SLOVENSKI STANDARD
oSIST prEN 15910:2009

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Kakovost vode - Navodilo za ocenjevanje ģtevilļ nosti rib z mobilno hidroakustiļ no metodo

Water quality - Guidance on the estimation of fish abundance with mobile hydroacoustic methods

Wasserbeschaffenheit - Aufnahme von Daten zur Fischpopulation mittels hydroakustischer Verahren

Qualité de l'eau - Guide sur l'estimation de l'abondance des poissons par des méthodes hydroacoustiques mobiles

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ICS:

13.060.70	Preiskava bioloških lastnosti vode	Examination of biological properties of water

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ICS

English Version

Water quality - Guidance on the estimation of fish abundance with mobile hydroacoustic methods

Qualité de l'eau -Echantillonnage de données de populations de poissons par hydroacoustique

Wasserbeschaffenheit - Aufnahme von Daten zur Fischpopulation mittels hydroakustischer Verahren

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 230.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This document (prEN 15910:2009) has been prepared by Technical Committee CEN/TC 230 “Water analysis”, the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

WARNING — Persons using this European Standard should be familiar with normal laboratory and fieldwork practice. This 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 safety and health 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.

Introduction

This is one of several European Standards developed for the evaluation of species composition, abundance and age structure of fish in rivers, lakes and transitional waters. The following standards have already been published:

EN 14011, *Water quality — Sampling of fish with electricity*

EN 14757, *Water quality — Sampling of fish with multi-mesh gill nets*

EN 14962, *Water quality — Guidance on the scope and selection of fish sampling methods*

Common abbreviations that are used in this document are compiled and explained in Annex A.

The initial draft of this document was constructed by an international group of experts during an ad hoc joint EIFAC/CEN workshop (see Annex G).

1 Scope

This European Standard describes a standardised method for data sampling and procedures for data evaluation of fish populations in large rivers, lakes and reservoirs, using hydroacoustic equipment deployed on mobile platforms (boats and vessels).

This standard covers fish population abundance estimates of pelagic and profundal waters > 15 m mean depth with the acoustic beam oriented vertically, and the inshore and surface waters of water bodies > 2 m depth with the beam oriented horizontally. The size structure of fish populations can only be determined to a relatively low degree of precision and accuracy, particularly from horizontally-deployed echosounders. As acoustic techniques are presently unable to identify species directly, other direct fish catching methods should always be used in combination.

This standard provides recommendations and requirements on equipment, survey design, data acquisition, post-processing of data and results and reporting. A selected literature with references in support of this standard is given in the Bibliography.

2 Normative references

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

EN 14757, *Water quality — Sampling of fish with multi-mesh gillnets*

EN 14962, *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 apply.

4 Principle and field of application

Hydroacoustic (or echosounding) technologies are effective and efficient methods for sampling fish in the water column [37]. Fisheries acoustics methods are analogous to remote sensing techniques and advantageous to other sampling methods as nearly the entire water column can be sampled quickly and non-destructively, areal coverage is continuous, data resolution is on the order of tenths of metres, and data can be post-processed in a variety of ways. However, other methods and procedures are required for determination of species identity and age structure.

Acoustics is used to gather information remotely by transmitting a pulsed beam of sound energy into a water body and subsequently detecting and analysing the returning echoes. Systems are available with single-, dual-, split- and multi-beams, although the latter two types have now superseded the other two systems. Acoustic systems are usually deployed from a moving boat in large water bodies. A computer is required for control of the echo sounder in the field and for the data processing.

This standard covers acoustic sampling of deep lakes, reservoirs, shallow lakes and wide lowland rivers. The pelagic and profundal waters of lakes > 15 m depth are surveyed with the acoustic beam oriented in the vertical axis, whilst inshore and surface waters of lakes and lowland rivers > 2 m depth are surveyed with the beam oriented horizontally [20], [24]. Water bodies of all trophic levels can be sampled acoustically and a wide range of fish communities and targets, ranging from young of the year to large mature fish can be detected and quantified (Table 1).

Mobile acoustic surveys provide several layers of information; from relatively simple presence / absence studies of target species, to spatial (or temporal) distributions of individuals or groups, to fully quantitative density and (when combined with other sampling techniques) system-wide biomass estimates.

Correctly obtained acoustic sampling data are directly related to population density. The strategy shall be to sample a defined area or volume of lake or river using appropriate equipment (Clause 5), data collection (Clause 7) and data processing procedures (Clause 8), presenting the results in a standard reporting format (Clause 9) to provide estimates of fish abundance. Abundance in this context can be either a relative or an absolute measure of assessment based on a single survey of a known area or volume of water.

Table 1 — Suitability of hydroacoustic sampling techniques for inland water bodies and fish communities

Application	Objectives	Water Types	Target Species and Life Stages	Limitations
Vertical Beaming	Fish population abundance estimates Fish population size structure	Lake Categorie 1[a] Lake Categorie 3[b]	Fish in pelagic and profundal waters YOY to adult	Poor coverage of surface and littoral waters Must be used in conjunction with direct capture methods for species composition and age structure
Horizontal Beaming	Fish population abundance estimates Fish population size structure	Lake Categorie 1[a] Lake Categorie 3[b] River Categorie 3[c] River Categorie 4[d] River Categorie 5[e]	Fish in littoral and surface waters YOY to adult	Poor coverage of pelagic and profundal waters Vulnerable to interference from macrophytes and entrained air Low confidence in size-structure from lakes and slow-flowing rivers Must be used in conjunction with direct capture methods for species composition
Combined Vertical and Horizontal Beaming	Fish population abundance estimates Fish population size structure	Lake Categorie 1[a] Lake Categorie 3[b]	Fish in pelagic, profundal, littoral and surface waters YOY to adult	Horizontal beaming vulnerable to interference from macrophytes and entrained air Low confidence in size-structure from horizontal beaming Must be used in conjunction with direct capture methods for species composition

Categories of lakes and rivers see EN 14962:

a With a pelagic or profundal zone, area < 0,5 km^2

b With a pelagic and profundal zone, Area > 0,5 km^2

c Width < 30 m, maximum depth > 2 m

d Width 30 m to 100 m, maximum depth > 2 m

e Width > 100 m maximum depth > 2 m

5 Equipment

Although current acoustic equipment is accurate and reliable, it must be used correctly with a fundamental understanding of factors that can affect its performance. Sources of systematic error or bias in acoustic survey results include calibration errors, hydrographic conditions, diel fish behaviour and migration [37]. Other practical limitations are sources of unwanted echoes (reverberation), such as plankton, debris, submerged macrophytes and entrained air bubbles.

5.1 System performance

Recommended equipment specifications are given below as minimum and optimum requirements:

Minimum:

Whilst it is accepted that useful information may be obtained from a wide variety of echosounder types, the minimum requirement for a scientific survey is that a “Scientific” sounder with the following characteristics be used:

- quantitative fisheries echosounder (calibrated) and operating at an appropriate frequency for the waterbody and target fish species, probably between 38 kHz and 1,8 MHz [34];
- enables data storage of calibrated data for reprocessing;
- enables data processing in order to generate abundance and size distribution outputs.

Optimum:

Because of their inherent and obvious advantages, it is recommended that scientific split or multi-beam sounders be used if possible.

5.2 Calibration

5.2.1 General

Calibrations are conducted to ensure that the echosounder and transducer are measuring fish abundance and fish size correctly. Secondly, they verify that the complete acoustic system is operating properly and remaining stable over time, permitting comparisons among survey periods and allowing inter-echosounder comparisons. All calibrations should be based on and follow the manufacturer’s manual and recommendations.

5.2.2 Types of calibration

5.2.2.1 “Full” instrument and equipment calibration

This is usually conducted by the manufacturer, once in a lifetime for most transducers, but it should also be done whenever the transducer has been subjected to physical damage.

5.2.2.2 “Beam pattern” calibration

This should be conducted at least once per year or whenever the transducer or cable is suspected of being subjected to physical damage.

5.2.2.3 “Standard Target” tests

These should be conducted at each survey site in order to verify that the system is operating properly and to correct for environmental factors.

The specific requirements for each calibration / standard target test are summarised below.

5.2.3 Full calibration

Full calibrations shall be conducted by the manufacturer, or at a facility approved by the manufacturer.

Shall be done separately for each transmitted pulse duration, transmit source level and receiver gain settings being used.

Should also be done if the transducer, transducer cable or echosounder have experienced any physical damage.

Records shall be kept of each calibration (if possible, raw data should be stored) in order to assess substantial changes in power parameters during the lifetime of the transducer.

5.2.4 Beam pattern calibration

For both vertical and horizontal applications (i.e. vertical deep or shallow lake surveys and horizontal lake and river surveys), beam pattern calibrations shall involve:

— Vertical calibration in a free field (i.e. one with no lateral boundaries) under high signal to noise ratio (SNR) conditions.

— Confirmation of temperature and salinity in order to accurately determine the speed of sound and absorption coefficient. Mean water temperature should be measured as a depth profile in 1 m intervals over the whole water column.

— A minimum target distance of 2 x the theoretical near-field[1)]

— Avoidance in the beam of scattering layers such as thermal stratification, fish, air bubbles or zooplankton.

— A minimum distance of 2 x the transmitted pulse length between the calibration sphere and the bottom.

— Parameters to be measured should include beam-width and angle-offset measurements.

— After physical trauma to the cable and transducer housing, damage shall be repaired and a new beam pattern calibration shall be conducted.

— If the calibration parameters do not deviate too much from previous calibrations, the transducer and cable can be considered fully functional. The manufacturer should be able to provide information about acceptable deviation.

5.2.5 Standard target test

For both vertical and horizontal applications (i.e. vertical deep or shallow lake surveys and horizontal lake and river surveys) the standard target test should ideally be carried out at the start of every new survey or day (irrespective of the survey location or strategy). It shall include:

— The passage of a standard target through the beam to check that results are, within tolerances, as expected (e.g. Table 2). Tolerances will vary depending on beam orientation (vertical or horizontal) and the signal to noise ratio (SNR). A minimum of 250 echoes is recommended on the acoustic axis and within each quadrant.

— The transducer shall be acclimated to water temperature and air bubbles removed from the transducer face and standard target.

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1) The transducer may need to be lowered well below the surface of a deep water body to avoid, for example, wave action and bubbles at the surface, whilst still having the necessary range available.

- The standard target test shall be conducted in the same environmental conditions (water temperature and salinity) as are experienced during the survey.

- Standard target tests shall be conducted with the same pulse durations, transmit powers, and bandwidths used during the survey.

- For mobile horizontal surveys, a horizontal standard target test, ideally with the standard target positioned at different ranges from the transducer, shall be performed. This is in order to determine if the Time Varied Gain (TVG) function follows normal spherical spreading. Otherwise, potential bias may be introduced when interpreting acoustic fish-size data.

- For mobile horizontal surveys, periodic fixed location temperature profile measurements shall be taken in order to verify normal spherical spreading of the acoustic beam.

No adjustments shall be made to the equipment settings as a result of this test, but a beam pattern or full calibration is required if the result is unsatisfactory. For shallow lakes or horizontal surveys this may require relocating to a suitable test site.

Table 2 — Target strengths (TS) of tungsten carbide spheres with different diameters for sound speed of 1 450 m^{s-1} in fresh water [37]

Frequency kHz	Diameter mm	Fresh WaterTS dB
38	38,1	-42,1
70	36,4	-40,9
70	38,1	-40,6
120	33,2	-40,8
120	38,1	-39,8
200	36,4	-39,5
200	38,1	-39,5
420	8,9	-52,3
420	21,2	-43,5

6 Survey design

6.1 General

Acoustic surveys are conducted to investigate large volumes of water. In practice, owing to the limited time available to perform the survey, only a small proportion of this volume can be observed acoustically. Transect-based surveys are, therefore, based on the assumption that the measurements, which are made along the survey tracks, are representative samples of the wider distribution of the target species in the water volume under study [37]. Since only a portion of the overall area of concern is actually sampled, any survey design consists of choices that need to address specific objectives, which can vary from an overall estimate of abundance for an entire population to simply the identification of locations of fish concentrations.

6.2 Design for appropriate resolution and detection

When planning a vertical acoustic survey, sampling should be planned in order to produce a three-dimensional picture of fish density using depth strata at least to the resolution of EN 14757 gillnet layers (0 m to 3 m, 3 m to 6 m, etc.). For both vertical and horizontal surveys, the signal to noise ratio should be maximised.

6.3 Pre-planning

Prior to conducting an acoustic survey, the following information should be assembled for the water body under study:

- Sufficient bathymetric data. If necessary, pre-surveys specifically for the collection of depth data should be conducted. For surveys of reservoirs, it is important to make a record of water depth at the time of the survey.
- Resident fish species data and limnological information.
- Potential temperature and oxygen stratification.
- Access permissions.
- Weather forecast (particularly wind speeds and direction).
- Identification of the cruise track:
  - Define the area to be covered by the survey. Ideally, this would be the entire lake or river, however some areas may not be feasible for hydroacoustics (e.g. too shallow or obstructed by stands of macrophytes).
  - Within the area under consideration, the choice of spacing and track layout (e.g., systematic parallel, random parallel, systematic zig-zag, etc.) should reflect an understanding of the serially correlated nature of the acoustic sampling technique and a consideration of the expected patchiness of the population of interest. For lakes:
    - The first preferred cruise track is a systematic parallel design, with allowance for inshore bathymetry and weather conditions.
    - The second preferred option is a zig-zag design.
    - Other options should only be considered if conditions preclude the above.
  - For rivers, the first preferred option is moving up one bank beaming horizontally to the far bank, returning along the other bank. Ideally, the surveyed stretch should be between impounding structures such as locks and weirs.
- When designing the cruise track, it is important to understand how the precision of the results depends upon the transect spacing. The coefficient of variation (CV) of the abundance estimate depends upon the degree of coverage [1], defined as:

$$\Lambda = D / \sqrt{A} \quad (1)$$

where

D is cruise track length;

A is the area being surveyed.

Then:

$$CV = a(\Lambda)^{-0,5} \quad (2)$$

where

a is a variable between 0,4 and 0,8, depending on fish distribution. Higher values of a are appropriate when fish are concentrated in a few large schools, low values when the fish are more uniformly distributed [37].

— The working time available for the collection of acoustic data should be calculated. For both water bodies, time may have to be factored in for stationary measurements for specific purposes, e.g. aspect identification for sizing Target Strength (TS) in horizontal surveys, hydrographic sampling etc.

— The survey plan (i.e. waypoints and transects) should be in a format suitable for transfer to GPS.

The selection of an appropriate vessel is important. This should be stable and low noise (with a preference for 4-stroke over 2-stroke motors, or electric if feasible). Cruise speed should be a maximum of 10 km hour^{-1} Actual speed selection should be appropriate for the ping rate and water depth, aiming for a minimum of 3 hits on a fish of interest when target-tracking / trace-counting.

6.4 Timing of surveys

The timing of acoustic surveys should consider the following factors:

— Surveys should be conducted during the period when the target fish are in open water and most dispersed.

— The following seasonal factors should be considered when planning an acoustic survey [39]:

  — Recruitment patterns. Depending on the objective of the survey, under-yearlings may be deliberately included or excluded.

  — Beware of spawning time generally.

  — Beware of winter aggregations.

  — Beware of migrations (e.g. diadromous species).

  — Beware of sources of acoustic interference (e.g. *Chaoborus* larvae, other invertebrates, fish larvae, macrophytes, bubbles as a result of decreased hydrostatic pressure associated with draw-down, leaves, increased noise during high flows, boat traffic etc.).

Note that optimal sampling periods may differ between countries and regions.

— Diel timing of acoustic surveys is also important:

  — If no pre-existing information on fish distribution patterns is available, then carry out both day and night surveys.

  — For night surveys, avoid the full moon.

  — Avoid transitional times (usually dawn and dusk). Restrict survey time from 1 h after sunset to 1 h before sunrise.

  — Night is usually best for surveys of both lakes and rivers.

  — Surveys shall be conducted under homogeneous environmental conditions. If conditions change significantly during the course of a survey, it should be abandoned.

6.5 Specific factors with respect to transducer orientation and position

In 6.3 and 6.4 factors, that are common to both vertical and horizontal surveys, are considered. There are also factors that are specific to the survey mode, requiring different approaches to equipment deployment and operation.

In general, the preferred method for acoustic sampling is vertical beaming. This is due to a number of factors:

- The uncertainties and potential errors are much greater for horizontal data. For example, horizontal surveys usually have lower signal to noise ratios, the aspect of fish to the transducer is often unknown, etc.
- Horizontal surveys are more susceptible to adverse weather conditions, particularly wind and heavy rain.
- Horizontal surveys are more susceptible to vessel instability.
- Horizontal surveys are more susceptible to acoustic interference from boat traffic.

Factors that are specific to vertical surveys include:

- The maximum pulse repetition rate shall be calculated according to the maximum depth sampled.
- The transducer depth should be as shallow as possible, but greater than depths that generate micro-bubbles.
- The transducer should be oriented as near as possible to the vertical.

Factors that are specific to horizontal surveys include:

- Transducers with a short nearfield and small side-lobes should be used in small, shallow rivers (width = 15 m, depth = 2 m).
- The transducer should be on an adjustable mount allowing small changes in both vertical (tilt) and horizontal (pan) planes.
- The transducer shall be at least one transducer face dimension below the surface of the water.
- The transducer shall be tilted in order to approach the Maximum Useable Range (MUR). This is a function of the space between the surface and bottom boundaries and the beam shape [21].
- The transducer tilt and pan angles shall be optimised, recorded and maintained during the course of an acoustic survey.
- The acoustic beam should be approximately perpendicular (or slightly forwards) relative to the cruise track.
- Care should be exercised selecting a ping-rate when beaming across substantial water widths towards a distant, non-smooth shore. One approach is to measure reverberation levels with increasing ping-rate, the optimal rate being just before reverberation levels sharply increase.

Combined vertical and horizontal surveys may be required on deeper lakes when a large proportion of the fish population are distributed close to the water surface [20].

6.6 Specific factors with respect to acoustic inter-comparisons[2)]

When inter-calibrating or comparing the outputs from different acoustic systems or survey teams, care must be taken to ensure there is no acoustic interference between the test echosounders.

Trials shall be conducted prior to the investigation to test for significant cross-talk between the systems on the survey vessel. In the absence of cross-talk, the echosounders can be operated simultaneously on the same boat.

2) EC Mandate M/424, ("*Mandate for standardisation addressed to CEN for the development or improvement of standards in support of the water framework directive*" WFD, 2000/60/EC) received from the European Commission, DG Environment, requires the validation of all standard methods according to ISO 5725. Collaborative studies based on reference materials or field trials must be performed before the draft texts are transmitted to CEN in the form of prENs. In the case of the Hydroacoustics standard, data from the inter-agency comparisons are awaited.