortality, maturity, stock structure, catch composition and biomass, and therefore underpin many stock assessment methods used by the Indian Ocean Tuna Commission (IOTC). Consistent measurement protocols are essential to ensure that biological information collected by different Contracting Parties and Cooperating Non-Contracting Parties (CPCs) is comparable across fisheries, fleets, seasons and years.

Because it is rarely practical to measure every fish landed or caught (census sampling), biological information is obtained from a sample of the catch (a given percentage of the catch, 1 fish in 1 tonne). The quality of the resulting data depends not only on the accuracy of the measurements themselves, but also on how representative the sampled fish are of the entire catch. In a budget and staff limited situation it is essential to go back to basics, set the priorities and select the essential variables to be collected. Therefore, data collection requires a logically structured approach as described in the guidelines for the routine collection of capture fishery data (FAO, 1999).

This document provides interim guidance on good practices for the collection of fish size measurements throughout the IOTC Convention Area. It focuses on representative sampling, recommended measurement types, good measurement practices, and the use of conversion relationships where alternative measurements are required. The guidelines are intended for observers, port samplers, fisheries technicians and scientific personnel involved in the collection of biological data.

Future versions of these guidelines will progressively incorporate updated morphometric relationships developed using CPC datasets and Secretariat analyses.

2. Principles of biological sampling

Good sampling is the art of learning about an entire population by carefully selecting the few individuals that best represent it. A robust sampling design provides the statistical framework required to minimise bias, quantify uncertainty and make reliable inferences about the target population.

2.1 Why sample?

The objective of biological sampling is to obtain measurements that accurately represent the size composition of the catch. Since only a subset of fish can normally be measured, sampling should minimise bias while remaining practical under commercial fishing conditions.

Sampling bias may arise because fish are:

- sorted by size;
- processed before sampling;
- mixed between fishing operations;
- selected for convenience rather than randomly;
- unavailable due to operational constraints.

Consequently, sampling should always aim to maximise representativeness while documenting any limitations.

2.2 Representative sampling

Representative sampling is achieved by ensuring that every fish within the target population has, as far as practical, an equal probability of being selected.

Whenever possible:

- select fish at random;
- avoid preferentially selecting large or small individuals;
- distribute sampling throughout the landing or fishing operation;
- record any departures from the recommended protocol.

2.3 Stratification

Where catches are heterogeneous, sampling should be stratified. Stratification is the process of partitioning a target data population (e.g. all fishing vessels) into a number of more homogeneous sub-sets based on their characteristics (e.g. trawl, gillnet, purse-seine; or large, medium, small; or commercial, artisanal, subsitence) (Stamatopoulos, 2002) and called stratum.

Typical stratification variables include:

- fishing area;
- season or quarter;
- fishing method;
- association (e.g. free school or floating object);
- vessel;
- product form;
- commercial size category.

Stratification generally improves precision and ensures that important components of the catch are adequately represented.

The challenge of stratification lies in finding the point where statistical rigour meets operational reality. Increasing the number of strata generally improves homogeneity and can reduce sampling variance. Beyond a certain point, however, additional strata provide diminishing statistical returns while increasing sampling costs, logistical complexity and the risk of inadequate sample sizes. An effective sampling design therefore seeks the simplest stratification capable of describing the principal sources of variation.

3. Sampling design

3.1 Introduction

A statistically sound sampling programme should be based on a clearly defined sampling design. Since it is generally impractical to measure every fish within a fishery, biological information is collected from a subset of the catch. The sampling design defines how this subset is selected so that it is representative of the target population.

Fishery catches are naturally organised into hierarchical groups. Fish belong to fishing operations, which belong to fishing trips, which are landed at ports or processing facilities and may subsequently be sorted into commercial categories. This hierarchical structure provides a natural framework for sampling.

A hierarchical sampling design divides the target population into progressively smaller **sampling units** until individual fish are selected for measurement. Each level of the hierarchy should be clearly defined before sampling begins. Where practical, the selection of sampling units should be random or probability-based to minimise sampling bias.

The choice of sampling units will depend on the objectives of the sampling programme, the characteristics of the fishery and operational constraints. Consequently, no single sampling design is appropriate for all fisheries. The examples presented below illustrate common sampling hierarchies that may be adapted to local circumstances.

3.2 Target population

The target population is the complete group of fish about which information is required. Depending on the objectives of the sampling programme, the target population may include:

- all fish caught by a fleet;
- all fish landed within a defined period;
- all fish from a particular gear, area or fishery;
- all fish delivered to a processing facility.

The target population should be clearly defined before selecting the sampling design.

3.3 Primary Sampling Units (PSUs)

Primary Sampling Units (PSUs) represent the highest level of the sampling hierarchy from which samples are selected. They should be chosen so that they adequately represent the target population while remaining practical to sample.

Examples of Primary Sampling Units include:

Sampling scenario	Possible PSUs
At-sea sampling	Vessel, fishing trip
Port sampling	Landing event, vessel landing
Port sampling after sorting	Landing event, processing lot
Transhipment sampling	Carrier visit, transhipment event

Sampling scenario	Possible PSUs
Factory sampling	Processing day, production batch

Only a subset of PSUs is normally selected for sampling.

3.4 Secondary Sampling Units (SSUs)

Secondary Sampling Units (SSUs) are subdivisions of a selected PSU and generally correspond to the level at which catches remain relatively homogeneous.

Examples include:

- fishing set;
- haul;
- fish hold or well;
- landing lot;
- unloading sequence;
- processing batch;
- commercial size category.

Not every SSU within a PSU needs to be sampled. Instead, one or more SSUs may be selected according to the sampling design.

3.5 Tertiary Sampling Units (TSUs)

Where necessary, Secondary Sampling Units may be further subdivided into Tertiary Sampling Units (TSUs).

Examples include:

- baskets;
- bins;
- pallets;
- conveyor batches;
- sorting tables;
- containers.

The lowest sampling unit should provide direct access to individual fish.

3.6 Observation units

The observation unit is the individual fish from which biological measurements are collected.

Whenever possible, individual fish should be selected randomly from the lowest sampling unit. Selection should not be influenced by fish size, commercial value or ease of access.

3.7 Examples of sampling hierarchies

The sampling hierarchy will vary according to the sampling location and fishery.

Example 1. At-sea sampling

Level	Sampling unit
Target population	Catch from a fleet

Level	Sampling unit
PSU	Fishing trip
SSU	Fishing set
TSU	Brail or sorting area
Observation unit	Individual fish

Example 2. Port sampling

Level	Sampling unit
Target population	Landings
PSU	Landing event
SSU	Fish hold or well
TSU	Basket or pallet
Observation unit	Individual fish

Example 3. Port sampling after commercial sorting

Level	Sampling unit
Target population	Landings
PSU	Landing event
SSU	Commercial size category
TSU	Pallet or container
Observation unit	Individual fish

Example 4. Sampling following transhipment

Level	Sampling unit
Target population	Transhipped catch
PSU	Transhipment event
SSU	Carrier hold or source vessel
TSU	Batch or unloading sequence
Observation unit	Individual fish

3.8 General recommendations

A well-designed sampling programme should:

- clearly define the target population;
- define all sampling units before sampling begins;
- use probability-based or random selection wherever practical;
- document the sampling design;
- record deviations from the planned sampling protocol;
- ensure that individual fish are selected independently of their size or commercial value whenever possible.

The use of a hierarchical sampling design facilitates transparent sampling procedures, improves the representativeness of biological samples and provides a sound statistical framework for estimating size compositions of the target population.

4. Sampling strategies

Different sampling opportunities present different advantages and limitations.

4.1 Sampling at sea

Sampling is conducted during fishing operations before commercial handling.

Advantages	Disadvantages
Fish available whole	Limited working time
Best representation of catches	Safety constraints
Direct link to fishing operation	Smaller sample sizes
Minimal commercial bias	Accessibility may influence selection

Recommended practice

- Sample throughout the fishing operation (if possible and safe).
  - Work out the sampling plan before hand.
- Avoid selecting fish from only one brail or one section of the catch.
  - Avoid selecting fish only from the top of the brail.
- Record fishing set or haul.
- Record product form.

4.2 Port sampling before commercial sorting

Sampling is conducted during unloading before fish have been graded.

Advantages	Disadvantages
Large sample sizes	Restricted access during unloading
Better measuring conditions	Partial unloading may occur
Whole fish available	Time constraints

Recommended practice

- Sample continuously throughout unloading.
- Randomly select baskets or bins.
- Avoid convenience sampling.

4.3 Port sampling after commercial sorting

Commercial grading changes the probability of selecting individual fish.

Advantages	Disadvantages
Easy access	Strong size bias
Large sample sizes	Whole catch no longer random

Recommended practice

Each commercial size class should be considered an independent sampling stratum.

Within each category:

- randomly select fish;
- record total quantity represented;
- record grading system.

4.4 Sampling following transhipment

Transhipment sampling provides an important opportunity where onboard sampling is unavailable.

Advantages	Disadvantages
Large sample sizes	Fish from multiple vessels may be mixed
Practical for industrial fisheries	Traceability may be reduced
Can coincide with unloading	Fish may already be frozen or processed

Recommended practice

Record:

- source vessel;
- trip;
- batch;
- product form;
- measurement type.

Whenever possible, select wells or batches before unloading begins.

4.9 Raising

Biological measurements are collected from a sample of the catch and subsequently raised or extrapolated to produce estimates that represent the target population (e.g. national landings or catches). The validity of these estimates depends on the collection of representative, unbiased samples and on the quality and accuracy of the underlying measurements. Extrapolation should therefore be conducted within well-defined sampling strata, following appropriate quality control procedures to ensure that the resulting estimates are statistically robust.

5. What should be measured?

The preferred measurement depends on both the species and the condition of the fish.

Fish condition	Preferred measurement	Alternative measurement
Whole tuna	Fork Length (FL)	Total Length (TL)
Whole billfish	Lower Jaw Fork Length (LJFL)	Eye Fork Length (EFL)
Bill removed	Eye Fork Length (EFL)	Pectoral Fork Length (PFL)
Head removed	Pectoral Fork Length (PFL)	Other carcass measurements
Whole shark	Total Length (TL) or Precaudal Length (PCL)	Species dependent

Fish condition	Preferred measurement	Alternative measurement
Dressed shark	Precaudal Length or carcass length	Species dependent

The measurement type should always be recorded together with the measurement value.

5.1 Species-specific recommended measurements

The recommended measurement type and measurement interval vary among species. The table below provides the current recommended measurement type, default measurement interval, maximum acceptable interval and plausible measurement range for priority species.

The default interval should be used wherever practical. Coarser intervals should not exceed the maximum interval shown. The plausible ranges are intended for data quality control: measurements outside these ranges should be checked and verified rather than automatically assumed to be impossible.

Species	Recommended measurement	Default interval (cm)	Maximum interval (cm)	Plausible range (cm)
Albacore (ALB)	Fork length (FL)	1	2	10–140
Pelagic thresher (ALV)	Fork length (FL)	5	10	30–760
Bigeye tuna (BET)	Fork length (FL)	2	4	10–250
Black marlin (BLM)	Lower-jaw fork length (LJFL)	3	5	15–465
Bullet tuna (BLT)	Fork length (FL)	1	2	10–50
Blue shark (BSH)	Fork length (FL)	5	10	30–400
Bigeye thresher (BTH)	Fork length (FL)	5	10	30–760
Blue marlin (BUM)	Lower-jaw fork length (LJFL)	3	5	15–500
Narrow-barred Spanish mackerel (COM)	Fork length (FL)	1	3	10–240
Silky shark (FAL)	Fork length (FL)	5	10	30–350
Frigate tuna (FRI)	Fork length (FL)	1	2	10–65
Indo-Pacific king mackerel (GUT)	Fork length (FL)	1	3	10–76
Kawakawa (KAW)	Fork length (FL)	1	2	10–70
Shortfin mako (LMA)	Fork length (FL)	5	10	30–417
Longtail tuna (LOT)	Fork length (FL)	1	3	10–145
Striped marlin (MLS)	Lower-jaw fork length (LJFL)	3	5	15–420
Oceanic whitetip shark (OCS)	Fork length (FL)	5	10	30–396
Porbeagle (POR)	Fork length (FL)	5	10	30–350
Crocodile shark (PSK)	Fork length (FL)	5	10	30–110
Indo-Pacific sailfish (SFA)	Lower-jaw fork length (LJFL)	3	5	15–300

Species	Recommended measurement	Default interval (cm)	Maximum interval (cm)	Plausible range (cm)
Skipjack tuna (SKJ)	Fork length (FL)	1	2	10–110
Scalloped hammerhead (SMA)	Fork length (FL)	5	10	30–400
Smooth hammerhead (SPL)	Fork length (FL)	5	10	30–430
Great hammerhead (SPZ)	Fork length (FL)	5	10	30–500
Swordfish (SWO)	Lower-jaw fork length (LJFL)	3	5	15–450
Yellowfin tuna (YFT)	Fork length (FL)	2	4	10–239

5.2 Recording weight

Where fish weight is collected, the method used to determine the weight should always be recorded together with the weight value. Weights may be measured directly, estimated visually, derived from the capacity of handling equipment, or calculated from other information. These methods are not equivalent and should not be combined without retaining information on how the weight was obtained.

The following weight determination methods are currently recognised:

Code	Method	Description
BR	Brail	Weight estimated from the known or assumed capacity of a brail used to lift fish from the net.
CA	Calculation	Weight derived from calculations based on other measurements or available information.
EB	Electronic balance	Weight measured using an electronic or digital weighing scale.
EM	Eye measurement (observer)	Weight estimated visually by an onboard observer based on experience and observation.
LO	Vessel logbook (eye measurement crew)	Weight estimated visually by the vessel crew and recorded in the vessel logbook.
LW	Length-weight relationship	Weight estimated from measured length using an established length-weight relationship.
MB	Mechanical balance	Weight measured using a mechanical weighing scale (non-electronic).
SB	Spring balance	Weight measured using a spring balance or hanging scale.
UN	Unknown	The method or tool used to determine the weight is not known.

6. Standard measurement definitions

This chapter will describe each standard measurement using diagrams.

Measurements to include:

- Total Length (TL)
- Fork Length (FL)
- Standard Length (SL)
- Lower Jaw Fork Length (LJFL)
- Eye Fork Length (EFL)
- Pectoral Fork Length (PFL)
- Precaudal Length (PCL)
- Disc Width (DW)

Each definition should include:

- anatomical landmarks;
- measuring procedure;
- species for which the measurement is recommended;
- common errors.

7. Transformation of measurements

Commercial processing often prevents the collection of the preferred standard measurement.

Published morphometric relationships allow alternative measurements to be converted into standard measurements suitable for stock assessment.

Species	Standard measurement	Alternative measurement	Reference
Yellowfin tuna	FL	TL	Published relationship
Bigeye tuna	FL	TL	Published relationship
Skipjack tuna	FL	TL	Published relationship
Swordfish	LJFL	EFL	Published relationship
Swordfish	LJFL	PFL	Published relationship
Billfishes	LJFL	Carcass measurements	Published relationship
Sharks	TL	PCL	Species-specific relationship

Future versions of these guidelines will include updated morphometric relationships derived from datasets available to the Secretariat.

8. Good measurement practices

The following principles apply irrespective of sampling location.

- Measure fish lying flat on a measuring board.
- Close the mouth where appropriate.
- Align the snout with the zero mark.
- Use the correct anatomical landmarks.
- Measure to the nearest recommended unit.

- Record the measurement type.
- Record the product form.
- Record damaged or incomplete specimens where appropriate.
- Record any deviations from standard procedures.

Fig. 1. Overview of recommended fish measurement methods, species identification guidance and good measurement practices. The figure combines original material with AI-generated graphical elements

9. References

(To be completed.)