SLOVENSKI STANDARD
SIST EN 15910:2014

01-marec-2014

Kakovost vode - Navodilo za ocenjevanje številčnosti rib z mobilnimi hidroakustičnimi metodami

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

Wasserbeschaffenheit - Anleitung zur Abschätzung der Fischabundanz mit mobilen hydroakustischen Verfahren

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

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Ta slovenski standard je istoveten z: **EN 15910:2014**

ICS:

13.060.70	Preiskava bioloških lastnosti vode	Examination of biological properties of water

SIST EN 15910:2014 **en,fr,de**

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 15910

January 2014

ICS 13.060.70

English Version

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

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

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Ref. No. EN 15910:2014 E

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Foreword

This document (EN 15910:2014) 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of an identical text or by endorsement, at the latest by July 2014, and conflicting national standards shall be withdrawn at the latest by July 2014.

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Introduction

This document 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 gillnets*;

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

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

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.

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1 Scope

This European Standard specifies a standardized 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 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*

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3 Terms, definitions, symbols and abbreviated terms

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3.1 Terms and definitions

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

3.2 Symbols and abbreviated terms

Common abbreviations used in this document:

— EDSU Elementary Distance Sampling Unit; Unit: Metre (m);
— GPS Global Positioning System;
— MUR Maximum Usable Range; Unit: Metre (m);
— PST Peak of Small Targets;
— S_a Area Backscattering Strength; Unit: decibel, dB re 1 (m^2 m^{-2});
— S_v Volume Backscattering Strength; Unit: decibel, dB re 1 m^{-1};
— SED Single Echo Detection;
— SNR Signal to Noise Ratio;
— ST Single Target;
— TS Target Strength; Units = dB re 1m^2;
— TVG Time Varied Gain;
— YOY Young of the year.

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4 Principle and field of application

Hydroacoustic (or echosounding) technologies are effective and efficient methods for sampling fish in the water column [35]. 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 ([21], [25]). 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.

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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.

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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 Category 1[a] Lake Category 3[b]	Fish in pelagic and profundal waters YOY to adult	Poor coverage of surface and littoral waters Shall 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 Category 1[a] Lake Category 3[b] River Category 3[c] River Category 4[d] River Category 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 Shall be used in conjunction with direct capture methods for species composition Temperature gradients can introduce biases in fish estimates due to bending of the sound beam.
Combined Vertical and Horizontal Beaming	Fish population abundance estimates Fish population size structure	Lake Category 1[a] Lake Category 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 Shall 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.

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5 Equipment

5.1 General

Although current acoustic equipment is accurate and reliable, it shall 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 ([35]). Other practical limitations are sources of unwanted echoes (reverberation), such as plankton, debris, submerged macrophytes and entrained air bubbles.

5.2 System performance

5.2.1 Minimum requirements

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 shall 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 [36];

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— enables data storage of calibrated data for reprocessing;

— enables data processing in order to generate abundance and size distribution outputs.

5.2.2 Optimum requirements

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

5.3 Calibration

5.3.1 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 amongst survey periods and allowing inter-echosounder comparisons. All calibrations should be based on and follow the manufacturer's manual and recommendations.

5.3.2 Types of calibration

5.3.2.1 Full instrument and equipment calibration

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

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

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

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

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

5.3.2.2 Beam pattern calibration

This should be conducted prior to each survey (as per manufacturer's instructions) or whenever the transducer or cable is suspected of being subjected to physical damage.

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 × the theoretical near field:

  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;

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— avoidance of scattering layers such as thermal stratification, fish, air bubbles or zooplankton;

— a minimum distance of 2 × the transmitted pulse length between the calibration sphere and the bottom;

— measurement of beam-width and angle-offset.

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.

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

5.3.2.3 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 (as per manufacturer's instructions).

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) and shall include the following.

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a) 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.

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

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

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

e) For mobile horizontal surveys, a horizontal standard target test, ideally with the standard target positioned at different ranges from the transducer, shall be performed. Low confidence in shallow water or near-boundary TS measurements can be expected due to the potential for non-spherical spreading between boundaries.

f) 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.

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Table 2 — Example values for target strengths (TS) of tungsten carbide spheres with different diameters for speed of sound (1 450 m/s) in fresh water [35]

Frequency kHz	Diameter mm	Fresh Water TS dB
38	38,1	−42,0
70	33,2	−41,3
70	38,1	−40,6
120	33,2	−41,0
120	38,1	−40,1
200	36,4	−39,8
200	38,1	−40,0
420	21,2	−44,3

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 [35]. 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.

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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 maximized.

6.3 Pre-planning

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

a) **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.

b) Resident **fish species data** and **limnological information**.

c) Potential **temperature and oxygen stratification**.

d) **Access permissions**.

e) **Weather forecast** (particularly wind speeds and direction).

f) Identification of the **cruise track**. Define the area to be covered by the survey. Ideally, this would be the entire lake or river, although 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