Practical guide for the standardisation of biological measurements

source Illustration: Océanothèque Ifremer

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Contents

1 Background

The aim of this document is to list the recommended methods for measuring biological parameters in fisheries research. The procedures described in this guide comply with the guidelines of Ifremer's Fisheries Information System (FIS) [*Système d'Informations Halieutiques*].

Standardised, qualitative data collection and analysis have become key elements of informed decision-making in all fields, and information systems such as the FIS play a crucial role in this development.

The objectives of the FIS are in line with one of Ifremer's ten strategic priorities: to contribute to sustainable fishing. The aim is to enable the fishing industry to ensure a sustainable supply of seafood products, while meeting the new challenges of resource status, rising energy prices, business profitability and habitat protection.

At Ifremer, the integration of biological parameters as fundamental data for stock assessment is of paramount importance for meeting the objectives of sustainable marine resource management. By formally considering this information, it becomes possible to guarantee the long-term preservation of marine ecosystems and to support the rational exploitation of resources, in harmony with the demands of environmental sustainability.

2 Biological parameters

The collection of biological data as part of the FIS, supported by actions such as ObsBio, ObsMer, ObsVentes and campaigns, is an essential component in achieving the objectives of sustainable marine resource management. This collection is part of a synergistic approach between research and management and makes it possible to collect crucial biological data such as size, weight, sex, maturity, fecundity, stomach contents, age estimates, etc. on fish, but also contextual biological data on their habitat, such as intermediate trophic levels (zooplankton, benthos). These data are needed to assess stock status, develop appropriate management models and provide keys to understanding the fisheries dynamics observed, in line with the requirements of the Data Collection Framework (DCF) and the objectives set out in the National Work Plan (NWP) [*Plan National de Travail*].

In addition to its importance for marine resource management, the collection of biological data is also of great interest for marine science research. The biological parameters recorded provide a better understanding of marine ecosystems and species life cycles, which can be used to improve our knowledge of marine ecology and to develop predictive models. Furthermore, the data collected can be used in a number of ways over the years, particularly in scientific publications.

To ensure the quality of the data collected and efficiency of the FIS, the standardisation of measurements for biological data collection is crucial. By standardising the biological parameters collected, the data can be more easily compared between different seasons and regions. For example, to date there have been around two different methods for measuring size for each given species among the 37 species listed in the NWP (see examples in Figure 3. Example of size-size relationship: standard length plotted against total length (Romdhani et al., 2016)3). If measurement methods are not harmonised, it is more difficult to exploit and add value to the data.

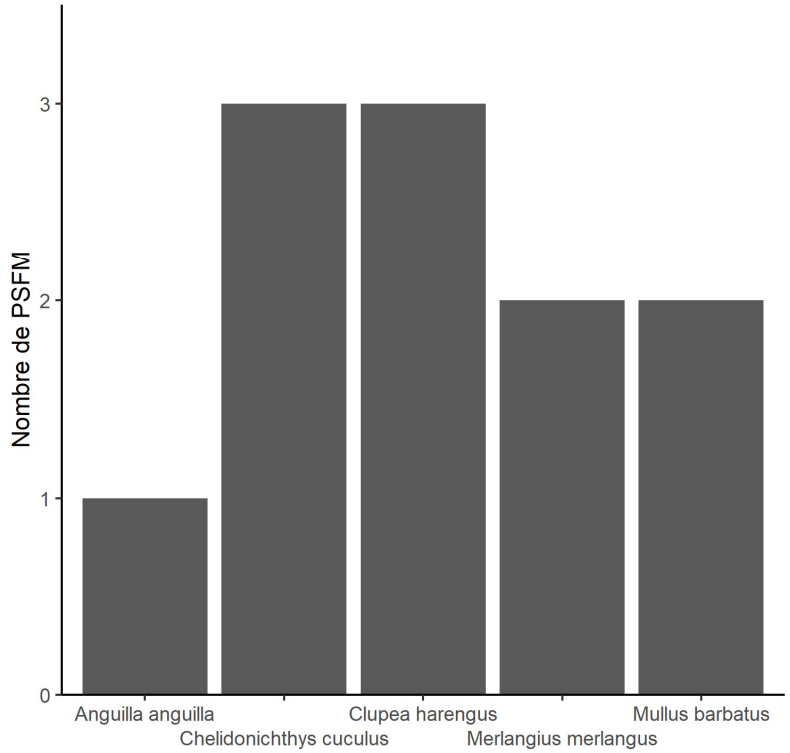

Figure 1. Illustration of the number of surveying methods for five species (source: Harmonie database bf 2023)

This guide attempts to summarise the error tolerances in the measurement tools used in the data collection process, such as balances and ichthyometers. It should also serve as a reference for equipment metrology, both internally (e.g. Ifremer's ISO9001 process 6 activities) and externally (e.g. requirements to be specified in tenders). These tolerances are set with regard to the requirements of the FIS and it is up to each collection manager outside the FIS to set their own acceptable discrepancies. For example, a research programme may be more or less strict about tolerances in relation to its objectives; these should be set out in a dedicated protocol.

2.1 Variables

In the European context, biological parameters are considered, such as individual measurements of height, weight, sex, maturity, fecundity, stomach contents and age. These parameters can, however, be complemented by other biological measurements relating to the habitat or biological communities co-occurring with the fish. The purpose of the FIS's ObsBio action is to collect, monitor, archive and make these data available (to researchers, experts, etc.). Since 2022, historical data from this action have been stored in the FIS national database called Harmonie. The aim of this database is to integrate data from all of FIS's actions and, progressively, fisheries data from a range of activities (e.g. research programmes). The variables collected, especially the biological parameters, are described in terms of 'Parameter, Support, Fraction, Method' (PSFM) for integration into the Harmonie database.

This description breaks down the variable to avoid analysis errors. The following gives size as an example:

Parameter	Support	Fraction	Method
Fork length (FL)	Individual	Total	Measurement to the nearest centimetre by an observer

However, this document does not deal with all the metadata associated with individual measurements, although these are important variables required for optimum use of these measurements. For example, it is crucial to specify the sample, the scientific name of the species, the sampling environment (such as the ICES area), the context (such as the scientific campaign) and the sampling date. Qualitative PSFMs, such as the presentation of the sample in the form of a selection list, are managed with references from the database. All the PSFMs available on the FIS website are accessible to Ifremer staff https://sih.ifremer.fr/prive/Acces-aux-donnees/Extractions/Referentiels/Tables-de-reference

Figure 2. Illustration of the FIS web interface for extracting PSFMs

Within a research project, it is crucial to specify a certain number of elements before collecting and entering the data. To do this, it is necessary to fill in the form « Utiliser un logiciel d'acquisition de données halieutiques ». The FIS team will then contact the project manager to identify the needs, find the appropriate data entry tool and choose the appropriate PSFMs. This will enable the optimisation of data use at the end of the project.

2.2 Measurement of individuals

An individual's size is the main biological parameter collected in association with other parameters such as weight and sex. The purpose of this document is to provide ranges of error tolerance for size measurements and to establish standards for the main species. For general guidelines on the measurement method, we recommend consulting the *Guide de la mensuration des espèces en halieutique*, which covers fish, molluscs, crustaceans, marine reptiles and marine mammals. You can view this guide by following the link https://archimer.ifremer.fr/doc/00001/6237/

The method used to measure an individual depends on the species, its maximum size (Linf, infinite length from the Von Bertalanffy model, 1938), and sometimes the precision required for the particular study or the condition of the specimen (e.g. certain large pelagics are landed with their heads removed). So called 'small' species (Linf < 30 cm) require more accurate measurements, as small variations in size can have a major impact on inferences from other biological parameters such as sexual maturity, age, etc. obtained through biometric relationships. In general, the following error tolerances are acceptable: 1 to 5 mm for small species and 1 to 2 cm for larger species (Linf > 30 cm). To ensure reliable measurements, appropriate error tolerances must be applied for each species.

Generally, only one size measurement is required from each individual. In specific cases however, such as the updating of size-size relation coefficients, additional measurements may be necessary. These would make it possible, for example, to convert the standard measurement of an individual into a measurement of total length by back calculation (Figure 3. Example of size-size relationship: standard length plotted against total length (Romdhani et al., 2016)3).

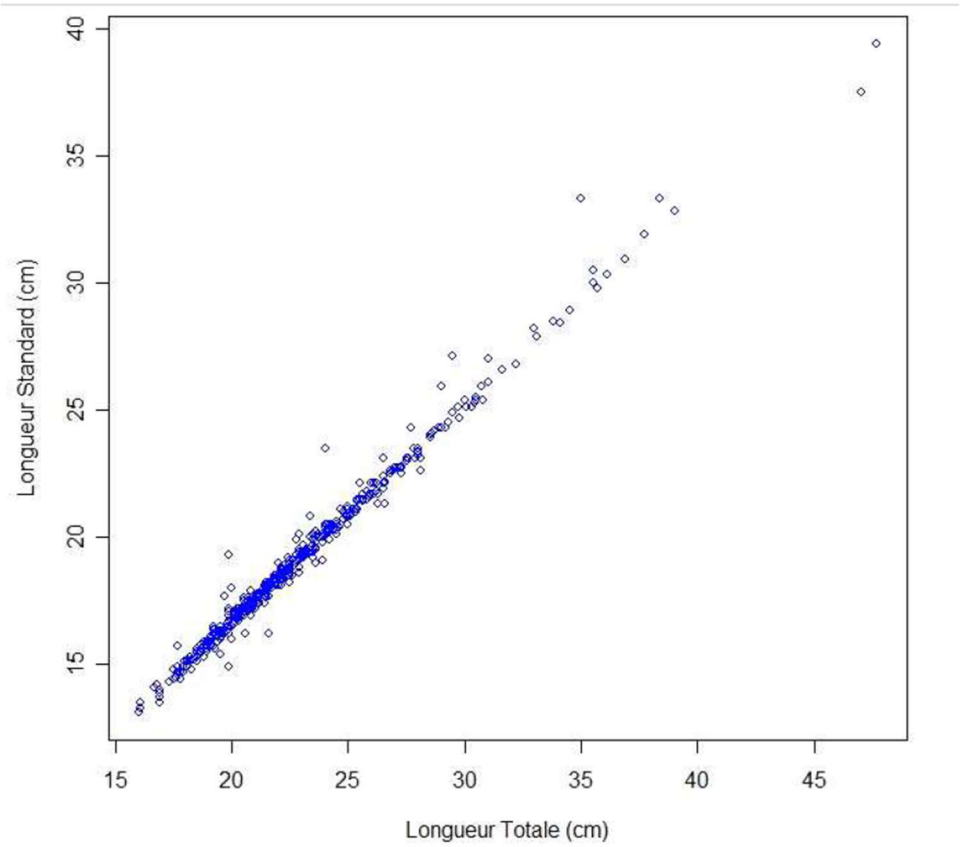

Figure 3. Example of size-size relationship: standard length plotted against total length (Romdhani et al., 2016)3

In practice, at the time of the publication of this guide, there is a list of 37 species monitored each year as part of the DCF that are included in the NWP. Measures have been selected for these species, with corresponding error tolerance thresholds (see appendix 'Size indicators: reference tables').

2.3 Weighing an individual

An individual's weight is another biological parameter that is very often measured in conjunction with other parameters such as height and sex. Although size is often considered to be the most important indicator, weight is a key factor generally also taken into account in biological studies of species. From the size/weight relationships of individuals, condition indices (K) can be calculated, according to sex and age group, which provide information about their state of health. The aim of this document is to provide tolerance ranges for weight measurements and to establish standards for the main species.

The method used to measure an individual's weight depends on the species, its maximum size/weight, and the precision required for the study. Smaller species (Linf < 30 cm) require more

accurate measurements as small variations in weight can have a significant impact on their biology. In general, the following error margins are accepted: from 1 to 5 g for small species and from 10 to 500 g for larger species (Linf >30 cm). To ensure reliable measurements, appropriate error tolerances must be applied for each species.

It is essential to follow the manufacturer's recommendations when calibrating your balance or spring scale. In addition, it is essential to use equipment that is adapted to the situation in the field, such as a motion compensating scale at sea.

As a general rule, a single weight measurement is sufficient for an individual. However, in certain specific circumstances, such as when updating the weight-weight relationship coefficients, additional measurements may be necessary. This can be used to convert a gutted weight to a total weight, for example.

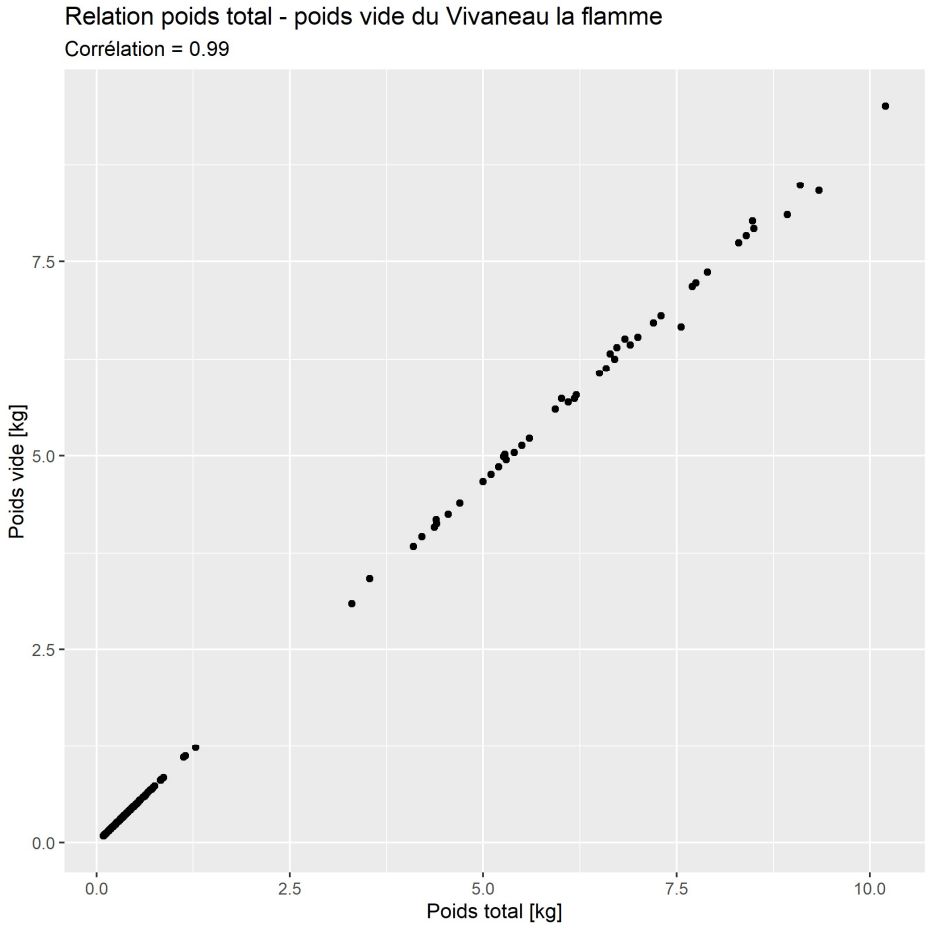

Figure 4. Example of a weight/weight relationship: gutted weight plotted against total weight for longtail red snapper Etelis coruscans (Roos et al., 2022)

As part of the DCF, the total weight of the fish is measured, with an acceptable tolerance margin for each species analysed, provided in the appendix 'Weight indicators: reference tables'. Depending on the sampling method, the fish may be in a different condition (e.g. gutted, head removed or tail cut off). It is important to enter this condition in the data entry software. It is also useful to check whether weight-weight conversion coefficients exist to enable accurate conversion.

In the Harmonie database, all weights are expressed in kilograms. However, the data entry tools connected to Harmonie can be used to enter data in other units. This is the case with the Allegro campaign software, which allows data to be entered in grams with decigram precision.

The usual PSFM for weight measurement at Ifremer, intended for integration into Harmonie, is as follows:

Parameter	Support	Fraction	Method
Weight (kg)	Individual	Total	Measurement by an observer

2.4 Weighing of gonads and liver

By sampling the gonads of an individual, we can calculate the gonado-somatic ratio (GSR) by dividing their weight by the total weight of the individual, which can be used to give us an idea of the spawning period and its duration over the year. Similarly, the weight of an individual's liver can be measured to assess the individual's physiological condition and fatness by calculating the hepato-somatic ratio (HSR) by dividing the weight of the liver by the total weight of the individual. To obtain accurate results, it is important to use a balance that weighs to milligram or gram accuracy, depending on the species and the tolerance limit, and to check or calibrate it regularly. Although gonad and liver weights are not required for the 37 species monitored and included in the NWP as part of the DCF, these weights are often used in research projects, with an acceptable tolerance margin for each species analysed. (see appendix 'Weight indicators: reference tables'*).*

The usual PSFM for measuring gonad weight at Ifremer, intended for integration into Harmonie, is as follows:

Parameter	Support	Fraction	Method
Weight (kg)	Individual	Gonads	Measurement by an observer

3 Additional measurements on the sample

3.1 Using fish body circumference and width

These measurements provide additional information about an individual's morphology. Body circumference measurements are usually taken in two places: at the opercules, to ensure uniformity of measurements, and at the point where the circumference is greatest. A tape measure is used to take the measurement accurately, making sure that the tape remains straight and that the measurement is taken on the same side each time. For the width of the fish, a measurement is generally taken at the tip of the opercules, using a calliper and without applying any pressure (Figure 5 & *Figure 6*).

The reference unit for this type of measurement is the millimetre, and the error tolerance is usually 5 millimetres (for a class 1 tape measure). A calliper with an accuracy of 50/100ths can be used (0.5 mm accuracy).

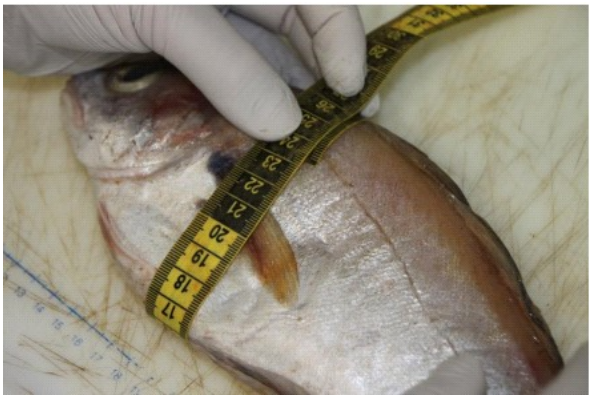

Figure 5. Illustration of body circumference measurement (Cresson et al., 2016)

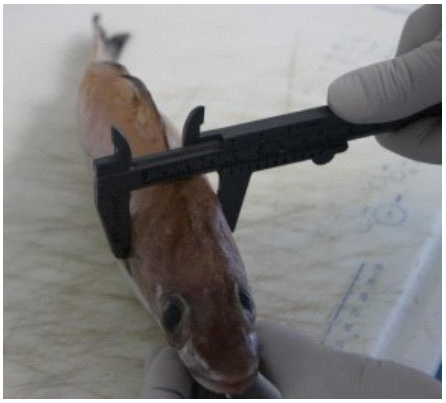

Figure 6. Illustration of width measurement (Cresson et al., 2016)

3.2 Measurements of fish mouth diameter

The size of the mouth is an important parameter for predatory fish. To measure this parameter, truncated cones of different diameters are inserted into the fish's mouth. The maximum diameter of the mouth opening is measured using the concentric circles present on the cylinder (Figure 7). These circles should be checked regularly with a calliper to ensure that they are not too worn, which can cause skewing of more than 2%.

Figure 7. Illustration of mouth diameter measurement (Cresson et al., 2016)

3.3 Measurement of fish eye diameter

Similarly, eye diameter (Figure 8) can also be considered as a trophic indicator or as having a direct relationship with fish size, as in the case of the anguilliformes, for which it is difficult to measure total length. If the roundness of the eye is not known for certain, it is preferable to separately measure the greatest height and greatest width in millimetres. A tolerance of 2% of the measurement is permitted.

Figure 8. Illustration of eye measurement (Cresson et al., 2016)

To measure the eye diameter, the asymmetry between the two sides of the fish must be taken into account by measuring both eyes and analysing statistically, as must the axis of measurement.

4 Complementary measurement from images

Image-based measurements, whether or not these are performed automatically, are of crucial importance in many fields.

In marine biology, measurements are often taken on images of organisms or parts of organisms such as calcified parts of fish, mollusc shells or coral skeletons. These measurements are important for identifying different species and understanding their biology. For example, measuring the length, width and surface area of calcified parts (e.g. otoliths in fish) can help to identify different species. Image analysis and measurements taken from images of individuals or whole communities of marine invertebrates are also important for understanding the habitat and trophic range context of the fish (zooplankton for pelagic fish, Grandrémy *et al*., 2023, and benthos for demersal fish).

To ensure the accuracy of the measurements made on images, it is essential to follow specific good practices. Ideally, the images should be taken against a uniform background, making it easier to identify and measure the different parts of the object or structure in question. In addition, it is crucial to use images calibrated to the correct resolution, as explained in detail on the following pages. By following these recommendations, measurements taken on the images can provide standardised data and, in some cases, be automated (see following pages for details).

These guidelines provide consistent recommendations to be taken into account for image standardisation:

- standardisation ensures that an image will always allow subsequent measurement by including an embedded reference, such as a calibration bar, graduated ruler, standard grid or metadata integrated into the image format (Tiff, CZI, etc.);
- position the sample on a contrasting image background to facilitate its distinction from this background;
- standardise the position of the sample in the image capture space by convention;
- use even, adjusted lighting to avoid shadows and overexposed areas;

- include the sample identifier in the image or in its name to help match it with the corresponding data.

These recommendations apply equally whether you are obtaining images of macroorganisms, small parts and/or organs, or microscopic organisms. Several guides exist for standardised image capture and analysis depending on the sample and the topics addressed by Ifremer or by specialised working groups (Cresson *et al.,* 2016; Elleboode *et al.,* 2022; Oudard *et al.,* 2012; Le Meleder *et al.,* 2012; ICES SmartDots User Manual, 2023; WGALES, 2022; Gorsky *et al.,*. 2010).

Depending on the nature of the samples to be imaged and measured, many parameters may vary, such as resolution, depth of field, length of exposure, etc. Similarly, the use of tools incorporated in software adapted for image capture and processing will have an impact, such as digital zoom, distortion correction, noise suppression and image fusion. The shape detection algorithm, if any, can have a significant impact on the quality and repeatability of the measurements obtained. Occasional or systematic verification of the results of image analysis, and estimation of identification or measurement errors, are therefore also often recommended to scientifically qualify data derived from image analysis techniques (Gorsky *et al*., 2010).

In order to ensure the quality of the measurements and to obtain verification of an error index, here is a list of checks that can be made:

- carry out duplicate or triplicate measurements to assess the repeatability of the results;
- carry out an analysis of measurement uncertainty to estimate the error associated with the results;
- check the quality of the image before and after processing;
- record all the stages of the measurement, including the image processing methods used, in order to provide a record of the data generation steps associated with the images worked on;
- use reference samples or measurement standards to calibrate measurements.

Similarly, if a series of measurements has to be interrupted and then resumed with different imaging equipment, for whatever reason (breakdown, obsolescence or technical upgrade), a comparison or benchmarking study is strongly recommended in order to assess and quantify any instrumental biases (Grandrémy *et al.*, 2023b) generated by the change of method or tool.

4.1 Standardisation of the image capture field in sclerochronology

Since 2008, the use of images to estimate the age of individuals has become increasingly frequent and standardised. In 2022, the ObsBio process was integrated into a standardised workflow including a suite of software for image capture and the monitoring and estimation of age (Elleboode *et al*., 2022; Elleboode *et al*., 2023). With the aim of standardising image capture for age estimation and facilitating the work of future deep learning algorithms (Andrialovanirina *et al*., 2023), a standardisation of the acquired image fields has been implemented. This standardisation also allows the expert's eye to become accustomed to a specific image field to avoid interpretation bias induced by magnification unsuited to the size of calcified specimens (WKARHOM3, 2018). The accuracy of growth ring radius measurements for age estimation in years is **0.05** millimetres, while for daily analyses, for example, an accuracy of **50** microns is preferable (see appendix: Standardised measurement of camera fields of view for assessing the age of reference calcified parts).

4.2 Zooplankton imaging for semi-automated analysis of fish eggs and pelagic trophic fields: ZooScan and ZooCAM

Analysis of fish eggs

Fish eggs are measured for a series of biological parameters agreed by DCF for several campaigns, for example PELGAS in the Bay of Biscay and IBTS in the Eastern Channel and North Sea. Fish eggs are collected continuously using a hull pump (CUFES, PELGAS, Doray *et al.,* 2018) or with a net (IBTS). In the past, using a binocular magnifier, the eggs were identified, their stages established (PELGAS), and they were counted, either on board the vessel (PELGAS) or ashore after the campaign (IBTS). The need to optimise the cost and time required for these analyses, combined with the scarcity of qualified taxonomic experts (due to retirement), has led to the adoption and specific development of methods based on imaging instruments, namely ZooScan (Gorsky *et al*., 2010) and ZooCAM (Colas *et al*., 2018).

Zooplankton analysis

Zooplankton have been collected and analysed on fishing surveys for several decades (IBTS 30 years, PELGAS 23 years, PELMED 7 years, EVHOE 9 years, CGFS 9 years). However, this biological parameter is not yet covered by the DCF agreement, despite increasingly frequent recommendations from ICES working groups (WGALES 2022, MEDIAS 2021, 2022, 2023, WGACEGG 2021, 2022).

The ZooScan and ZooCam instruments should enable the taxonomic identification of fish eggs and zooplankton in sufficient detail to meet the expectations of the DCF and the scientific questions relating to plankton-fish relationships. As image analysis can also be used to measure the size of organisms and ecological traits (Oreinstein *et al*., 2023), these instruments must provide precise and repeatable information on these parameters for the studies in question. Finally, these two instruments, used individually or jointly, must also be interoperable to ensure continuity of series and interoperability of data, in quantitative terms, particularly for calculating abundance.

Technical aspects of imaging

As emphasised above, the quality of images depends on having a sufficiently stable and powerful illumination system combined with a homogeneous and contrasting image background (in relation to the objects of interest) to generate raw images in which the objects of interest are easily distinguishable from the image background. ZooScan uses white-light planar illumination on a black background. ZooCAM uses a collimated red LED in pulsed mode. Both illumination devices provide thumbnails of objects of interest with sufficient contrast for efficient processing and identification and are adjusted by their suppliers and developers. These lighting devices are functional, adapted to their use and are not intended to be adjusted or modified by users during the life of the instrument, except in the event of a breakdown.

Focusing: managing image sharpness

ZooScan does not have a focus adjustment device. Focusing is done automatically by ensuring that the objects to be imaged are positioned in contact with the scanner glass under a few mm of water. If some objects float to the surface, they need to be manually sunk onto the scanner glass so that they can be imaged in focus. The sharpness of the images also depends on the horizontality and stability of the ZooScan. The instrument must be set up horizontally with a spirit level and in

a vibration-free environment. ZooCAM has a manual focusing system. Focusing is carried out by adjusting the position of the cell between the light source and the sensor (camera) using three screws. The focus is estimated visually, using a trial-and-error process, until the operators judge that the objects are correctly displayed.

The two instruments have a similar resolution (10.56 µm/pixel and 10.3 µm/pixel, for ZooScan and ZooCAM, respectively), which enables objects between 0.3 and 3.39 mm to be imaged and identified in an interoperable way (Grandrémy *et al*., 2023b). This size range is suitable for fish eggs and large mesozooplankton. ZooScan is, however, better suited to imaging large objects (> 2.5 mm) that can sometimes only be partially imaged with ZooCAM due to the dynamic nature of image capture and the size of the field of view in the optical cell (Colas *et al*., 2018; Grandrémy *et al*., 2023a).

Technical aspects: automatic identification and taxonomic validation

The two instruments are controlled by different dedicated software packages but offer much the same functionality in terms of analysis outputs and output processing pipelines. Typically, these outputs are organised into a batch of thumbnails of individual objects associated with a text file containing metadata (sample: stations, geographical coordinates of the station, etc.; image capture settings; image processing) and data associated with each object imaged (size and other morphometric descriptors) per sample. With both instruments, it is essential to ensure that these two types of output are both saved, so as to be able to generate data that can be used scientifically. This scientific data is obtained by sorting and taxonomically counting batches of images using machine learning tools.

Machine learning and sorting tools

The software that drives ZooCAM includes a machine learning module that enables output to be processed directly (sorting of thumbnails and associated data). ZooScan output, in contrast, must be processed using the Ecotaxa web application (Picheral *et al*., 2017). However, the ZooScan outputs are formatted in such a way that they can be imported directly into Ecotaxa without any further manipulation.

In both cases, the operator must generate or use a training dataset, which enables a machine learning algorithm, or classifier, to create a sorting model. The training dataset consists of thumbnails and their associated data, sorted into taxonomic groups by an experienced taxonomist. This is a kind of ‘example' provided to the classifier. The taxonomic detail of this training dataset will have a direct impact on the final sorting of the set of as yet unidentified 'sample' vignettes. Applying a classifier to an unidentified set of thumbnails is known as automatic sorting or prediction. The accuracy of automatic sorting therefore depends on the training dataset used and the operator's sorting skills. It should be noted here that automatic sorting is never perfect and contains errors that can be quantified and corrected. Automatic sorting can be seen as an intermediate stage, facilitated by machine learning tools. For a baseline of training dataset characteristics adapted to zooplankton imaging data, please see Gorsky *et al*., 2010. Simply put, it is not necessary to create or use training datasets with more than 30 categories, and each category must contain at least 300 to 400 objects. For a systematic review on this topic, please refer to Irisson *et al*., 2022. In all cases, if time permits, these two authors recommend carrying out an evaluation-correction/validation step on the automatic sorting.

Expert validation

Expert validation follows the automatic sorting stage, generating scientifically usable data. This consists of a visual inspection of all the objects identified automatically, and an explicit, individual validation or correction of the automatic sorting. Expert validation can also be used to refine automatic sorting: for example, organisms automatically sorted into a category can be divided among finer taxonomic categories, if discernible by the taxonomist in charge of validation. This stage, although time-consuming and sometimes a source of errors (Culverhouse, 2014), enables the qualification of data from imagery for scientific use.

Appendices

Measurement tolerances and measurement tools: classes and precision

Measurement tolerances indicate the extent to which the results of a measurement may vary from the real value. Measurement tools can be classified into different categories according to their accuracy and use. The higher the class, the more precise the tool.

For example, in metrology (the science of measurement), the following classes are generally used:

Class I: Very high precision,

Class II: High precision,

Class III: Medium precision,

Class IV: Lower precision.

Calibration

Calibration verifies whether the measuring instrument is providing reliable and accurate results by comparing it with a measurement standard recognised for its stability and accuracy. If differences are identified during the calibration process, adjustments can be made to the instrument to correct measurement errors.

The uncertainty of the standard, also known as the 'measurement uncertainty', is a key component of calibration. It represents the estimated difference between the measurement result provided by the reference standard and the real value (the 'true' value) of the quantity to be measured. The uncertainty thus expresses the confidence that can be placed in the measurement taken with the calibrated instrument.

Maximum Tolerated Error

The maximum tolerated error of a measuring tool is the greatest acceptable deviation or difference between the measurement made by this tool and the true value of the quantity to be measured. In other words, it is the permissible error limit for the measurement to be considered acceptable in a given context. When you take a measurement with a tool, it is almost inevitable that there will be a discrepancy between the measured value and the true value. This difference is due to various factors, such as flaws in the tool, temperature variations, instrument wear, etc. To ensure that measurements remain within acceptable limits, manufacturers generally specify a maximum tolerated error for their measuring instruments. This error is often expressed as a percentage of the instrument's full scale or in absolute units of measurement.

For example, a thermometer with a maximum permissible error of ±1°C means that the actual measurement may vary by plus or minus 1°C from the true temperature. When a measuring tool exceeds the maximum tolerated error or is no longer capable of providing accurate measurements it is generally time to recalibrate or replace it.

Recalibration involves adjusting the tool to correct its errors and bring it back within the required accuracy specifications. It is essential to know the Maximum Tolerated Error (MTE) of the measurement tool used to ensure that the results obtained are reliable and relevant. Measurement errors may vary according to specific applications and requirements. It is therefore

important to choose the right measuring tool for the task in hand, depending on the needs and the importance of precision in each situation.

For a precise, illustrated example, you can consult the webpage at the following link: https://www.process-instruments.ma/post/comment-se-fixer-des-tol%C3%A9rances-sur-les-pes%C3%A9es

Ifremer's P6 process team (who operate, maintain, develop experimental resources and control measuring equipment) is there to help you and provide guidance on these specifications.

Size indicators: reference table

Classification	Species	Maximum Tolerated Error for size measurement	Preferred PSFM (DCF)
Argentimaculatus (Clupeiformes)	*Engraulis encrasicolus*	0.5 cm	Total length (TL) - cm - individual - total - Measured to the nearest 1/2 cm by an observer
Argentimaculatus (Clupeiformes)	*Sardina pilchardus*	0.5 cm	Total length (TL) - cm - individual - total - Measured to the nearest 1/2 cm by an observer
Argentimaculatus (Clupeiformes)	*Sprattus sprattus*	0.5 cm	Total length (TL) - cm - individual - total - Measured to the nearest 1/2 cm by an observer
Argentimaculatus (Clupeiformes)	*Clupea harengus*	0.5 cm	Total length (TL) - cm - individual - total - Measured to the nearest 1/2 cm by an observer
Pleuronectiformes	*Solea solea*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer
Pleuronectiformes	*Pleuronectes platessa*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer
Pleuronectiformes	*Glyptocephalus cynoglossus*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer
Pleuronectiformes	*Lepidorhombus whiffiagonis*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer
Pleuronectiformes	*Scophthalmus maximus*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer
Pleuronectiformes	*Scophthalmus rhombus*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer
Pleuronectiformes	*Limanda limanda*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer
Gadiformes	*Gadus morhua*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer
Gadiformes	*Molva molva*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer
Gadiformes	*Molva dypterygia*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer
Gadiformes	*Pollachius pollachius*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer
Gadiformes	*Pollachius virens*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer
Gadiformes	*Phycis blennoides*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer
Gadiformes	*Merluccius merluccius*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer

Gadiformes	*Merlangius merlangus*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer
Perciformes	*Dicentrarchus labrax*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer
Perciformes	*Chelidonichthys cuculus*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer
Perciformes	*Sparus aurata*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer
Perciformes	*Pagellus bogaraveo*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer
Perciformes	*Mullus barbatus*	0.5 cm	Total length (TL) - cm - individual - total - Measured to the nearest 1/2 cm by an observer
Perciformes	*Mullus surmuletus*	0.5 cm	Total length (TL) - cm - individual - total - Measured to the nearest 1/2 cm by an observer
Scombriformes	*Thunnus alalunga*	1 cm	Fork length (FL) - cm - individual - total - Measurement to the nearest cm by an observer
Scombriformes	*Thunnus obesus*	1 cm	Fork length (FL) - cm - individual - total - Measurement to the nearest cm by an observer
Scombriformes	*Thunnus albacares*	1 cm	Fork length (FL) - cm - individual - total - Measurement to the nearest cm by an observer
Scombriformes	*Istiophorus platypterus*	1 cm	Fork length (FL) - cm - individual - total - Measurement to the nearest cm by an observer
Scombriformes	*Kajikia audax*	1 cm	Fork length (FL) - cm - individual - total - Measurement to the nearest cm by an observer
Perciformes	*Argyrosomus regius*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer
Lophiiformes	*Lophius budegassa*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer
Lophiiformes	*Lophius piscatorius*	1 cm	Total length (TL) - cm - individual - total - Measured to the nearest cm by an observer
Xiphiiformes	*Xiphias gladius*	1 cm	Length cleithrum quille (LCK) - cm - individual - Cleithrum-quille - Measured to the nearest cm by an observer
Decapoda	*Homarus gammarus*	0.5 cm	Cephalothoracic length (CL) - mm - individual - cephalothorax - Measurement to the nearest mm by an observer
Istiophoriformes	*Coryphaena hippurus*	1 cm	Fork length (FL) - cm - individual - total - Measurement to the nearest cm by an observer
Istiophoriformes	*Istiompax indica*	1 cm	Fork length (FL) - cm - individual - total - Measurement to the nearest cm by an observer

Weight indicators: reference table

Classification	Species	Maximum Tolerated Error for the measurement of weight in grams	Preferred PSFM (DCF)
Argentimaculatus (Clupeiformes)	*Engraulis encrasicolus*	1	Weight - kg - individual - Measurement by an observer
Argentimaculatus (Clupeiformes)	*Sardina pilchardus*	1	
Argentimaculatus (Clupeiformes)	*Sprattus sprattus*	1	
Argentimaculatus (Clupeiformes)	*Clupea harengus*	1	
Pleuronectiformes	*Solea solea*	1	
Pleuronectiformes	*Pleuronectes platessa*	1	
Pleuronectiformes	*Glyptocephalus cynoglossus*	1	
Pleuronectiformes	*Lepidorhombus whiffiagonis*	1	
Pleuronectiformes	*Scophthalmus maximus*	1	
Pleuronectiformes	*Scophthalmus rhombus*	1	
Pleuronectiformes	*Limanda limanda*	1	
Gadiformes	*Gadus morhua*	1	
Gadiformes	*Molva molva*	1	
Gadiformes	*Molva dypterygia*	1	
Gadiformes	*Pollachius pollachius*	1	
Gadiformes	*Pollachius virens*	1	
Gadiformes	*Phycis blennoides*	1	
Gadiformes	*Merluccius merluccius*	1	
Gadiformes	*Merlangius merlangus*	1	
Perciformes	*Dicentrarchus labrax*	1	

Perciformes	*Chelidonichthys cuculus*	1	
Perciformes	*Sparus aurata*	1	
Perciformes	*Pagellus bogaraveo*	1	
Perciformes	*Mullus barbatus*	1	
Perciformes	*Mullus surmuletus*	1	
Scombriformes	*Thunnus alalunga*	500	
Scombriformes	*Thunnus obesus*	500	
Scombriformes	*Thunnus albacares*	500	
Scombriformes	*Istiophorus platypterus*	500	
Scombriformes	*Kajikia audax*	500	
Perciformes	*Argyrosomus regius*	1	
Lophiiformes	*Lophius budegassa*	1	
Lophiiformes	*Lophius piscatorius*	1	
Xiphiiformes	*Xiphias gladius*	500	
Decapoda	*Homarus gammarus*	1	
Istiophoriformes	*Coryphaena hippurus*	500	
Istiophoriformes	*Istiompax indica*	500	

Classification	Species	Tolerance for measuring gonad weight in grams	Preferred PSFM	Tolerance for measuring liver weight in grams
Argentimaculatus (Clupeiformes)	*Engraulis encrasicolus*	0.01	Weight - kg - individual - Gonads - Measurement by an observer	0.01
Argentimaculatus (Clupeiformes)	*Sardina pilchardus*	0.01		0.01
Argentimaculatus (Clupeiformes)	*Sprattus sprattus*	0.01		0.01
Argentimaculatus (Clupeiformes)	*Clupea harengus*	0.01		0.01
Pleuronectiformes	*Solea solea*	0.01		0.01
Pleuronectiformes	*Pleuronectes platessa*	0.01		0.01
Pleuronectiformes	*Glyptocephalus cynoglossus*	0.01		0.01
Pleuronectiformes	*Lepidorhombus whiffiagonis*	0.01		0.01
Pleuronectiformes	*Scophthalmus maximus*	0.01		0.01
Pleuronectiformes	*Scophthalmus rhombus*	0.01		0.01
Pleuronectiformes	*Limanda limanda*	0.01		0.01
Gadiformes	*Gadus morhua*	0.01		0.01
Gadiformes	*Molva molva*	0.01		0.01
Gadiformes	*Molva dypterygia*	0.01		0.01
Gadiformes	*Pollachius pollachius*	0.01		0.01
Gadiformes	*Pollachius virens*	0.01		0.01
Gadiformes	*Phycis blennoides*	0.01		0.01
Gadiformes	*Merluccius merluccius*	0.01		0.01
Gadiformes	*Merlangius merlangus*	0.01		0.01
Perciformes	*Dicentrarchus labrax*	0.01		0.01
Perciformes	*Chelidonichthys cuculus*	0.01		0.01

Perciformes	*Sparus aurata*	0.01	Weight - kg - individual - Gonads - Measurement by an observer	0.01
Perciformes	*Pagellus bogaraveo*	0.01		0.01
Perciformes	*Mullus barbatus*	0.01		0.01
Perciformes	*Mullus surmuletus*	0.01		0.01
Scombriformes	*Thunnus alalunga*	0.050		0.050
Scombriformes	*Thunnus obesus*	0.050		0.050
Scombriformes	*Thunnus albacares*	0.050		0.050
Scombriformes	*Istiophorus platypterus*	0.050		0.050
Scombriformes	*Kajikia audax*	0.050		0.050
Perciformes	*Argyrosomus regius*	0.01		0.01
Lophiiformes	*Lophius budegassa*	0.01		0.01
Lophiiformes	*Lophius piscatorius*	0.01		0.01
Xiphiiformes	*Xiphias gladius*	0.050		0.050
Decapoda	*Homarus gammarus*	0.01		0.01
Istiophoriformes	*Coryphaena hippurus*	0.050		0.050
Istiophoriformes	*Istiompax indica*	0.050		0.050

Standardised measurement of camera fields of view for assessing the age of reference calcified parts (fields of view under a binocular microscope, in mm).

	Champs de vision bino (mm)
Micromesistius poutassou	17,42 x 13,06
Pleuronectes platessa	
Lepidorhombus whiffiagonis	14 x 10,5
Argyrosomus regius	
Melanogrammus aeglefinus	11,22 X 8,41
Pollachius pollachius	
Pollachius virens	
Gadus morhua	
Chelidonichthys cuculus	8,78 X 6,58
Molva molva	
Merlangius merlangus	
Phycis blennoides	
Trachurus trachurus	6,98 X 5,23
Clupea harengus	
Trisopterus luscus	
Engraulis encrasicolu	5,62 x 4,41
Anguilla anguilla	
Scomber scombrus	
Sardina pilchardus	
Solea solea	

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