BS EN 14757:2015

BSI Standards Publication

Water quality — Sampling of fish with multi-mesh gillnets

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National foreword

This British Standard is the UK implementation of EN 14757:2015. It supersedes BS EN 14757:2005 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EH/3/5, Biological Methods.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Water quality - Sampling of fish with multi-mesh gillnets

Qualité de l'eau - Echantillonnage des poissons à l'aide de filets maillants

Wasserbeschaffenheit - Probenahme von Fisch mittels Multi-Maschen-Kiemennetzen

This European Standard was approved by CEN on 16 April 2015.

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This document (EN 14757:2015) has been prepared by Technical Committee CEN/TC 230 “Water analysis”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2015, and conflicting national standards shall be withdrawn at the latest by November 2015.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 14757:2005.

This document contains the following technical changes compared with the previous edition:

a) this European Standard was revised to clarify that using pelagic gillnets is an option for fish sampling with gillnets;

b) the sampling design for the location of benthic gillnets was revised;

c) the requirements for the planning, sampling duration and sampling procedure were revised;

d) the requirements for data collection, data storage and data processing were revised;

e) the specifications concerning the handling of effects caused by gillnet selectivity were revised and shortened;

f) details and references for alternative sampling methods were included;

g) details for age and growth analyses where excluded from the normative part and added in an informative annex (Annex B).

According to the CEN/CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This is one of several European Standards developed for evaluation of species composition, abundance and age structure of fish in rivers, lakes and transitional waters. Other standards describe “Sampling of fish with electricity” (EN 14011), “Guidance on the scope and selection of fish sampling methods” (EN 14962) and “Guidance on the estimation of fish abundance with mobile hydroacoustic methods” (EN 15910).

In most countries the use of the method specified in this European Standard requires permits from landowners and national or regional authorities. In many countries permits are also required from authorities for animal rights and animal welfare demands. Both fish diseases and diseases specific for other organisms, such as freshwater crayfish, may be spread by placing equipment contaminated with pathogens or parasites in the lake. The user of this method should check which national legislation is applicable.

WARNING — Persons using this European Standard should be familiar with usual laboratory and fieldwork practice. This European Standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user to establish appropriate health and safety practices and to ensure compliance with any national regulatory conditions.

IMPORTANT — It is absolutely essential that tests conducted according to this European Standard be carried out by suitably trained staff.

1 Scope

This European Standard specifies a method for the sampling of fish in lakes, using benthic multi-mesh gillnets and gives recommendations on sampling of fish with pelagic multi-mesh gillnets. The method provides a whole-lake estimate for species occurrence, quantitative relative fish abundance, biomass expressed as Catch Per Unit Effort (CPUE) and size structure of fish assemblages in temperate lakes. It also provides estimates that are comparable over time within a lake and between lakes.

This European Standard specifies routines for sampling, data handling and reporting, and provides information on applications and further treatment of data. It also provides guidance for the sampling of fish for age and growth analyses. According to the principles of this standard other lentic water bodies can be sampled.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 14962:2006, *Water quality - Guidance on the scope and selection of fish sampling methods.*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 14962:2006 and the following apply.

3.1
sampling effort
number of gillnet-nights

Note 1 to entry: A gillnet-night is one gillnet fishing during one night. For example a sampling effort of 8 gillnet-nights is 8 gillnets fishing during one night, or 4 gillnets fishing during 2 nights etc.

4 Principle

The sampling procedure is based on stratified random sampling. The sampled lake is divided in depth strata and random sampling is performed within each depth stratum. Sampling of benthic fish is performed with specially designed multi-mesh gillnets which are 30 m long and 1,5 m deep. The gillnets are composed of 12 different mesh-sizes ranging from 5 mm to 55 mm knot to knot following a geometric series. Similar nets can be applied also for sampling of pelagic fish. In larger and deeper lakes and reservoirs sampling of pelagic fish with multi-mesh gillnets is highly recommended. The sampling effort (number of gillnet-nights) necessary to allow detection of 50 % changes in relative abundance between sampling occasions, ranges between 8 gillnet-nights for small, shallow lakes, up to 64 gillnet-nights for lakes of about 5 000 ha. If less accurate estimates of abundance are needed, an inventory sampling procedure may be used, thereby reducing the necessary sampling effort.

5 Equipment

5.1 Benthic gillnets

The multi-mesh gillnets have been designed for catching all types of freshwater fish species. Each gillnet shall be composed of 12 different mesh-sizes ranging from 5 mm to 55 mm (knot to knot). The mesh-sizes follow a geometric series, with a ratio between mesh-sizes of about 1,25. All gillnets shall have the same order of mesh panels (see Table 1).

If experience has shown that large fish of certain species (e. g. bream *Abramis brama*, carp *Cyprinus carpio*, pikeperch *Sander lucioperca*, pike *Esox lucius*, tench *Tinca tinca*) are difficult to catch with the mesh sizes shown in Table 1, it is possible to add larger mesh sizes. However, this modification shall be recorded in the report (fishing protocol) and the catch in the standardized mesh sizes shall be recorded separately from the catch in the added mesh sizes to allow comparisons between lakes and years.

Table 1 — Mesh-size distribution (knot to knot) and thread diameter in multi-mesh benthic gillnets

Mesh no.	Mesh size mm	Thread diameter mm
1	43	0,20
2	19,5	0,15
3	6,25	0,10
4	10	0,12
5	55	0,25
6	8	0,10
7	12,5	0,12
8	24	0,17
9	15,5	0,15
10	5	0,10
11	35	0,20
12	29	0,17

Gillnets shall be made out of homogeneous, uncoloured nylon. Each gillnet shall be 30 m long and 1,5 m deep. Each mesh panel shall be 2,5 m long and mounted on a 30 m long buoyancy line (with a recommended linear density in water of 6 g/m), and a 33 m long lead line (recommended linear density in air 22 g/m and in water 9,9 g/m) made out of plastic in light grey colour. The diameter of the thread varies between 0,10 mm for the 5 mm mesh, to 0,25 mm for the 55 mm mesh (see Table 1). The hanging ratio is 0,5 for all mesh sizes.

NOTE All mesh panels are commercially available.

5.2 Pelagic gillnets

Each pelagic gillnet should preferably consist of the same mesh sizes in the same order as in the benthic gillnets. The height of the pelagic gillnets may be higher than the benthic gillnets, and the height used should always be recorded. When using all the 12 mesh sizes, the length is 30 m. The buoyancy line is 30 m, and the lead line is 33 m to 45 m, depending on the height of the net, with a hanging ratio of 0,5. The weight of the lines is determined by the gillnet height. A gillnet manufacturer should provide such lines to ensure correct gillnet performance.

6 Sampling design and procedure

6.1 Sampling design

Fish are not randomly distributed in a lake. Depth distribution varies between fish species and with the ontogeny of the fish. The horizontal distribution may also be influenced by habitat heterogeneity. Neither is the distribution constant over the year, but will vary with temperature and season.

To cope with this uneven distribution a stratified random sampling design shall be used. The lake shall be stratified in depth strata and a random sampling should be performed within each depth stratum. Each gillnet shall be placed to represent an independent sample of the fish assemblage. By randomising the location of each gillnet within each depth stratum an independent sample of the fish in each stratum will be achieved. It is important that the entire gillnet is within the correct depth stratum. Randomisation is performed prior to fishing by the aid of depth maps and a co-ordinate grid.

Large lakes or elongated reservoirs may be treated as two or more separate parts. Then randomising gillnet locations should be made within sub-basins or longitudinal parts.

6.2 Planning

In order to maximise the output of the sampling effort, a thorough planning shall precede all fish sampling. When a lake has been selected for sampling, permission from the fishing right owner(s) shall be obtained. To avoid misunderstandings, the responsible persons should be informed about the aim and magnitude of the fishing activities, and the results should be communicated to responsible persons afterwards.

If a map of the lake with depth contours is available, it could be used to determine the necessary sampling effort. The map with depth contours is used to divide the lake into appropriate depth strata and to determine the number of gillnet-nights in each stratum. If the lake is to be sampled for the first time, a randomisation of the gillnet locations should be performed in advance. If data on depth of the lake is lacking, the sampling shall be preceded by a sounding. This could be performed using a simple echo sounder and by running the boat in predetermined transects over the lake before gillnets are set for the first time. The beam angle of the echo sounder should be as narrow as possible (maximum 10°). Wider angles cause underestimation of the depth at sloped bottoms.

If possible, supplementary information about the lake and the surroundings should be collected before sampling. Relevant information about geography, water quality, the fishery and introduced fish species in the lake should be collected.

6.3 Sampling period

The results of fish sampling using passive gears is highly influenced by water temperature, life history and time for spawning of specific fish species. This means that the optimal sampling period may differ between countries and regions. To minimise between-year variation, due to differences in activity between species, the sampling period should be defined for each lake or region to be sampled in order to make sampling data between different lakes and years comparable. To level the effects of different weather conditions, yearly sampling may be distributed to several days and by distributing the nets in all depth strata every day.

For example, fish sampling in northern Europe should take place between July 15 and August 31. During this period most freshwater fish species in lakes do not spawn, and the epilimnion temperature usually exceeds 15 °C in most non-alpine areas. Due to decreasing epilimnion water temperature in September it is not recommended to extend the sampling period, because the catch may decline substantially when epilimnion temperature drops below 15 °C. Some species, and especially cyprinids, might also change their behaviour during autumn, thereby affecting the representativeness of the sampling. Only if it is known that the catch is good for the present species even at temperatures down to 10 °C, the sampling season may be extended until September 15.

6.4 Sampling

The setting time for the gillnets should ensure that the activity peaks of each fish species will be included. Activity peaks of most European species are best covered when gillnets are set 2 h to 3 h before the sunset and lifted 2 h to 3 h after sunrise. During each sampling period the catches will be affected by saturation as well as fish escaping the net after being temporarily entangled. Saturation and fish escapes decrease estimated fish density in a nonlinear way. Avoid calculating abundance relative to hours of setting time as gillnet catch is dependent on setting time in a nonlinear way. In dense fish communities where saturation effect is expected to be great, sampling of only evening peak of fish activity with appropriate correction is a possibility.

The water depth of the most shallow and deepest points where the net is placed shall be recorded. The distribution of gillnets for each fishing night should be such that all depth strata are included, in order to avoid bias due to differences in weather conditions between nights. A GPS (Global Positioning System) instrument is recommended to locate and record gillnet positions. The co-ordinates of both ends of the gillnet should be recorded using GPS. Thereby, the gillnet angle to the shoreline is also recorded.

The catches should be treated by nets and within a net, separation by mesh sizes is strongly recommended due to the following reasons:

1) representative subsamples for reliable size distribution estimates can be obtained;

2) assorting to species and size classes is easier;

3) quality control and back-tracking of mistakes is possible;

4) correction for gillnet selectivity is possible.

After the nets have been emptied they should be cleaned and dried until the next setting. Further handling and measurements of the fish should be performed as soon as possible. If the weather is warm, the caught fish shall be kept cold, either in a cold-storage room or by use of ice.

6.5 Safety instructions

During all fish sampling activities the safety instructions for fieldwork on water should be followed. There should always be at least two persons able two swim on board the fishing vessel. The personnel should be equipped with life jackets, a device for communication such as a mobile phone or a flag, megaphone or whistle to alert people on land, and a first-aid box.

7 Time series sampling

7.1 Sampling effort

When the sampling aims at quantifying relative abundance or biomass of different fish species, and comparing differences over time and between lakes, the variance of the estimate of the mean shall be quantified. All fish should have approximately the same probability of getting caught, and, therefore, a representative sampling in a lake shall be performed. The sampling effort needed at each sampling occasion is determined both by the minimum sampling effort needed to catch all catchable fish species and by the required precision of the mean value. Usually the number of gillnet-nights needed to catch all catchable fish species is lower than the number required for an acceptable precision of the estimate.

A commonly used minimum requirement for time series sampling has been to detect a 50 % difference between sampling occasions in relative abundance of the most abundant fish. The sampling effort needed is determined by the precision, the lake area and the maximum depth of the lake. The higher the desired precision, and the larger and deeper the lake, the higher the sampling effort. The number of gillnet-nights required to achieve a precision, which makes it possible statistically to determine a 50 % difference between sampling occasions, is given in Table 2. By convenience the lakes are divided into six size classes (≤ 20 ha, 21 ha to 50 ha, 51 ha to 100 ha, 101 ha to 250 ha, 251 ha to 1 000 ha, 1 001 ha to 5 000 ha), and the number of gillnet-nights is based on multiples of 8, which is a usual workload for a one night sampling made by two persons.

Table 2 — Number of gillnet-nights with benthic gillnets required to allow the detection of 50 % changes between sampling occasions in relation to lake area and maximum depth

Depth m	**Lake area** ha					
	≤ 20	21 to 50	51 to 100	101 to 250	251 to 1 000	1 001 to 5 000
0 to 5,9	8	8	16	16	24	24
6 to 11,9	8	16	24	24	32	32
12 to 19,9	16	16	24	32	40	40
20 to 34,9	16	24	32	40	48	56
35 to 49,9	16	32	32	40	48	56
50 to 74,9			40	40	56	64
≥75					56	64

For small (< 10 ha) and shallow lakes even 8 gillnet-nights could overexploit the fish community, and especially deplete the reproducing stock of certain species too much. The sampling effort should, however, never be less than 4 gillnet-nights (see also 8.1).

Whole-lake estimates of the relative fish abundance in lakes larger than 5 000 ha usually require such a large sampling effort that it is practically impossible to use the recommended technique. In cases when larger lakes shall be sampled, it is recommended that the lake is divided into separate basins, and that each basin is treated as a separate lake. In large lakes, where whole-lake estimates of the fish fauna are not of main priority, sampling can be performed at specific stations.

Stratification of gillnets is basically related to depth. The principles for depth stratification are given below. In lakes with vegetation cover and in large shallow lakes, other stratification principles shall be considered. However, it should be considered that depth is less variable over time than vegetation, and, therefore, stratification related to vegetation shall be reconsidered at each successive sampling in a particular lake. Reservoirs or lakes with steep banks may also be subjected to a modified stratification of gillnets.

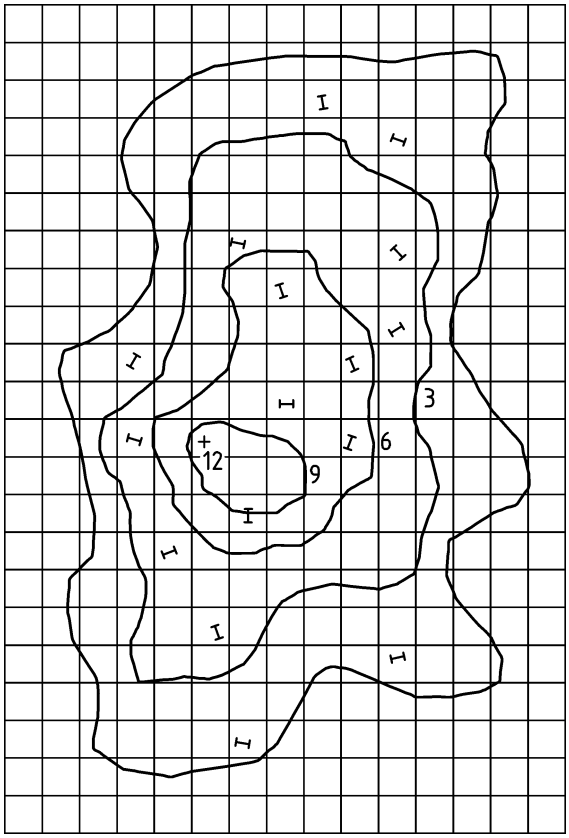
7.2 Depth stratification of benthic gillnets

The depth strata are determined in relation to the surface area of each stratum in such a way that each depth stratum approximately equalises the same volume of water. Even if lake morphometry may vary considerably between lakes, it is convenient to use a standardized scheme for stratification. For most lakes an approximation of the depth strata can be based on morphometric lake data. Each lake is divided in approximately equal water volumes resulting in the following depth strata: 0 m to 2,9 m, 3 m to 5,9 m, 6 m to 11,9 m, 12 m to 19,9 m, 20 m to 34,9 m, 35 m to 49,9 m, 50 m to 74,9 m, > 75 m. Lakes deeper than 75 m are rarely subjected to fish sampling using this type of benthic gillnets (see EN 14962). If the exact proportions of the surface area covered by different depth strata are not known, the number of benthic gillnets recommended in each depth stratum is given in Annex A. The table in Annex A includes optional benthic gillnets at depth > 75 m for large lakes (251 ha to 5 000 ha). Experience has shown that fish can be caught in these gillnets,

e. g. smelt *Osmerus eperlanus*, Arctic char *Salvelinus alpinus alpinus* and bullhead *Cottus gobio*. The information obtained from these gillnets should be determined on a case-to-case basis.

If there is a morphometric map of the lake (see Figure 1), the surface area of each depth stratum should be calculated. The total number of gillnet-nights used might be distributed between depth strata in relation to the surface area of each stratum, and/or the surface area proportions might be used for weighting catches in different depth strata for the whole-lake estimates of catch per unit effort (CPUE).

If the deepest stratum is too small for setting benthic gillnets which are independent of each other, it should not be treated as a separate depth stratum. When distributing gillnets over the lake, this depth stratum is treated as a part of the stratum just above it.



NOTE Example map: Co-ordinate grid, depth contours at 3 m, 6 m and 9 m, location of benthic gillnets (small marks "I") are shown.

Figure 1 — Morphometric map of a hypothetical lake of 40 ha with maximum depth of 12 m.

Gillnets shall be set in straight lines and at an angle to end up in the desired depth stratum.

The catch in each gillnet shall be treated as an independent sample for that particular depth stratum. Gillnets shall not be attached to each other.

7.3 Sampling of the pelagic habitat

Some of the fish species caught by benthic gillnets will also occur in the pelagic habitat, however, the community structures may differ markedly. The larger the volume of the pelagic habitat, the larger the life space for pelagic specialists, with low catchability in the benthic habitat. Especially in larger lakes, the volumes of water in the open water may represent the bulk of the lake volume what should be taken in account when characterizing the fish community. The pelagic habitat may be sampled in a depth profile at the deepest part of the lake, or in a stratified random design, similar to the sampling with benthic gillnets. The same sampling protocol used in pelagic as well as in benthic habitat will enable comparison of both quantity and quality of fish assemblages. Pelagic gillnets of 1,5 m height may be used in a stratified random design, while pelagic nets of higher height may be more efficient in depth profile sampling of deeper lakes. A flexible sampling design implies need for careful recording of gillnet position as well as gillnet area.

8 Inventory sampling

8.1 Sampling effort

The inventory sampling is a simplified method for fish sampling which will provide a rough estimate of the occurrence and abundance of dominating fish species in the lake. This type of sampling may be used in studies aimed at describing the distribution of species and in inventory studies, when the precision of the fish abundance is of less importance.

The sampling effort is dependent on the number of gillnet-nights necessary to catch all catchable species in a lake. Therefore, the lake area determines the size of the sampling effort. In general, 4 gillnet-nights is a minimum, independent of lake size. The lakes are divided into four size classes (≤ 50 ha, 51 ha to 300 ha, 301 ha to 2 000 ha, > 2 000 ha) to determine the sampling effort. In lakes larger than 5 000 ha an inventory sampling shall be accomplished using other sampling methods. The lowest number of necessary gillnet-nights and the distribution of gillnets within the lake are given in Table 3. The sampling effort may be increased in order to increase the probability to catch all catchable fish species.

Table 3 — Minimum sampling effort with benthic gillnets in an inventory sampling in relation to lake area

Lake area ha	**Number of gillnet-nights**		
	Total	**In epilimnion/metalimnion**	**In hypolimnion**
≤ 50	4	2	2
51 to 300	8	4	4
301 to 2 000	16	8	8
>2 000	24	12	12

8.2 Depth stratification of benthic gillnets

The depth stratification varies between species and may also vary between size classes within the same species. Therefore, it is important that both the epilimnion and the hypolimnion in thermally stratified lakes are sampled, and that all depths of the lake are sampled, even if there is no clear thermal stratification.

Gillnets shall be set randomly over the whole lake:

a) over the depth stratum which covers the epilimnion and metalimnion;

b) in the hypolimnion.

If there is no thermal stratification in the lake, the same number of gillnets shall be used as if the lake has a metalimnion. Each single gillnet is loosely set in a straight line and at an angle to end up in the desired depth stratum.

The catch in each gillnet shall be treated as an independent sample. Gillnets shall not be attached to each other.

9 Data handling and reporting

9.1 Fish data

For each sampling occasion the sampling effort, the geographical location of each gillnet in the lake, and the maximum and minimum depth for each single gillnet shall be recorded (for forms, see examples in Annex C). The locations of gillnets shall be marked on a lake map with depth contours or as co-ordinates if GPS equipment is used.

Minimum requirements for fish data registration and reporting is given in Table 4. The catch within each gillnet shall be registered as total number of individuals and total weight for each species.

Optionally the catch within each mesh panel should be registered in such a way that it is possible to track each specific individual back to the gillnet and specific mesh panel in which it was caught. This will be of importance if a more detailed correction for gillnet selectivity is to be performed, and to detect possible errors in the data (quality control). Accordingly, the total length for each single specimen is registered in such way that each individual could be tracked back to the individual gillnets (and if desirable also mesh panel) in which it was caught. Optionally, the wet weight of each specimen could be recorded in a similar way. Total lengths are determined to the nearest millimetre and weight to the nearest gram.

If there is a lot of fish (hundreds) per gillnet, sub-samples for length measurements may be taken. If every mesh size in each gillnet is handled separately, stratified sampling for length measurements is easy and adequate sub-samples are 30 to 50 individuals per species and mesh size in one gillnet. Before reporting the results, the sub-samples are weighed with the total number of individuals.

Raw data should not be processed before they are stored in a database. Data should preferably be stored in a database using lake (or lake ID), date for fishing, and gillnet number as ID-variables. Using the lake map, it will then be possible to describe the exact location in the lake where the specific individual was caught.

Table 4 — Minimum requirements for fish data registration and reporting

Requirement	Explanation
List of fish species	A list of species caught in the gillnets shall be provided. As the sampling technique is based on a passive system, the probability to get caught varies among species and the species list may therefore not be used as a definite list of fish species in the lake. However, the sampling effort is calculated so that on average all catchable species are caught at least on one occasion, which make the list comparable between years.
Total number of caught fish	The total number of each species.
Total weight of caught fish	The total weight of each species.
Number Per Unit Effort (NPUE)	The simplest way to calculate NPUE is the arithmetic mean for the catch of each species. The variance estimates will be larger if stratification is considered. By estimating mean and variance for each single depth stratum, the variance may be minimised (see 11.1). NPUE should also be given as the number of the fish caught in each depth strata in a way that it is possible to calculate the mean value for the lake and to describe depth distribution of each species.
Weight Per Unit Effort (WPUE)	Should be calculated similarly as for NPUE.
Length (and/or weight) frequency distributions	Length (and/or weight) frequency distributions should be given for all dominant species in the lake. When there is a special interest for some species, the frequency distributions could be corrected for gillnet selectivity (see Clause 10). However, usually the difference between corrected length distributions and non-corrected distributions is of minor importance for many species when the general fish population structure should be given.

9.2 Supplementary data

The outcome of the fish sampling is affected by physical/geographical factors such as lake size and depth, water transparency, temperature and weather conditions during sampling. Therefore, supplementary data should always be provided. This is shown in Table 5. Secchi depth and a temperature profile should be recorded at each sampling occasion. A current weather report for the sampling occasion, including strength and direction of the wind should also be registered.

A map with depth contours showing the location and identity of each gillnet should be added to each sampling occasion (see Figure 1). The quality of the map should be such that the sampling could be repeated without additional knowledge.

Table 5 — Supplementary data used in assessment of fish sampling data

Required Data	Explanation
Geographical information	
Lake identification	Name and number of the lake (co-ordinates in national grid system or longitude-latitude).
Watershed identification	Name and number of water system (drainage area code).
Altitude	Altitude is given in metres (m) above sea level. Preferably data from national geographical or hydrological institutes are used.
Lake or basin area	The area of the lake or basin should be given according to accepted references. If the area substantially deviates from the area measured from maps or by other sources, both areas and references should be given.
Lake or basin depth	If available both maximum and average depth should be given in metres (m). If no published data are available, data obtained during fish sampling using e. g. echo sounding may be given as preliminary data.
Physical data (usually measured once during fish sampling)	
Vegetation	Coverage and plant infested volume shall be given, if appropriate.
Water transparency (at deepest part)	Water transparency, usually is measured as Secchi disc depth, given in fractions of a metre (m).
Temperature (at deepest part)	A temperature profile is registered at 0,5 m and then at each full metre – 1 m, 2 m, and so on down to 25 m depth and then, if needed, every 5 m to the bottom.
Water quality (at deepest part)	If available, water quality data should be added to the fish sampling. Data reflecting nutrient load (phosphorous and nitrogen), oxygen depletion (oxygen at hypolimnion) and acidification status (pH, alkalinity and/or ANC (acid-neutralizing capacity)) are preferable.
Water level	For lakes with variable water levels, the deviation from reference levels should be given. Altitude, area and depth are all affected when the water level changes. Altitude of water level should be measured by GPS or other device in metres (m).
Sampling information	
Date and time for gillnet setting	Date and time for setting and lifting of the gillnets should be given. The time should be given with an hourly precision.
Number of gillnet-nights	The total number of gillnet-nights used at different depth strata in the sampling should be recorded.
Type of pelagic gillnets used	If pelagic gillnets are used, the length and height shall be recorded. This makes it possible to calculate the catch in terms of caught fish per square metre (m^2).
Type of sampling design	The type of sampling design (time series/ inventory sampling) should be given, as part of the quality control.
Responsibility	The performer and institute responsible for the sampling should always be given.

9.3 Databases and quality control

Data from fish sampling should be stored in specially designed databases. A quality control should always accomplish data storage, thereby minimising typing errors and avoiding preposterous data. To improve the quality of the data and the detection and correction of errors, each mesh size in each gillnet can be handled separately. The purpose is to provide data of high quality for international, national, regional and local investigations and reports.

It is recommended that all activities during the fish sampling procedure are subject to a quality assurance programme in order to produce consistent results of high quality. The quality control should include all parts of the sampling including training of fishermen, handling of equipment, fieldwork, handling of fish, analyses, data handling, and reporting.

10 Dealing with gillnet selectivity

If a passive sampling gear is used, the outcome of the sampling depends upon the movements of the fish and the mechanical properties of the gear to catch and to retain the fish. The properties of the gear affect the composition of the sample, and only a particular part of the population is collected in the sample. This means that the sampled population might not be the same as the biological population of interest. Selectivity of gillnets include any process that causes the probability of being sampled to vary with the characteristics of a fish. For a passive gear, selectivity usually is divided into

a) encounter probability,

b) the probability of being caught in the mesh, and

c) the probability of being retained in the gillnet after being caught.

Selectivity of multi-mesh gillnets has been estimated for several fish species, using different models (see Bibliography). It may be expected that the condition of the fish may affect the gillnet selectivity due to changes of shape of the fish. However, differences in condition (i. e. fish shape) between lakes have no practical effect on the catch composition because gillnets are composed of mesh-sizes following a geometric series. Adjacent mesh sizes would cover each other and correct for this error.

Gillnet selectivity may result in under- or overestimation of certain species. Underestimation may affect territorial species with limited area covered over a gillnet setting period (e. g. littoral individuals of pike) which reduces probability of encounter the gillnet. Eels are very rarely caught in gillnets due to their smooth body morphology and motoric abilities. On the other hand, structured body surfaces of some species (e. g. the family *Percidae*) can increase probability of tangling a fish in the gillnet by spines and opercula. Further, differences in activity among species can influence the probability of encounter the gillnet. The sampling method provides relative abundance estimates only for fish from about 40 mm to 400 mm total length of fish species catchable in gillnets. Size selectivity represents an additional bias of gillnet catches. Especially small fish (young-of-the-year and one year old fish) are known to be underestimated in catches. Therefore, every size distribution of gillnets catches shall be interpreted with respect to size selectivity.

Uncorrected data should always be reported in the final data set. In addition, if any corrections for gillnet selectivity have been made, these shall be clearly specified.

11 Estimation of sampling variance

11.1 Within-lake variation

The precision of the catch per unit effort (CPUE) within each depth stratum can be estimated if a stratified random sampling design is used. CPUE is initially transposed using $\log_{10}(\mathrm{CPUE}+1)$ in order to achieve a normal distribution. Assuming that the variances of CPUE are approximately equal after transformation, the mean and variances of CPUE are weighted with regard to the number of gillnet-nights used in each stratum, and pooled estimates for the entire lake are calculated. The total number of gillnet-nights recommended for sampling (see Table 2) is determined so that 50 % differences of the dominating fish species can be detected.

The sampling effort needed to achieve a certain precision within a lake is calculated according to Formula (1):

$$N = s^2 / (\text{CPUE}^2 \cdot C_{V,m}{}^2)$$

where

N is the number of gillnet-nights

s is the standard deviation

$C_{V,m}$ is the coefficient of variation of the mean.

The more commonly used C_V (Coefficient of Variation) is the standard deviation divided by the mean.

11.2 Within-lake and between-year variation

When comparing differences within-lakes between-years, mean and variance estimates according to 11.1 may be used. However, using a $\log_{10}(\text{CPUE}+1)$ transformation of CPUE in order to normalise data, should be performed with caution, because the inclusion of a constant in the transformation may give arbitrary effects on different scales. The median coefficient of variation for between-year variation of biomass and abundance for several lakes has been less than 25 %, and it did not differ significantly from the corresponding sampling precision.

11.3 Between-lake variation

When comparing CPUE among lakes, the sampling design usually forms a hierarchical structure that includes random effects (gillnet location within lake) and/or repeated effects (time, day, year etc.) and the fixed effect under study (lake). General or generalized linear mixed model estimation is recommended for analysing differences in CPUE between lakes. If different sized gillnets are to be used, the gillnet size (in m^2, logarithmic scale) should be included in the statistical analysis as a covariate or as an offset variable.

12 Applications and further analyses

The analyses and reporting from a standardized fish sampling depend on the objectives of the particular study or the particular monitoring programme. Irrespective of a more detailed analysis of the outcome of the sampling, it is recommended that some basic results always be provided (see Table 4 and Table 5). Data and results may often be used for further analyses in other studies or for comparison with results from other lakes or studies.

It is important that the sampling procedure is clearly described. Total number of gillnet-nights, distribution of nets within the lake including depth distribution, and time of sampling (time of year and time of day) are necessary to determine the quality of the sampling. Also, supplementary data are necessary to evaluate possible biases in the sampling. By optional analyses of the fish, such as ageing, stomach analyses, determination of parasites, and individual measurements such as Fulton's condition index, and other type of indices, a more thorough assessment of the fish community can be performed.

The standardized sampling technique has been used for freshwater fish monitoring in a number of studies, both at a national and regional scale. The main purposes of these studies have been to assess the effects of environmental disturbance on fish and fish assemblages and biodiversity assessment. Fish data from standardized sampling have been used to analyse ecological problems connected with species distribution, habitat preferences, life histories and for ecological classification according to the Water Framework Directive. They have also been used to evaluate the effects of fishing pressure on population structure and dynamics of different species.

13 Limitations and supplementary sampling

Like all sampling methods, sampling with gillnets is biased. It is important to be aware of the main limitations of the method when analysing and presenting data. A multi-mesh gillnet is a passive gear, the sample depends on the actual movement of the fish. Extrinsic factors such as temperature, weather conditions, location of the gillnets and water transparency affect the outcome of the sampling. Intrinsic factors such as activity due to feeding and spawning are also important. For instance, eel may be abundant in a lake without getting caught in the gillnet, and pike is usually caught in the gillnets, however, not in a representative number. Behaviour and habitat selection might also affect the representation of different size classes of fish. For some species, e. g. perch, roach and other cyprinids, and some *salmonid* species, the Y-O-Y (young-of-the-year individuals) are dwelling in the vegetation or the bottom substrate during their first summer in order to escape from predation. These fish are usually less represented in the gillnet catch.

To cope with these problems it is recommended to use a supplementary sampling method. Such methods are given in EN 14962. For littoral species, sampling may be complemented with seining, fyke nets or electro-fishing at selected stretches of the shoreline.

Another limitation is the ability of the gillnet to catch fish of all occurring sizes. Within the interval of 40 mm to 400 mm, large fishes are often over-represented in the catch, whereas small fishes are under-represented. To some extent this bias could be compensated for by using gillnet selectivity correction factors, but a certain error will remain. The relative thickness of the thread also affects the possibility to catch the smallest fish sizes, and thereby Y-O-Y fish (< 60 mm) are usually not caught in a representative manner. If Y-O-Y should be included in the sampling, traps may be used for sampling some *salmonid* species, whereas seining may be used for sampling *percid* and *cyprinid* species. Also electro-fishing may be used during suitable conditions. For sampling of pelagic Y-O-Y a trawl or a push-net is recommended.

Sampling with multi-mesh gillnets provides a relative estimate of the fish abundance in a lake. The CPUE is considered to be directly proportional to the actual abundance of a species, and to a constant called "catchability". Because the catchability constant varies between species and between seasons, it is not possible to provide a general transformation of the obtained relative abundance values to absolute abundance values (e. g. number of fish per ha, or biomass per ha). There may be several reasons for this e. g. the catchability may depend upon several environmental factors that vary among lakes. However, for time series analyses, and for comparative studies among lakes, this is usually not a major problem if a strictly standardized sampling method is used. It may, though, be a problem when relating fish biomass to biomass estimates for other organisms. In that case, one or several alternative sampling methods should be used, and especially echo-sounding for pelagic fish or mark-recapture methods may be suitable.

Sampling efficiency may also be affected by the gillnet quality. The fishing efficiency of a certain gillnet is difficult to test. Therefore, the person using these nets should make certain that they are functioning properly by inspecting them before they are used and replace them with new nets whenever they are suspected to be less efficient.

14 Alternative sampling

Sampling with multi-mesh gillnets is currently the most suitable method to provide a whole-lake estimate of species composition, relative abundance and age structure of fish. Usually just a small fraction of the fish population is caught, but it is a destructive sampling method, because most of the sampled fish are killed. Under some circumstances, for example in lakes in alpine regions with fish species or populations which might be sensitive to overfishing, a reduced sampling effort should be considered.

There are also other, less-destructive, methods which should be considered if the investigation does not require a whole-lake estimate of the fish population, such as electrofishing in the littoral, seining, hydroacoustics and fyke nets (see EN 14962).

Annex A
(informative)
Distribution of benthic multi-mesh gillnets at different depth strata in lakes with different area and maximum depth

Table A.1

	Depth stratum m	**Maximum depth** m						
		< 6	6 to 11,9	12 to 19,9	20 to 34,9	35 to 49,9	50 to 75	> 75
Lake area < 20 ha	< 3	4	3	4	4	3		
	3 to 5,9	4	3	4	3	3		
	6 to 11,9		2	4	3	3		
	12 to 19,9			4	3	3		
	20 to 34,9				3	2		
	35 to 49,9					2		
Total number of gillnet-nights		8	8	16	16	16		
Lake area 21 ha to 50 ha	<3	4	5	5	5	5		
	3 to 5,9	4	6	5	5	5		
	6 to 11,9		5	3	5	6		
	12 to 19,9			3	5	6		
	20 to 34,9				4	6		
	35 to 49,9					4		
Total number of gillnet-nights		8	16	16	24	32		
Lake area 51 ha to 100 ha	< 3	8	8	7	7	7	7	
	3 to 5,9	8	8	7	7	7	7	
	6 to 11,9		8	5	9	7	10	
	12 to 19,9			5	6	4	4	
	20 to 34,9				3	4	4	
	35 to 49,9					3	4	
	50 to 75						4	
Total number of gillnet-nights		16	24	24	32	32	40	
Lake area 101 ha to 250 ha	< 3	8	8	8	7	7	7	
	3 to 5,9	8	8	8	7	7	7	
	6 to 11,9		8	8	10	10	6	
	12 to 19,9			8	8	6	6	
	20 to 34,9				8	6	6	
	35 to 49,9					4	4	
	50 to 75						4	
Total number of gillnet-nights		16	24	32	40	40	40	

	Depth stratum m	**Maximum depth** m						
		<6	6 to 11,9	12 to 19,9	20 to 34,9	35 to 49,9	50 to 75	>75
Lake area 251 ha to 1 000 ha	< 3	12	11	10	10	10	10	10
	3 to 5,9	12	11	10	10	10	10	10
	6 to 11,9		10	10	10	10	10	10
	12 to 19,9			10	10	8	8	8
	20 to 34,9				8	6	8	5
	35 to 49,9					4	6	5
	50 to 75						4	4
Optional	>75							0 or 4
Total number of gillnet-nights		24	32	40	48	48	56	52 to 56
Lake area 1 001 ha to 5 000 ha	<3	12	11	10	10	10	10	10
	3 to 5,9	12	11	10	10	10	10	10
	6 to 11,9		10	10	12	12	10	10
	12 to 19,9			10	12	9	10	10
	20 to 34,9				12	9	10	10
	35 to 49,9					6	10	6
	50 to 75						4	4
Optional	>75							0 or 4
Total number of gillnet-nights		24	32	40	56	56	64	60 to 64

Annex B
(informative)
Sampling fish for age and growth analysis

B.1 General

Age and growth analyses of the caught fish will increase the information of the sampling. Based on age estimates, growth can be calculated and sometimes also recruitment and mortality. Age analysis can be performed on most freshwater fish species. The age of a particular specimen is determined from checks, often similar to annulus, formed in some of the hard structures of the fish. These check marks are formed as a result of the annual variation in metabolism and growth of the fish. Usually this variation results in a cyclic pattern in several different tissues, such as scales, bones and otoliths. Which structure should be used for estimating the age differs between species. Usually otoliths are the most reliable structure to be used for determination of age. For several fish species it has been shown that age determined from scales and operculum bones underestimate the actual age of older individuals. Although both scales and bones may be degenerated during periods of starvation or harsh climate, these structures usually reflect the growth of the fish. Otoliths, on the other hand, are more dependent on the metabolism of the fish, and usually will grow also during periods of reduced growth. As a general rule, several structures should be used when estimating the age of fish.

Age determination should be conducted only by experienced personnel who are actively working with age determination of the specific species. To assure the quality of the analyses, it is recommended that only laboratories that are taking active part in inter-calibrations should perform fish ageing.

B.2 Selection of individuals

Sampling of individuals for age analysis is usually performed on the fish caught in the bottom set gillnets for benthic species, and fish caught in the pelagic gillnets for pelagic species. However, depending on the aim of the study, it is important to note which part of the fish population is used for the ageing analysis. It is desirable that as large part as possible of the catch is used for age determination. However, as it is normally not practicable to determine the age for all fish caught, a sub-sample shall be taken from the caught fish.

In order to achieve a sample that reflects the catch as correctly as possible, several possibilities may be used. Although the size of the sample is dependent on the aim of the study, it is important that the sample contains enough individuals of both sexes over the whole range of ages. It is recommended that the length distribution of the fish sampled for age analysis reflects the size frequency of all the caught fish. However, as large individuals usually may have a relatively larger impact than small individuals, and because large individuals usually are relatively few in the catch, these should normally be over-represented in the age determination sample. The sample could be taken in such way that the size distribution of each single species successively is noted as a length-frequency chart during the fishing, and the age data may be superimposed on this chart.

For each specimen sampled for age analysis, time of sampling, name and identification of the lake, identification of gillnet, species, total length (nearest millimetre), weight (nearest gram for larger fish but for smaller fish gram with one decimal is desirable) and the sex is recorded.

B.3 Choice of hard structure for age and growth analysis

B.3.1 General requirements

The selections of hard structures used for determination of age and growth depend on the fish species. However, it is recommended that otoliths are always used for age determination, irrespective of species. There are three pairs of otoliths in all fish species (*sagitta*, *lapillus* and *asteriscus*). The type of otolith that is most convenient to use will be species specific, usually *sagitta* is used for most species except cyprinids, for which *lapillus* is recommended (see Table B.1).

Table B.1 — List of hard structures, additional to otoliths, used for determination of age and growth of freshwater fish

Species	Additional hard structure
E. perch *(Perca fluviatilis)*	Operculum bones
Pikeperch *(Sander lucioperca)*	Scales, operculum bones
Ruffe *(Gymnocephalus cernua)*	Scales
Roach *(Rutilus rutilus)*	Scales
Bream *(Abramis brama)*	Scales
Rudd *(Scardinius erythrophthalmus)*	Scales
Chub *(Squalius cephalus)*	Scales
Asp *(Leuciscus aspius)*	Operculum bones
Ide *(Leuciscus idus)*	Operculum bones
Pike *(Esox lucius)*	Cleithrum, metapterygoid
Burbot *(Lota lota)*	[Only otoliths used]
Tench *(Tinca tinca)*	Operculum bones
E. minnow *(Phoxinus phoxinus)*	[Only otoliths used]
Bull head *(Cottus gobio)*	[Only otoliths used]
Whitefish *(Coregonus. sp)*	Scales, cleithrum, operculum bones
Vendace *(Coregonus albula)*	Scales
Smelt *(Osmerus eperlanus)*	Scales
B. trout *(Salmo trutta)*	Scales
A. char *(Salvelinus alpinus)*	Scales
A. salmon *(Salmo salar)*	Scales
Grayling *(Thymallus thymallus)*	Scales
E. eel *(Anguilla anguilla)*	[Only otoliths used]

B.3.2 Otoliths

Otoliths can be removed in different ways. Most commonly, a horizontal or vertical cut is made through the fish's head using a scalpel (or a knife for larger fish) after which the otoliths are picked using tweezers. Alternatively, the skull can be divided by cleaving the head. After removal the otoliths are cleared from membranes, carefully rinsed in water and stored in dry paper bags. As otoliths are quite fragile they should be handled with care. Otoliths are analysed under microscope, and for several species it is recommended that the otoliths are prepared (burnt and broken or cut into thin sections and stained) before analysis.

B.3.3 Scales

Scale samples are taken by scraping about ten intact scales from one specific part of the fish using a clean knife. The site on the fish used for scale sampling varies among species. Usually the scales from *coregonid* species are taken from the ventral side, just in front of the anal fin. On other *salmonid* fish species (salmon, trout and grayling) scale samples are usually taken from the side of the fish, above the lateral line just below the dorsal fin. On cyprinids and pikeperch the scale samples are taken just below the lateral line, behind the pelvic fin. The scales are stored in a paper bag. Growth of mold is avoided by ventilated and dry storage. Before analysis, place the scales between two clear plastic plates and press them together under high pressure, thus making prints of the scales. The prints on the plastic plates are then analysed in a microfiche reader.

B.3.4 Operculum bones

On perch, the operculum bones are usually used for age and growth determination. Both operculum bones are cut off from the fish. The bones should not be boiled due to the risk of making them clouded. Instead, boiling water is pored over the pairs of bones to separate muscle tissue from the bone structures. Thereafter the bones are carefully rinsed and washed in water. After drying, the bones are stored in paper bags. Age determination is performed without further preparation using a stereomicroscope.

B.3.5 Cleithrum and metapterygoid

Both the *cleithrum* bone and the *metapterygoid* may be used for age determination. The *metapterygoid* is located just behind and below the eye of the fish. The head of the fish is boiled, and after a short while the *metapterygoid* can be removed, rinsed, dried and analysed under stereomicroscope. The *cleithrum* bone is located just behind the operculum bone. The bone from small pikes could be picked out by hand, but on larger fish it shall be cut. As for *operculum* bones, the *cleithrum* shall be gently boiled, rinsed and washed, and dried before analysis.

Annex C
(informative)
Example of forms for registration of fish and supplementary data

Lake name:		*Altitude (m):*		*Fishermen (names):*			
Lake area (ha):		*Maximum depth (m):*		*Date (first setting-last uptake):*			
Type of benthic gillnet (mark with cross)		*Type of pelagic gillnet (mark with cross)*		*Water temperature (Temperature profile)*			
❒ Nordic, 12 mesh sizes		❒ Nordic, 12 mesh sizes		Surface:	5 m:	10 m:	15 m:	20 m:	25 m:
				1 m:	6 m:	11 m:	16 m:	21 m:	30 m:
				2 m:	7 m:	12 m:	17 m:	22 m:	35 m:
❒ Others:		❒ Others:		3 m:	8 m:	13 m:	18 m:	23 m:	40 m:
				4 m:	9 m:	14 m:	19 m:	24 m:	Bottom:
Total number of benthic gillnets:		*Total number of pelagic gillnets:*		*Metalimnion:*		*metre*	*Secchi disc depth:*		*metre*
Method (mark with cross):	*Weather conditions (at setting (S) and lifting (L) time: Air temp (s): Wind:*								*Other observations:*
❒ Standardized	❒ Clear	❒ Rain showers	*Point*			❒ Halfgale (>14 m/s)			
						❒ Fresh breeze (8 m/s to 14 m/s)			
❒ Inventory	❒ Partly cloudy	❒ Mist	*wind direction*			❒ Gentle breeze (4 m/s to 8 m/s)			
❒ Others:	❒ Cloudy	❒ Rain	*with an arrow:*			❒ Light breeze (0,5 m/s to 4 m/s)			
	❒ Fog	❒ Others:				❒ No wind (0 to 0,5 m/s)			

The user of this document is allowed to copy the forms in this annex.

Setting no: Date: Setting time: Lifting time:

	Net number		Net number		Net number		Net number		Net number		Net number	
Depth:	-		-		-		-		-		-	
Species	Number	Weight (g)	Number	Weight (g)	Number	Weight (g)	Number	Weight (g)	Number	Weight (g)	Number	Weight (g)

	Net number		Net number		Net number		Net number		Net number		Net number	
Depth:	-		-		-		-		-		-	
Species	Number	Weight (g)	Number	Weight (g)	Number	Weight (g)	Number	Weight (g)	Number	Weight (g)	Number	Weight (g)

	Lake:								Date:				Sign:			
	Species:		Species:		Species:		Species:		Species:		Species:		Species:		Species:	
	Net number:		Net number:		Net number:		Net number:		Net number:		Net number:		Net number:		Net number:	
	Mesh	Length (mm)	Mesh	Length (mm)	Mesh	Length (mm)	Mesh	Length (mm)	Mesh	Length (mm)	Mesh	Length (mm)	Mesh	Length (mm)	Mesh	Length (mm)
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