GÖTEBORGS UNIVERSITET

Swedish standard methods for sampling freshwater fish with multi-mesh gillnets

Stratified random sampling with Nordic multi-mesh gillnets provide reliable whole-lake estimates of the relative abundance and biomass of freshwater fish in temperate lakes

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MAGNUS APPELBERG

FISKERIVERKET

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Content

Summary

The aim of the present paper is to describe a standardised method for sampling fish in lakes, using multi-mesh gillnets. The method provides a whole-lake estimate for species occurrence, quantitative relative abundance and biomass expressed as catch per unit effort (CPUE), and size structure of fish assemblages in temperate lakes. It also provides estimates comparable over time within a lake, and estimates comparable between lakes. The method is the result of a development that has been going on for several decades at the Institute of Freshwater Research, Drottningholm, and an extensive co-operation within a joint Nordic workshop (Nordic Freshwater Fish Group; NOFF). The sampling method is commonly used in national and regional fish sampling programmes in Sweden. The paper provides information on sampling routines, data handling and reporting, sampling of fish for age- and growth analyses as well as applications and further treatment of data.

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 NORDIC multi-mesh gillnets which are 30 m long and 1.5 m deep. The gillnets are composed of 12 different mesh-sizes ranging between 5 to 55 mm knot to knot following a geometric series. Gillnets used for sampling pelagic fish are 27.5 m long and 6 m deep, with the smallest mesh-size being 6.25 mm. The number of efforts needed to allow detection of 50% changes in relative abundance between sampling occasions, range between 8 gillnets per night (efforts) for small, shallow lakes, up to 64 efforts for lakes of about 5 000 ha. When less accurate estimates of abundance is needed, an inventory sampling procedure may be used, thereby reducing the number of efforts needed.

Correction factors for gillnet selectivity of the NORDIC gillnets has been estimated six fish species, common in Nordic lakes. Fish sampling performed with an earlier Swedish multi-mesh gillnet standard may be transposed to the NORDIC gillnets, and at the moment correction factors are available for perch (*Perca fluviatilis*) and roach (*Rutilus rutilus*). The sampling method only provides abundance estimates for fish larger than about 5 mm total length of fish species catchable in gillnets. Abundance estimates of some less catchable species, such as eel (*Anguilla anguilla*), burbot (*Lota lota*) and pike (*Esox lucius*), as well as small Y-O-Y individuals, may be underestimated.

1. Introduction

Achieving representative data on fish abundance and size structure from lakes has since long been a challenge to most freshwater fishery biologists. The purpose has been to increase the knowledge about the fish species, their abundance and life history traits and their relation to the environment. The demand for standardised sampling methods making it possible to compare fish status between sampling occasions within lakes (time series) and between lakes has increased. Standardised methods are also a basic requirement for performing national and international fish monitoring programmes (e.g. SEPA 1995, Malmqvist et al. 1999). Main emphasis is focused on representative sampling of occurring fish species, life history characteristics of specific species as well as fish assemblage structure and function.

In Sweden, fish sampling in lakes has been performed with a number of different equipment. Most often different types of gillnet have been used. During 1940th to 1960th the prevailing type of gillnets used for fish assessment studies were different types of gillnet series. These series were composed of a number of nine gillnets with seven different mesh-sizes, sometimes knit together in a series of about 270 m length (Filipsson 1972, Hammar and Filipsson 1985). These series were used as benthic (bottom set) gillnets. The pelagic gillnet series (free floating gillnets) were composed of nine gillnets with nine different mesh-sizes. In late 1960th a small multi-mesh gillnet, 36 m long and 1.5 m deep was developed. The net was composed of 12 different panels of 3 m each, with mesh sizes ranging from 10 to 75 mm knot to knot (Filipsson 1972, Hammar and Filipsson 1985). These gillnets had the advantage that each net could be treated as one single sample of the fish assemblages. In the middle of the 1980th two additional mesh-sizes (6.25 and 8.0 mm) were added to the series so that the multi-mesh gillnets comprised 14 mesh-sizes ranging from 6.25 mm to 75 mm (Hammar and Filipsson 1985).

In early 1990th it was realised that the Swedish gillnets were not optimal to provide an as good as possible representation of the size structure of the caught fish. Several of the mesh-sizes were close to each other, thereby over-representing some fish sizes. Therefore a new multi-mesh gillnet was developed in co-operation between Institute of Freshwater Research (Sweden), Finnish Game and Fisheries Research Institute (Finland) and Norwegian Institute of Nature Research (Norway) (Appelberg et al. 1995a). This new multi-mesh gillnet is based on the idea of an exponential series of mesh-sizes, initially presented by Jensen (1986).

2. Aim

The aim of the present paper is to describe a standardised method for sampling fish in lakes, using multi-mesh gillnets. The method provides a whole-lake estimate for species occurrence, quantitative relative abundance and biomass expressed as catch per unit effort (CPUE), and size structure of fish assemblages in temperate lakes. It also provides estimates comparable over time within a lake, and estimates comparable between lakes. By further development, the method also will form the basis for estimating actual fish biomass in lakes in the future.

The method is based on a development that has been going on for several decades at the Institute of Freshwater Research, Drottningholm. The method is commonly used in national and regional fish sampling programmes in Sweden (SEPA 1995). The basic ideas for the method was initialised in 1983 (Hammar and Filipsson 1985, Degerman et al. 1988), and has in its present

form being applied in Swedish national and regional environmental monitoring programmes since 1994 (Appelberg 1994). It has in an earlier form also been adapted to African reservoirs (Fjälling and Fürst 1991). An extensive co-operation within a joint Nordic workshop (Nordic Freshwater Fish Group: NOFF) has facilitated the development of the NORDIC gillnets.

3. Sampling design and equipment

3.1. Sampling design

Fish usually are not randomly distributed over a lake. Depth distribution varies considerably between different fish species, and may also vary with the ontogeny of the fish (e.g. Nyberg et al. 1986b). The horizontal distribution may be influenced by habitat heterogeneity. Neither is the distribution constant over the year, but will vary with temperature and time of season.

To cope with this uneven distribution, stratified random sampling has been used. The lake is stratified in depth strata and random sampling is performed within each depth stratum. The location of each gillnet is performed in such way that each gillnet will act as an independent sample of the fish assemblage. By randomising the location of each gillnet within each depth stratum, and randomising the angle of the gillnet in relation to shoreline, an independent sample of the fish in each stratum will be achieved. Randomising should be performed prior to fishing by use of depth maps and a co-ordinate grid.

3.2. Benthic gillnets

The used multi-mesh gillnets, named NORDIC, is developed by the Nordic Freshwater Fish Group (NOFF) during the 1990th. The goal has been to produce the best possible gillnet for catching all types of freshwater fish species in the Nordic countries. The gillnets are composed of 12 different mesh-sizes ranging between 5 to 55 mm knot to knot (Table 1). The mesh-sizes follow a geometric series according to Jensen (1986), with a ratio between mesh-sizes of about 1.25.

Table 1. Mesh-size distribution (knot to knot) and thread diameter in the NORDIC multi-mesh 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	0.13
5	55	0.23
6	8	0.10
7	12.5	0.13
8	24	0.16
9	15.5	0.15
10	5	0.10
11	35	0.20
12	29	0.16

The mesh panels were initially stratified in three size groups, and within in each mesh-size group, the mesh panels have been randomly distributed over the gillnet. All gillnets have the same order of mesh panels.

The gillnets are made out of homogeneous, uncoloured, nylon. Each gillnet is 30 m long and 1.5 m deep. Each mesh panel is 2.5 m long and mounted on buoyancy line 1.5 (30 m long), and lead line 1.5 (33 m long) made out of plastic in light grey colour (Appelberg et al. 1995a). The diameter of the thread varies between 0.10 mm for the 5 mm mesh, to 0.23 mm for the 55 mm mesh. All mesh panels are commercially available. The hanging ratio is 0.5 for all mesh sizes. The buoyancy rope is 6 g m^{-1} and the plastic sinking rope 9.9 g m^{-1} in water.

3.3. Pelagic gillnets

Gillnets used for sampling pelagic habitat are similar to the benthic gillnets with the following exception. By practical reasons, the smallest mesh (5 mm) has to be excluded, due to that it has not been possible to manufacture 5 mm panels mesh as deep as 6 m. Each pelagic gillnet therefore is 27.5 m long and 6 m deep. The buoyancy line is 30 m and lead line 45 m with a hanging ratio of 0.5. The nets are divided in half at 3 m depth by a darkish colour.

3.4. Time for sampling

The result of fish sampling using passive gears to a large extent is determined by water temperature (Neuman 1974, 1979, Degerman et al. 1992), life history and time for spawning of specific fish species (Nyberg and Degerman 1988). The sampling period therefore has to be chosen in such way that each single species is neither over- nor underrepresented in the catch. To minimise between-year variation due to differences in activity between species, sampling period has been chosen to the late part of July and in August. At that time of year no freshwater fish species spawn in Nordic lakes, 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 prolong the sampling period as the catch may decline substantially when epilimnion temperature drops below 15 °C (Institute of Freshwater Research, unpublished data). Some species, especially cyprinids, may also change behaviour during autumn, thereby affecting the representativeness of the sampling.

3.5. Sampling period

The setting time for the gillnets should ensure that the activity peaks of each fish species will be included. On the other hand, it should be as short that the fish does not degrade or will be damaged by predatory fish while being caught in the gillnet. In the Nordic countries this usually means that the gillnets should be set before dusk and rose after dawn (Westin and Anér 1987). To avoid calculating abundance relative to hours of setting time, a period of 12 h is recommended, setting the gillnets between 6 and 8 p.m. and lifting the nets between 6 and 8 a.m.

In highly productive lakes with abundant fish populations, it may be necessary to shorten the setting time. Otherwise the gillnets (or at least some mesh-panels in the gillnets) may be saturated with fish, thereby affecting the outcome of the sampling (Fjälling and Fürst 1991). Hamley (1980) reported that saturation might start bias the catch when more than 0.12 kg fish per m^2 in a 19 mm mesh, or 0.34 kg per m^2 in a 70 mm mesh, is caught. Assuming a random distribution of fish over all mesh-sizes, this means that saturation in a NORDIC gillnet may start to affect the outcome when about 6 kg fish is caught (Appelberg unpubl. data). In such cases, it is recommended to calculate the catch per unit effort (CPUE) relative to hours of setting time.

4. Time series sampling

4.1. Sampling effort

When the sampling aims at quantifying relative abundance or biomass of different fish species, and to compare differences over time and between lakes, the variance of the estimate of the mean has to be quantified. As all fish must have the same probability of getting caught in a gillnet, a representative sampling of all habitats in a lake must be performed. The number of gillnets used at each sampling occasion is determined both by the minimum number of efforts needed to catch all catchable fish species and by the required precision of the mean value. Usually the number of efforts needed to catch all catchable fish species is lower than the number of effort required to provide an acceptable precision of the estimate. The minimum requirement for time series sampling is to detect 50% differences between sampling occasions in relative abundance of the most abundant fish species (Bohlin 1984, Nyberg and Degerman 1988, Degerman et al. 1988).

The amount of gillnet-nights needed is determined by the precision, the lake area and the maximum depth of the lake. The higher precision, and the larger and the deeper the lake, the more gillnet-nights are required. The number of gillnets required to achieve a precision which makes it possible to statistically determine 50% differences between sampling occasions is given in Table 2 (Nyberg and Degerman 1988). By convenience the lakes are divided in six size classes: <20, 21-50, 51-100, 101-250, 251-1000, 1001-5000 ha, and the number of efforts based on multiples of 8, which ususally is a normal workload for one nights sampling for two persons.

Table 2. Number of efforts with benthic gillnets required to allow the detection of 50% changes between sampling occasions in relation to lake area and maximum depth (after Nyberg and Degerman 1988).

	Lake area (ha)					
Depth (m)	<20	21-50	51-100	101-250	251-1000	1001-5000
0- 5.9	8	8	16	16	24	24
6-11.9	8	16	24	24	32	32
12-19.9	16	16	24	32	40	40
20-34.9	16	24	32	40	48	56
35-49.9	16	32	32	40	48	56
50-74.9			40	40	56	64
75-					56	64

Whole-lake estimates of the relative fish abundance in lakes larger than 5,000 ha usually require such large effort that it is practically impossible to use the recommended technique. In case larger lakes shall be sampled, it is recommended that the lake is divided in 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 in accordance to Thoresson (1992)

4.2. Depth stratification of benthic gillnets

The depth zones are determined in relation to the volume of each stratum in such way that each depth stratum approximately equalises the same volume of water. Although the lake morphometry may vary considerably, it is convenient to use a standardised scheme for stratification for practical use. For Swedish lakes, Degerman et al. (1988) suggested an approximation of the depth strata based on morphometric lake data from Andersson et al. (1987).

Each lake is divided in approximately equal water volumes resulting in following depth strata: 0-2.9, 3-5.9, 6-11.9, 12-19.9, 20-34.9, 35-49.9, 50-75 m. Lakes deeper than 75 m are rarely subjected to fish sampling using gillnets. The number of gillnets recommended in each depth stratum is given in Appendix 1 (after Nyberg and Degerman 1988).

To achieve a better estimate of the total fish abundance in lakes with extreme morphometry, the volume of each depth stratum should be calculated, and the number of gillnets used at each stratum should be distributed in relation to the volume of each stratum. In case the deepest stratum is too small to be used for setting benthic gillnets independent of each other, it should be excluded in calculations of the total number of gillnets used. When distributing gillnets over the lake, this depth stratum is treated as a part of the stratum just above it.

4.3. Location of benthic gillnets

The location of each gillnet in the lake is determined in such way that the total catch should constitute an unbiased sample of the catchable part of the fish assemblage in the lake. With "catchable" fish is meant fish species that usually are caught in gillnets. Some predatory species with a typical ambush behaviour, such as northern pike (*Esox lucius*), and some benthic species living very close to the bottom substrate, such as eel (*Anguilla anguilla*), burbot (*Lota lota*) and bullhead (*Cottus sp.*), are often underrepresented in the gillnet catch.

Within the different depth strata, gillnets are set randomly over the whole lake. This could be performed by use of a pre-prepared co-ordinate grid placed over depth map of the lake. By a randomisation procedure each sampling location is located in each depth stratum, respectively (Fig 1). Gillnets are set in straight lines, in random angles to the shoreline.

As the catch in each gillnet should be treated as an independent sample for that particular depth zone, no gillnets must be knit to each other.

4.4. Depth stratification of pelagic gillnets

To include samples also from the pelagic habitat, sampling with benthic gillnets should be supplemented by sampling with pelagic gillnets in lakes with maximum depth greater than 10 m. Even if there are no apparent pelagic species in the lake, several fish species show a typical pelagic preference during part of their life history. In contrast to sampling with benthic gillnets, the pelagic sampling does not provide an estimate over the total water volume by practical reasons. Instead, pelagic sampling is performed as a depth profile over the deepest part of the lake. The number of pelagic gillnets to be used is determined by the maximum depth of the lake. In more shallow lakes, the benthic gillnets will provide a sufficient estimate of the pelagic fish in most cases.
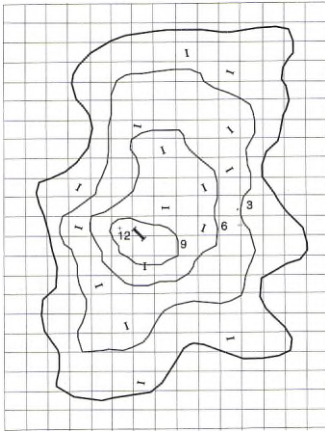
Fig. 1. Morphometric map of a hypothetical 40 ha lake with 12 m maximum depth. Co-ordinate grid, depth contours at 3, 6 and 9 m, location of benthic gillnets (small marks) and pelagic gillnet (large mark) are shown.

5. Inventory sampling

The inventory sampling is a simplified method for fish sampling mainly providing a rough estimate of the occurrence and abundance of dominating fish species in the lake. This type of sampling may be used in studies aiming at describing the distribution of species, and inventory studies where the precision of the fish abundance is of less importance.

5.1. Depth stratification
The depth stratification varies between species and may also vary between size classes within the same species. It is therefore important that both epi- and hypolimnion in thermally stratified lakes are covered by the effort. When choosing one has to strive for that all depths of the lake is sampled. This is also of importance in case there is no clear thermal stratification.

5.2. Location of gillnets
The benthic gillnets are distributed in the lake in such way that all types of habitats are sampled. Gillnets are randomly set a) over the depth zone which covers the epi- and metalimnion, and b) in the hypolimnion. Within these two depth zones, the gillnets are set randomly over the whole lake. In the absence of a marked thermal stratification, the same effort is used as if the lake has had a metalimnion. Each single gillnet is loosely set in a straight line, in a random angle from the shoreline.

As the catch from each single gillnet should comprise an independent sample, it must be independent of other gillnets. The gillnets should therefore not be coupled to each other.

5.3. Sampling effort
The number of efforts used is dependent on the number of gillnets needed to catch all catchable species in a lake (Degerman et al. 1988, Appelberg unpubl. data). The lake area thus determines the size of the effort. Fewer than 4 gillnets are never used, independent of the lake size. The lakes are divided into four size classes:

<50, 51-300, 301-2,000, >2,000 ha

In lakes larger than 5,000 ha an inventory sampling has to be accomplished by other sampling methods. The lowest number of gillnets which should be used and the distribution of gillnets within the lake are calculated according to Table 3. The effort may be increased in order to increase the probability to catch all catchable fish species.

Table 3. Minimum effort (# of gillnet-nights) used in an inventory sampling in relation to lake area.

Lake area (ha)	Total	Number of gillnet-nights	
		Epi/metalimnion	Hypolimnion
< 50	4	2	2
51-300	8	4	4
301-2000	16	8	8
> 2000	24	12	12

6. Sampling routine

6.1. Pre-sampling

A thorough planning in order to maximise the output of the sampling effort must precede all fish sampling. When a lake has been selected for sampling, permission from the fishing right owner(s) has to be obtained. For Swedish lakes this usually will not be a hindrance, as long as responsible persons are informed about the fishing activities, and the results are communicated to responsible persons afterwards. To mitigate spreading of diseases due to fishing activities, a risk assessment for dispersion of pathogens has to be made. Both fish diseases and diseases specific for other organisms, such as freshwater crayfish, may be spread by placing equipment contaminated with diseases or parasites in the lake.

If there already is a map over the lake with depth contours, this could be used to determine the total number of efforts needed, and to determine if pelagic gillnets should be used. The map with depth contours is used to divide the lake in appropriate depth strata and to determine the number of efforts that should be used at each stratum. If it is the first time the lake is being sampled, randomisation of the gillnet locations should be performed on before hand. If the lake has been sampled earlier, the locations of the gillnets should as much as possible resemble the earlier distribution in the lake. If data on depth of the lake is lacking, the sampling has to 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.

Supplementary information about the lake and the surroundings should be collected before sampling if possible. All types of geographical and water chemical information should be collected. Especially should information about the fishing in the lake and on introduced fish species be collected.

6.2. Sampling

All gillnets are set between 6 to 8 p.m. Benthic gillnets are set randomly relative to the shore line at the predetermined locations, and the depth of the most shallow and deepest points of the net are recorded (Fig 1). The distribution of gillnets at 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. Pelagic gillnets are set over the deepest part of the lake. During the first night, gillnets are placed at depth 0-6 m. The second night they are lowered to 6-12 m and so on until the whole water column has been sampled according to Fig 2. Usually it is possible for two experienced fishermen to fish with eight benthic gillnets and two pelagic gillnets per night in oligo- to mesotrophic lakes. In eutrophic, highly productive lakes, the

number of efforts per night has to be reduced since catch usually is so large that it will not be possible to rinse the gillnets and handle the fish within the day after.

The day after setting, the gillnets are lifted at 6 to 8 a.m. After landing the nets, they are rinsed and the fish are collected separately in marked net bags for each gillnet. If the fish are going to be used for gillnet selectivity studies, the fish has also to be kept separated by mesh size. After the nets have been rinsed they should be cleaned and dried until the next setting. Further treatments of the fish are performed as soon as possible. If the weather is warm, the caught fish has to be kept in cold, either in a cold-storage room or by use of ice. When all fish are processed, gillnets are set again between 6 and 8 p.m.
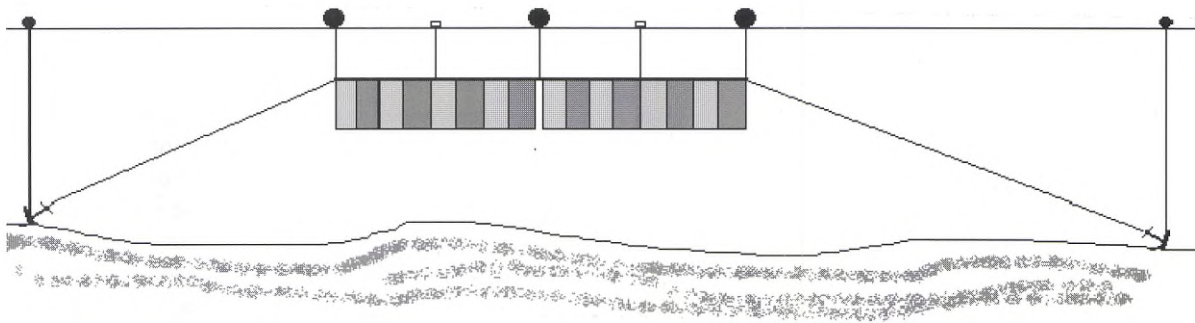
Fig 2. Schematic view of the setting of pelagic multi-mesh gillnets, 6 m deep and 27.5 m long. The gillnets are set over the deepest part of the lake, and lowered 6 m each day of fishing.

In all fish sampling the safety instructions for fieldwork on sea 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, device for communication, and first-aid box.

7. Data handling and reporting

7.1. Fish data

For each sampling occasion following data are registered; running number of the gillnet at that particular sampling occasion, geographical localisation of each gillnet in the lake, maximum and minimum depth for each single gillnet (for forms, see Appendix 3). The localisation of gillnets are also marked on a lake map with depth contours or as co-ordinates if GPS equipment is used.

The catch within each gillnet is registered as number of individuals and total weight for each species (Table 4). Optionally the catch within each mesh panel is registered in such 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. Accordingly, 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, wet weight of each specimen could be recorded in a similar way. Total lengths are determined to the nearest mm, weight determinations to the nearest gram.

Raw data should not be processed before it is stored in a database. Data is preferably 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 requirement for fish data registration and reporting

List of fish species caught

A list of species caught in the gillnets should always be provided. As the sampling technique is based on a passive gear, the probability to getting 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 effort (number of gillnets nights) is calculated so that on average all catchable species are caught at 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 calculated NPUE is the arithmetic mean for the catch of each species. The variance estimates will be larger compared to if consideration is taken to the stratification. By estimating mean and variance for each single depth strata, the variance may be minimised (see 9.1). 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 similar 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 9.1). 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.

7.2. Supplementary data

As the outcome of the fish sampling to a considerable extent is affected by physical-/geographical factors such as lake size and depth, water transparency, temperature, weather conditions during sampling, supplementary data should always comprise some basic information (Inst. of Freshwater Research, unpubl. data; Table 5). Secchi disc 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 be registered.

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

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 m above sea level. Preferably data from national geographical or hydrological institutes are used

Lake area

The area of the lake 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 depth

If available both maximum and average depth should be given in m. If no published data are available, data obtained during fish sampling using e.g. echo sounder may be given as preliminary data.

Physical data

Water transparency

Water transparency, usually is measured as Secchi disc depth, given in fractions of a m.

Table 5 cont.

Temperature
A temperature profile is registered at each full m starting with 0.5 m, 1 m, 2 m, and so on down to 25 m depth.

Water chemistry
When available, water chemistry data should be added to the fish sampling. Water quality data reflecting nutrient load (phosphorous and nitrogen), oxygen depletion (oxygen at hypolimimion) and acidification status (pH, alkalinity and/or ANC) are preferable.

Sampling information

Date for fishing.
First and last date for setting and lifting the gillnets should be given. By convenience the first sampling date may be used as ID-variable in the database.

Number of efforts
The total number of gillnet nights (efforts) used at different depth strata in the sampling should be recorded. Often the standardised scheme is violated, and in order to determine the size of the error it is important to include data on gillnet distribution.

Type of gillnets used
If standardised gillnets are used, the length, weight and depth of the gillnets are known. This makes it possible to calculate the catch in terms of caught fish per m2. If other types of multi-mesh gillnets are used this information has to be added.

Type of sampling design
The type of sampling design (Time series/ Inventory sampling) should be given, as it is part of the quality control. If neither of the two designs is followed it should be marked as "unclassified".

Time for gillnet setting
The time for setting and lifting the gillnets in the lakes should be given with an hourly precision. This makes it possible to calculate the catch in relation to hour instead of "night".

Responsibility
The performer and institute responsible for the sampling should always be given.

Additional to the supplementary data, a map with depth contours showing the location and running number of each gillnet should be added to each sampling occasion (see Fig 1). The quality of the map should be such that the sampling could be repeated without additional knowledge.

7.3. Databases and quality control

Data from the fish sampling should be stored in specially designed databases. A quality control should always accomplish data storing, thereby minimising typing errors and avoiding preposterous data. In Sweden, fish data from national and regional environmental monitoring programmes in lakes and streams are stored in national databases at the National Board of Fisheries (NBF). Since 1996, NBF is responsible for collecting, controlling data quality and storing fish data from freshwaters and the coastal zone in Sweden. Data from various types of fish sampling programmes are included. The purpose is to providing data of high quality for national investigations and reports. The database also serves as a reference for local and regional investigations. Data are available for the public at [www.fiskeriverket.se].

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

8. Corrections for gillnet selectivity

8.1. Gillnet selectivity of NORDIC gillnets

Using a passive sampling gear, the outcome of the sampling will be dependent on the movements of the fish, and the mechanical properties of the gear to catch and to retain the fish. The properties of the gear will affect the composition of the sample, and only a particular part of the population will be selected in the sample. This means that the statistical population may not be the biological population of interest. Selectivity of gillnets include any process that causes the probability to be sampled to vary with the characteristics of a fish (Hamley 1975, 1980). For a passive gear, selectivity usually is divided into a) encounter probability, b) the probability to being caught in the mesh, and c) the probability to being retained in the gillnet after being caught (Kurkilahti 1999).

Gillnet selectivity of the NORDIC gillnets has been estimated for several fish species during recent years (Jensen and Hesthagen 1996, Kurkilahti and Rask 1996, Kurkilahti et al. 1998, Kurkilahti et al. 1999b, Kurkilahti 1999). 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 in the NORDIC gillnets because the gillnets are composed by mesh-sizes following a geometric series. Adjacent mesh sizes would then cover each other and correct for this error (Kurkilahti et al. 1999a).

8.2. Corrections for gillnet selectivity for five fish species

Corrections for gillnet selectivity have been estimated for six fish species, common in Nordic lakes; two percid species (E. perch, *Perca fluviatilis*) and ruffe (*Gymnocephalus cernuus*), one cyprinid species (roach, *Rutilus rutilus*) and three salmonid species; brown trout (*Salmo trutta*), Arctic char (*Salvelinus alpinus*) and smelt (*Osmerus eperlanus*). The correction factors are to some extent reflecting the differences in body shape between the different species. For example the more spiny ruffe, show a steep selectivity curve, whereas the more slender roach and the salmonid species showed more flat selectivity, but increasing, curves (Table 6). Perch showed the most flat curve of all species.

Table 6. Pooled Relative Efficiency (PRE) curves for NORDIC multi-mesh gillnets for six freshwater fish species estimated by fitting a 3rd order polynomial equation. Length (L) measured in cm (after Kurkilahti 1999).

Species	Function	Range
E. perch (*Perca fluviatilis*)	$PRE=0.4167+0.00128*L+0.00093*L^2-1.53E-05*L^3$	40-380 mm
Ruffe (*Gymnocephalus cernuus*)	$PRE=0.02862+0.2735*L-0.03936*L^2+0.00179*L^3$	40-140 mm
Roach (*Rutilus rutilus*)	$PRE=0.2599+0.021*L-0.00121*L^2+3.76E-05*L^3$	50-330 mm
Brown trout (*Salmo trutta*)	$PRE=0.6449+0.05121*L-0.03936*L^2-5.52E-05*L^3$	80-340 mm
Arctic char (*Salvelinus alpinus*)	$PRE=0.4077+0.00351*L+0.000658*L^2+3.96E-06*L^3$	60-300 mm
Smelt (*Osmerus eperlanus*)	$PRE=-1.6278+0.3031*L+0.00428*L^2-3.70E-04*L^3$	90-170 mm

These relations are used for reconstructing a more probable size distribution of each single species. Since selectivity curves have not been estimated for all fish species, corrections are usually made only in case when a specific species is assessed.

In practice, the gillnet selectivity is corrected for by a species-specific 3rd order polynomial function. The correction of CPUE is calculated by using the polynomial estimate of relative length frequency distribution (RLFD) for each species given in Table 7 (Kurkilahti 1999). Corrected values of CPUEs are achieved by multiplying the observed number of specimens by the relative

efficiency (RLFD) within each length class. The resulting product is rounded to the nearest integer and pooled together over the length classes. The corrected biomass for each length class is calculated by multiplying the corrected frequency with the mean individual biomass of that length class.

Table 7. Gillnet selectivity for six common fish species caught in NORDIC multi-mesh gillnets. Relative Length Frequency Distribution (RLFD) curves estimated by fitting a third order polynomial equation. Length (L) measured in cm (after Kurkilahti 1999).

Species	Function	Range
E. perch (*Perca fluviatilis*)	RLFD=1.7159-0.04595*L+0.00031*L^2-4.82E-06*L^3	40-380 mm
Ruffe (*Gymnocephalus cernuus*)	RLFD=1.5285-0.01547*L-0.00074*L^2+7.96E-06*L^3	40-140 mm
Roach (*Rutilus rutilus*)	RLFD=1.36386-0.10525*L+0.01897*L^2-1.13E-03*L^3	50-330 mm
Brown trout (*Salmo trutta*)	RLFD=1.25629+0.04187*L-0.00440*L^2+7.18E-05*L^3	80-340 mm
Arctic char (*Salvelinus alpinus*)	RLFD=1.48571-5.32E-05*L+0.00220*L^2+3.98E-05*L^3	60-300 mm
Smelt (*Osmerus eperlanus*)	RLFD=1.02857-3.69E-05*L-0.00153*L^2+2.76E-05*L^3	90-170 mm
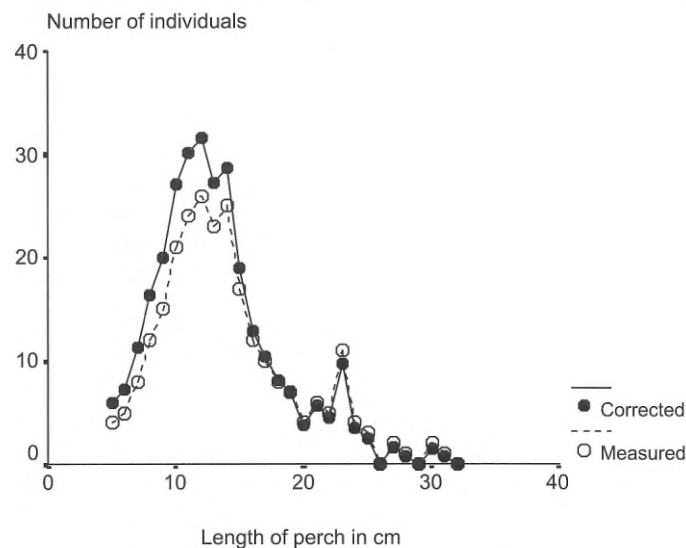
Fig 3. Example of measured and corrected length distribution of a theoretical perch population. The correction increased the estimated total number of caught fish with 16%.

An example of the measured and corrected length distribution of a theoretical perch population is shown in Fig 3. Depending on the slope of the correction factor, the small sized fish has a larger correction factor compared to the large sized fish.

Kurkilahti (1999) reported that the observed means of CPUE in both number and biomass in general were smaller than the corrected means. Also the observed variances were smaller than the corrected. Relative abundance data were generally more biased than relative biomass.

8.3. Converting catch data obtained by earlier gillnet standard

Fish sampling performed with the earlier Swedish multi-mesh gillnet standard, comprising 14 mesh panels (Hammar and Filipsson 1985, Degerman et al. 1988), may be transposed to the NORDIC gillnet by approximate correction factors for each length class of fish. At the moment correction factors are available for the two most common fish species in Sweden, perch and roach (Appendix 2). The catch in each length class with earlier Swedish 14 panel multi-mesh gillnets, is multiplied with the corresponding correction factor for that length class. This correction will approximate the catch by NORDIC gillnets.

In general, the differences in mean number and weight per effort are relatively small. In Fig 4, CPUE obtained by earlier Swedish multi-mesh gillnet standard, and corrected estimates of CPUE, is compared to the catch in NORDIC gillnets in a pair-wise test. The catch in the NORDIC nets is significantly higher (18%, pair-wise t-test, p<0.01), than in uncorrected Old Swedish gillnets. After correction the difference is reduced to in average 10%, (p>0.1).

CPUE Old Swedish gillnets
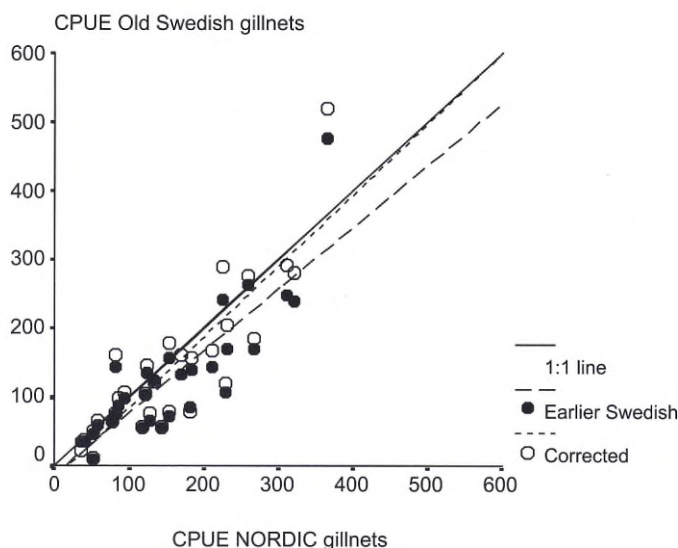
Fig 4. Pair-wise comparison of the catch of perch and roach in earlier Swedish multi-mesh gillnet standard, corrected catch from the same gillnets, and catch with NORDIC gillnets in 14 Swedish lakes at in total 30 sampling occasions.

9. Estimate of sampling variance

9.1. Within-lake variation

The precision of the catch per unit effort (CPUE) within each depth strata can be estimated according to Pringle (1984). CPUE is initially transposed using $Log_{10}[CPUE+1]$ 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 gillnets used in each stratum, and pooled estimates for the entire lake are calculated (Edmondson 1971, Box et al. 1978, Degerman et al. 1988). The total number of gillnets recommended for sampling (see Table 2) is determined so that 50% differences of the dominating fish species should be able to detect (Degerman et al. 1988).

The number of gillnets needed to achieve a certain precision within a lake is calculated according to:

$$No\ of\ gillnets = (SD)^2/[(CPUE)^2 * (C.V.M.)^2]$$

where SD is the standard deviation, C.V.M. is the Coefficient of Variation of the Mean, i.e. SE divided by mean CPUE. Usually C.V. is used which is the SD divided by the mean.

By using only two pelagic gillnets within each depth stratum, the sampling effort is generally too small to allow further statistical treatment of the variation within the lake. To determine a significant 50% change in mean value of CPUE Degerman et al. (1988) estimated that at least 16 pelagic gillnets per depth stratum were needed. However, Aldén (1992) showed that

two pelagic gillnets may be enough to achieve a precision of the estimate to allow the detection of a 100% difference in the upper most depth stratum.

Although only one part of the lake is sampled and thereby the horizontal variation is not taken into account, sampling with pelagic gillnets generally provides an adequate estimate of the vertical distribution of the pelagic fish. Comparing gillnets, trawling and echo sounding, Enderlein and Appelberg (1992) showed that vendace was underestimated in gillnets at larger depths and overestimated at shallower depths as compared to echo-sounding data. Comparing length-frequency distribution in trawl catches and gillnet catches the differences were minor for smelt (Kurkilahti et al. 1998)

9.2. Within-lake between-year variation

When comparing differences within-lakes between-years, mean and variance estimates according to 9.1 may be used. However, using a $Log_{10}(x+1)$ transformation of CPUE in order to normalise data, should be performed with caution. Including a constant in the transformation may give arbitrary effects on different scales (Holmgren 1999). In a study of 26 lakes sampled over a four-year period Holmgren (1999) showed that most species were observed on all sampling occasions in the lakes that they were caught. Exceptions related to low catchability were observed for eel, pike and burbot. Exceptions related to rare occurrence of species were observed for some species in three separate lakes. Within a lake, total biomass (weight per unit effort) was usually equally or less variable than abundance (number per unit effort). The median coefficient of variation for between-year variation of biomass and abundance for the 26 lakes were less than 25%, and it did not differ significantly from the corresponding sampling precision.

9.3 Among-lake variation

When comparing CPUE among lakes, pooled variances may not be used. The calculated variance emancipating from within-lake estimates will only describe the variances among gillnets within the lake, i.e. the heterogeneity of fish distribution within the lake. As the variances of the mean values from two different lakes may not be regarded to be of the same statistical population, it cannot be used to test differences between lakes. Thus, when comparing CPUE among lakes, the estimated mean value for the catch within a single lake should be treated as a single observation without use of estimate of variance.

10. Sampling fish for age- and growth analyses

10.1. Choice of hard structure for age- and growth analysis

Age- and growth analyses of the caught fish considerably increase the information of test fishing. Based on age estimates, growth can be calculated and sometimes also recruitment and mortality. Age analysis can be performed on all freshwater fish species in Sweden. The age of a particular specimen is determined from checks, often similar as annulus, formed in some of the hard structures of the fish. These check marks are formed as a result in the 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 that should be used for ageing is dependent on the specific species. However, 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 (Beamish and McFarlane 1987). 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 different structures should be used when ageing fish.

10.2. Choice of individuals

Sampling of individuals for age analysis usually is 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. 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 age all fish caught, a sub-sample has to be taken out from the caught fish.

In order to achieve a sample that reflects the catch as correct 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 contain 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 is reflecting the size frequency of all the caught fish. However, as large individuals usually may have a relatively larger impact on small individuals, and because large individuals usually are relatively few in the catch, these should 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.

10.3. Sampling

Which hard structures that should be used for age- and growth determination depend on the fish species. However, it is recommended that otoliths always are used for age determination, irrespective of species. There are three pairs of otoliths in all fish species; *sagitta, lapillus* and *asteriscus*. Which type of otolith that is most convenient to use will be species specific, usually *sagitta* is used for most species except cyprinids, where *lapillus* is recommended (Table 7).

Otoliths
Otoliths are removed by cutting the uppermost part of the head of the fish. A cut is laid by the scalpel (or sharp knife) from the neck above the operculum bone through the upper part of the eyes of the fish. The cut off piece of the skull is removed and the brain is carefully removed with a pair of tweezers. The otoliths could then be picked out from both sides of the bottom of the brain cavity. Alternatively, the skull could be divided by cleaving the head with one cut. After removing the otoliths, they are 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, stained) before analysis.

Scales
Scale samples are taken by scraping about ten scales from one specific part of the fish using a clean knife. The site of the fish used for scale sampling varies among species. Usually the scales from coregonid species are taken on the ventral side, just in front of the anal. On other salmonid fish species (salmon, trout and grayling) scale samples are usually taken on 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 put in a paper bag. Before analysis, prints of the scales are made by putting the scales between two clear plastic plates and pressure these

with high pressure. The prints on the plastic plates are then analysed in a microfiche reader with a magnification of 30x.

Operculum bones
On perch, the operculum bones are usually used for age- and growth determination. Both operculum bones are cut off from the fish. Boiling water are pored over the pairs of bones and thereafter rinsed and washed in water. After drying the bones are kept in paper bags. Age determination is performed without further preparation using stereomicroscope.

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 are boiled, and after a short while the metapterygoid could 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 has to be cut. As for operculum bones, it must be gently boiled, rinsed and washed, where after it has to be dried before analysis.

Table 7. Otoliths should always be used for ageing fish. Listed are additional hard structures used for age- and growth determination of freshwater fish in Sweden. Structures in italic are used at Institute of Freshwater Research, Drottningholm.

Species	Structure
E. perch (*Perca fluviatilis*)	*Operculum bones*
Pikeperch (*Stizostedion luciperca*)	Scales, operculum bones
Ruffe (*Gymnocephalus cernuus*)	*Scales*
Roach (*Rutilus rutilus*)	*Scales*
Bream (*Abramis brama*)	*Scales*
Rudd (*Scardinius erythrophtalmus*)	*Scales*
Aspen (*Aspius 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]

For each specimen sampled for age analysis, time for sampling, name and identification of the lake, identification of gillnet running number, species, total length (nearest mm), weight (nearest gram) and sex is recorded.

10.4. Age determination
Age determination should only be conducted 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 intercalibration exchange should perform fish ageing.

11. Applications and further analyses

The analyses and reporting from a standardised fish sampling depends 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 are provided (see "7. Data handling and reporting"). 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 efforts used, distribution of efforts in the lake, depth stratification, time of year and time for setting is needed to determine the quality of the sampling. Also, supplementary data is needed 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 standardised 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 (Nyberg et al. 1986a, Degerman and Nyberg 1987, Appelberg et al. 1992, Appelberg et al. 1995b, Beier et al.1997, Appelberg 1998). Standardised fishing with multi-mesh gillnets is used in bio monitoring of Swedish lakes (Appelberg et al. 1999). It is also recommended for monitoring of nature quality in the Nordic countries (Malmqvist et al. 1999)

Fish data from a standardised sampling have also been used to analyse ecological problems such as life history studies and distribution of specific species (e.g. Nyberg et al. 1986a, 1986b, Appelberg et al. 1989, Winfield et al. 1998, Hammar 1998). In a recent study, Beier (1999) used data achieved by standardised gillnetting to assess the co-occurrence and habitat selection of three freshwater fish species. Filipsson (in prep.) used the standardised technique to evaluate the effects of reduced fishing in order to promote better quality of fish in an alpine lake. Standardised gillnet sampling has also been used in studies of fish assemblages and the relation between fish assemblages and the environment (Degerman and Nyberg 1987, Appelberg et al. 1989, Appelberg and Degerman 1991, Holmgren 1999, Holmgren and Appelberg, submitted).

12. Limitations and supplementary sampling

As all sampling methods, standardised sampling with gillnets also is biased. It is important to be aware of the main limitations of the method when analysing and presenting data. Firstly, as a multi-mesh gillnet is a passive gear, the sample will be dependent on the actual movement of the fish. Thus, extrinsic factors such as temperature, weather conditions, location of the gillnets and water transparency affect the outcome of the sampling. Also intrinsic factors such as activity due to feeding and spawning will be of importance. 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 may 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 are dwelling in the vegetation or the bottom substrate part of their first summer in order to escape from predation. These fish are usually less represented in the gillnet catch.

To cope with this problem it is recommended that an alternative sampling method is used. For littoral species, sampling may be complemented with seining, fyke nets or electro-fishing at some given stretches of the shoreline. Examples on alternative methods are given in Malmqvist et al. (1999).

Another limitation concerns the ability of the gillnet to catch fish of all different sizes. As the relative thickness of the thread in the different panels in the gillnet decreases with the size of the mesh. Large fish most often are over represented in the catch, whereas small fish is under represented. To some extent this bias could be compensated for by using the gillnet selectivity correction factors, but there will still be an error (Kurkilahti 1999). The relative thickness of the thread also affects the possibility to catch the smallest fish sizes, and thereby 0+ fish (< 60 mm) usually are 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 electrofishing may be used during suitable conditions. For sampling of pelagic Y-O-Y bongo-trawls or push-net is recommended.

Sampling with multi-mesh gillnets provides a relative value 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" (Hamley 1980). 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. # fish per ha, or biomass per ha). The reasons for this may be several; for instance may the catchability depend on 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 standardised sampling method is used. It may though be a problem when relating fish biomass to other 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.

13. Acknowledgements

14. References

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Appendix 1

Distribution of benthic multi-mesh gillnets at different depth strata in lakes with different area and maximum depth (after Nyberg och Degerman 1988)

Lake area	Depth zone (m)	Maximum depth (m)						
		<6	6-11.9	12-19.9	20-34.9	35-49.9	50-75	>75
<20 ha	<3	4	3	4	4	3		
	3-5.9	4	3	4	3	3		
	6-11.9		2	4	3	3		
	12-19.9			4	3	3		
	20-34.9				3	2		
	35-49.9					2		
	Total # gillnet-nights	*8*	*8*	*16*	*16*	*16*		
21-50 ha	<3	4	5	5	5	5		
	3-5.9	4	6	5	5	5		
	6-11.9		5	3	5	6		
	12-19.9			3	5	6		
	20-34.9				4	6		
	35-49.9					4		
	Total # gillnet-nights	*8*	*16*	*16*	*24*	*32*		
51-100 ha	<3	8	8	7	7	7	7	
	3-5.9	8	8	7	7	7	7	
	6-11.9		8	5	9	7	10	
	12-19.9			5	6	4	4	
	20-34.9				3	4	4	
	35-49.9					3	4	
	50-75						4	
	Total # gillnet-nights	*16*	*24*	*24*	*32*	*32*	*40*	
101-250 ha	<3	8	8	8	7	7	7	
	3-5.9	8	8	8	7	7	7	
	6-11.9		8	8	10	10	6	
	12-19.9			8	8	6	6	
	20-34.9				8	6	6	
	35-49.9					4	4	
	50-75						4	
	Total # gillnet-nights	*16*	*24*	*32*	*40*	*40*	*40*	
251-1000 ha	<3	12	11	10	10	10	10	10
	3-5.9	12	11	10	10	10	10	10
	6-11.9		10	10	10	10	10	10
	12-19.9			10	10	8	8	8
	20-34.9				8	6	8	5
	35-49.9					4	6	5
	50-75						4	4
	>75							4
	Total # gillnet-nights	*24*	*32*	*40*	*48*	*48*	*56*	*56*
1001-5000 ha	<3	12	11	10	10	10	10	10
	3-5.9	12	11	10	10	10	10	10
	6-11.9		10	10	12	12	10	10
	12-19.9			10	12	9	10	10
	20-34.9				12	9	10	10
	35-49.9					6	10	6
	50-75						4	4
	>75							4
	Total # gillnet-nights	*24*	*32*	*40*	*56*	*56*	*64*	*64*

Appendix 2

Correction factors for transposing CPUE of perch and roach caught in earlier Swedish multi-mesh gillnet standards (Hammar and Filipsson 1985, Degerman et al. 1988) to NORDIC gillnet series.

Length class (cm)	Perch	Roach
4	6.12	4.57
5	1.62	1.46
6	1.22	1.18
7	1.14	1.09
8	1.02	0.99
9	0.97	0.92
10	1.05	0.93
11	1.16	1.07
12	1.26	1.23
13	1.28	1.33
14	1.33	1.30
15	1.34	1.34
16	1.25	1.39
17	1.11	1.34
18	1.03	1.16
19	0.98	1.02
20	0.93	0.95
21	0.89	0.88
22	0.86	0.83
23	0.82	0.82
24	0.79	0.80
25	0.77	0.78
26	0.77	0.75
27	0.76	0.73
28	0.75	0.71
29	0.73	0.71
30	0.73	0.70
31	0.73	0.69
32	0.74	0.67
33	0.75	0.66
34	0.77	0.66
35	0.79	0.68
36	0.83	0.70
37	0.87	0.72
38	0.91	0.75
39	0.95	0.78
40	0.99	0.83
41	1.01	0.87
42	1.03	0.93
43	1.04	1.00
44	1.04	1.07
45	1.03	1.13
46	0.99	1.18
47	0.95	1.21
48	0.92	1.22
49	0.89	1.19
50	0.87	1.13

Appendix 3

Forms for registration of fish and supplementary data. used at the Institute of Freshwater Research. Drottningholm.

Catch form

Name of the lake: _____   Altitude (m): _____   Fishermen: _____

Lake area (ha): _____   Maximum depth: _____   Date (first setting-last uptake): _____

Type of benthic gillnet (mark with cross)

☐ Nordic, 12 mesh sizes
☐ Drottningholm, 14 mesh sizes
☐ Drottningholm, 12 mesh sizes
☐ Others: _____

Type of pelagic gillnet (mark with cross)

☐ Nordic, 11 mesh sizes
☐ Drottningholm, 14 mesh sizes
☐ Drottningholm, 12 mesh sizes
☐ Others: _____

Water temperature

Surface: _____   4 m: _____   8 m: _____   12 m: _____   16 m: _____   20 m: _____
1 m: _____   5 m: _____   9 m: _____   13 m: _____   17 m: _____   25 m: _____
2 m: _____   6 m: _____   10 m: _____   14 m: _____   18 m: _____   30 m: _____
3 m: _____   7 m: _____   11 m: _____   15 m: _____   19 m: _____   Bottom: _____

Metalimnion: _____ meter   Secci depth: _____ meter

Total number of benthic gillnets: _____   Total number of pelagic gillnets: _____

Method (mark with cross):

☐ Standardised
☐ Inventory
☐ Others: _____

Weather conditions (at setting time):

☐ Clear
☐ Partly cloudy
☐ Cloudy
☐ Fog

☐ Rain showers
☐ Mist
☐ Rain
☐ Others: _____

Air temp: _____

Wind: _____

Point
winddirection
with an arrow: _____

N

☐ Halfgale (> 14 m/s)
☐ Fresh breeze (8-14 m/s)
☐ Gentle breeze (4-8 m/s)
☐ Light breeze (0,5-4 m/s)
☐ No wind (0,5-4 m/s)

Other observations:

Setting nr: _____   Date: _____   Setting time: _____   Lifting time: _____

Species	Depth:	Running net number. -		Running net number. -		Running net number. -		Running net number. -		Running net number. -		Running net number. -		Running net number. -	
		Number	Weight (g)	Number	Weight (g)	Number	Weight (g)	Number	Weight (g)	Number	Weight (g)	Number	Weight (g)	Number	Weight (g)

Setting nr: Date: Setting time: Lifting time:

Species	Running net number.		Running net number.		Running net number.		Running net number.	
Depth:	Number	Weight (g)	Number	Weight (g)	Number	Weight (g)	Number	Weight (g)

Species	Running net number.		Running net number.		Running net number.		Running net number.	
Depth:	Number	Weight (g)	Number	Weight (g)	Number	Weight (g)	Number	Weight (g)

Lenght form

Lake: Altitude: Date: Sign:

	Fishspecie: Net number:		Fishspecie: Net number:		Fishspecie: Net number:		Fishspecie: Net number:		Fishspecie: Net number:		Fishspecie: Net number:		Fishspecie: Net number:	
	Mesh	Lenght (mm)	Mesh	Lenght (mm)	Mesh	Lenght (mm)	Mesh	Lenght (mm)	Mesh	Lenght (mm)	Mesh	Lenght (mm)	Mesh	Lenght (mm)
1														
2														
3														
4														
5														
6														
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30														

Lenght form

Lake:　　　　　　　Altitude:　　　　　　　Date:　　　　　　　Sign:

| Fishspecie: | | Fishspecie: | | Fishspecie: | | Fishspecie: | | Fishspecie: | | Fishspecie: | |
| Net number: | | Net number: | | Net number: | | Net number: | | Net number: | | Net number: | |
Mesh	Lenght (mm)	Mesh	Lenght (mm)	Mesh	Lenght (mm)	Mesh	Lenght (mm)	Mesh	Lenght (mm)	Mesh	Lenght (mm)
1											
2											
3											
4											
5											
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FISKERIVERKET INFORMATION
har under 1999 utkommit med följande nummer:

FISKERIVERKET RAPPORT
har under 1999 utkommit med följande nummer:

The map of Sweden showing: Luleå, Kälarne, Härnösand, Älvkarleby, Öregrund, Örebro, Drottningholm, Lysekil, Göteborg, Jönköping, Karlskrona

The National Board of Fisheries is the central government authority for conservation and fisheries in Sweden. The Board aim to further the responsible use of fish resources in order to facilitate the long-term development of sustainable professional as well as recreational fishing.

The Board also furthers biological diversity and strives to create abundant and diverse fish stocks. Other important tasks include working for and improved opportunities for a viable fishing industry, increasing fishing possibilities for the public and promoting accessibility to high quality fish.

Furthermore, the Board is responsible for the environmental protection within the sector, as well as the promotion of bio-diversity. The mission to promote research and development within fisheries is fulfilled by the *Institute of Marine Research* in Lysekil with the *Baltic Sea Research Station* in Karlskrona, the *Institute of Freshwater Research* in Drottningholm, the *Institute of Coastal Reserch* in Öregrund, two *Research Stations* (Älvkarleby and Kälarne) and two *Regional Research Offices* (Luleå/Härnösand and Jönköping) all of which are part of the Board.

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