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SLOVENSKI STANDARD
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Kakovost vode - Navodilo za ocenjevanje učinkovitosti sistemov ribjih prehodov in s tem povezanih metrik s telemetrijo

Water quality - Guidance for assessing the efficiency and related metrics of fish passage solutions using telemetry

Wasserbeschaffenheit - Anleitung zur Beurteilung der Wirksamkeit und zugehöriger Kennwerte von Fischaufstiegshilfen mittels Fernmessung

Recommandations pour l'évaluation par télémétrie de l'efficacité des dispositifs de franchissement piscicole et d'indicateurs associés

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Water quality - Guidance for assessing the efficiency and related metrics of fish passage solutions using telemetry

Qualité de l'eau - Recommandations pour l'évaluation par télémétrie de l'efficacité des dispositifs de franchissement piscicole et d'indicateurs associés

Wasserbeschaffenheit - Anleitung zur Beurteilung der Wirksamkeit und zugehöriger Kennwerte von Fischaufstiegshilfen mittels Fernmessung

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

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European foreword

This document (EN 17233:2021) 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of an identical text or by endorsement, at the latest by October 2021, and conflicting national standards shall be withdrawn at the latest by October 2021.

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

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Introduction

Fish passage solutions (FPS) are measures to help fish pass a cross-river obstacle or impediment in upstream and/or downstream directions. The ideal solution, from a global-ecological perspective, would be to re-establish natural river connectivity by decommissioning or removing the obstacle which would at the same time eliminate or reduce any impounded section and allow unimpeded sediment transport. In the last two decades or so, the number of constructed upstream FPS has increased significantly at least in some parts of the world, and the range of proposed FPS designs has also increased. However, despite careful control of FPS design both pre-and post-construction, the performance of FPS needs comprehensive field monitoring for the following reasons: FPS designs globally rely on laboratory experiments that need validating *in situ*; the efficiency of initially well-designed FPS may be modified by changes to the environment (e.g. discharge, river morphology) and require improvement; and the efficiency for new target species or life stages that were not considered during the initial design process could be necessary. In addition, whilst the design of FPS for some species and life stages is well advanced (e.g. adult migratory salmonids), the requirements of other species and for downstream migration are not fully understood. Only systematic, reproducible monitoring studies assessing the performance of FPS will enable us to improve and develop current fish pass designs.

In general terms, FPS monitoring is the activity of assessing by appropriate means the degree of success (or failure) of fish overcoming an impediment and dealing with the conditions of an implemented FPS.

FPS monitoring can serve several purposes:

— It can help to determine the appropriateness of the chosen design of a FPS by providing data about the effectiveness (assessment or count of the number and type of fish successfully negotiating the FPS in relation to the fish community present) and/or the efficiency (percentage of available fish attempting to pass an impediment(s) that find, enter and successfully negotiate, the FPS) for fish that have to cross the impediment. As a result, a documented well-functioning solution can serve as an example for a solution in a similar river type with a similar fish community. Any reduction in performance should be carefully analysed, and the reasons for failures identified and addressed through adjustments, i.e. by structural changes (e.g. modifications of the design of [different parts of] the pass) or by operational solutions (e.g. by optimizing the attraction to the entrance, by adapting the discharge through the pass or by adapting the operation of the turbines).

— Technical information which is indispensable for the design development or optimization of future FPS can be gathered along with the observations of fish behaviour.

— Provided that appropriate methods are used, FPS monitoring can support informed management of fish populations upstream or downstream of the impediment, e.g. supporting EU eel regulations, Directive 2000/60/EC (Water Framework Directive) or direct management of freshwater fishery resources, and the general biodiversity in the river.

FPS monitoring studies can provide several layers of information. Methods for assessing FPS effectiveness are not covered by this document. These include; trapping, video, acoustic cameras, direct observation/online surveillance, physiological telemetry (e.g. EMG (electromyogram), accelerometry and heart rate), eDNA (environmental Deoxyribonucleic Acid), Catch Per Unit Effort (CPUE) and flume studies (see [10] and [11] for further information about these methods). These methods do not provide information on the numbers of fish approaching the impediment that are available to pass, therefore the failure rate cannot be assessed.

If efficiency needs to be addressed, measures of the proportion of fishes passing successfully, relative to those attempting, is crucial, together with evidence concerning passage-related delay, mortality or other health impacts [2]. For this purpose, telemetry (acoustic, radio and Passive Integrated Transponder [PIT] tagging) techniques that enable estimation of a percentage of fish that passed the impediment in relation to the number of fish approaching the impediment to pass, have major advantages over other methods. Acoustic and radio telemetry methods are typically applied in medium to large sized river systems. For smaller sized rivers with lower depths PIT telemetry is often a more suitable approach. Telemetry methods can be costly procedures for fish-pass monitoring and are inherently associated with implantation, surgery and therefore animal welfare and always require an animal testing approval. Some aspects of efficiency (FPS passage efficiency) can be also gathered by other methods (capture–mark-recapture [CMR], traps in combination with electric-fishing) in certain situations, mainly in smaller rivers. However, these other methods are not covered in this document.

It should be noted that telemetry methods used in isolation usually look only at a single species and/or fish of a limited size range (e.g. adults, sub-adults) and are therefore unsuitable to judge the overall FPS performance for the whole fish community and age classes present. In addition, other highly relevant aspects of fish passage related to FPS performance (number of species, size classes etc.) cannot be assessed by telemetry methods and can be much better assessed by using other methods in combination. A fully comprehensive monitoring programme should ideally target the whole range of species and fish sizes present, therefore requiring a multi-method approach.

Telemetry techniques involve the tagging of individual fish and subsequent tracking of these individuals as they approach an impediment and either pass or fail to pass. The proportion of fish that successfully negotiate the FPS can be calculated and further information about the point of failure derived from the tracking information e.g. a high attraction efficiency but low passage efficiency can highlight possible problems concerning the hydraulic conditions within the FPS. This detailed information has the potential to be used to improve current fish pass designs if enough comparable monitoring information can be collected to allow detailed assessments of the performance of fish passes for different species or of different fish pass designs. Currently, however, due to non-standardized monitoring methods, definitions and protocols, data from fish pass efficiency monitoring studies using telemetry across Europe are not directly comparable.

This document on assessing the efficiency and related metrics of FPS deals exclusively with telemetry as an agreed method for the judgement of the efficiency (attraction efficiency, entrance efficiency, passage efficiency, and overall FPS efficiency) of a FPS to achieve highly standardized and comparable results for selected species and age classes.

1 Scope

This document specifies standardized methods for assessing the efficiency and related metrics of fish passage solutions using telemetry techniques that allow individual fish approaching an impediment to be monitored.

It covers studies using fish that have been electronically tagged with acoustic, passive integrated transponder or radio tags in order to provide a variety of defined passage efficiency metrics and includes both upstream and downstream passage of fish.

It provides recommendations and requirements for equipment, study design, data analysis and reporting. Selected literature with references in support of this document is given in the Bibliography.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

NOTE 1 Not all definitions listed below are necessarily applicable to all studies. Only those which are relevant to the aims and objectives of the study in question are required.

NOTE 2 This document defines efficiency metrics in the following terms.

3.1
fish passage solution
FPS
any device, structure or mechanism which is designed or managed to facilitate the safe movement of fish in an upstream and/or downstream direction when overcoming one or several impediments

3.2
FPS performance
overall capability of the FPS to meet its design objective

Note 1 to entry: The design objective will include objectives related to the target fish community, target species, attraction and passage efficiencies and effectiveness.

3.3
available fish
f_a
number of tagged fish approaching the impediment

Note 1 to entry: The point at which fish are considered to be approaching the impediment will be site specific. Once past this point, fish are assumed to be motivated to pass.

3.4
overall FPS efficiency
η_{fps}
percentage of available fish attempting to pass an impediment(s) that find, enter and successfully negotiate, the FPS

Note 1 to entry: Encompasses attraction, entrance and passage efficiencies.

3.5
FPS attraction efficiency
η_a
percentage of available fish that are attracted to the FPS entrance

3.6
FPS entrance efficiency
η_e
percentage of fish attracted to the FPS entrance that subsequently enter

3.7
FPS passage efficiency
η_p
percentage of fish entering the FPS that successfully negotiate and exit the FPS

3.8
overall FPS passage time
time from first approach of fish to an impediment to exit from the FPS

3.9
FPS attraction time
time from first approach of fish to an impediment to arrival at the entrance area of the FPS

3.10
FPS entrance time
time from first arrival of fish at the FPS until first entrance

3.11
FPS passage time
time from first entrance of fish to FPS until exit

3.12
FPS effectiveness
assessment or count of the number and type of fish successfully negotiating the FPS in relation to the fish community present

3.13
number of attempts
count of the number of times each tagged fish entered the FPS until successful negotiation and exit from the FPS

3.14
fall-back
percentage of fish that move back downstream/upstream after ascending/descending an impediment (whether by FPS or other route)

3.15
impediment passage efficiency
η_{ip}
proportion of fish attempting to pass an impediment that successfully negotiate it, by any route

3.16
overall impediment passage time
time from fish first approach to an impediment to successful passage, by any route

3.17
telemetry
use of electronic tags such as radio and acoustic transmitters, data storage tags, pop-up satellite archival tags and PIT-tags to obtain information on free-ranging fish

4 Principle and field of application

Impediments to fish migration and associated FPS occur in freshwater and transitional water bodies within a wide range of habitat types ranging from shallow headwaters to deep, wide lowland rivers; busy urban environments to remote rural locations. The telemetry techniques covered by this document enable monitoring in all of these, although no single method can be used across the whole range of water body types.

Fish passage efficiency encompasses attraction, entrance into, and successful passage through, the FPS. In order to evaluate the efficiency of FPS, it is necessary to be able to identify individual fish approaching the impediment that are available to pass so that the success or failure of each fish is known. Individual detection is best provided by telemetry.

Telemetric methods for assessing the efficiency of FPS that are covered by this document are:

— acoustic telemetry;

— radio telemetry;

— Combined Acoustic Radio Transmitters (CART);

— PIT telemetry;

— permutations of the above.

The suitability and limitations of these methods are summarized in Annex A.

Each of these techniques involves the electronic tagging of individual fish and positioning of receiver units to track individual fish as they approach and pass (or fail to pass) an impediment. The positioning of receiver units as described in this document allows relevant aspects of FPS efficiency (attraction, passage, overall) to be assessed, depending on the specific aims and objectives of the study.

Guidance is provided on the selection of appropriate monitoring equipment, the experimental design of FPS monitoring studies and data collection (see Clause 6), data processing procedures (see Clause 7), quality control and assurance (see Clause 8), and presenting the results in a standard reporting format (see Clause 9) to provide essential fish passage efficiency and delay metrics.

5 Equipment

5.1 General

In order to provide near-continuous detection performance and precise detection times, telemetric determination of FPS performance will involve the use of automated receiver systems and antenna/hydrophone arrays. The choice of telemetry method and associated equipment is based on many factors, including study objectives, environmental factors such as channel depth and width, target fish species and size and sample size. Annex A (Table A.1) summarizes the suitability and limitations of the different telemetry methods for assessing the efficiency of fish passes.

5.2 Calibration and system checks

5.2.1 General

Thorough calibration and tuning of the receiving equipment is crucial to ensure the collection of good quality, accurate data. It is essential that the detection range of the receiving equipment is fully mapped and understood. Regular system checks shall be performed to take into account changing conditions that can modify receiver detection ranges; for example temperature, entrained air and electromagnetic fields. Data on tag failure rates should be obtained from the manufacturer or, better, tested for a subset under experimental conditions; this enables one variable for tag loss during tracking to be quantified. Similarly, careful quality controls need to be placed upon false positive records of tags, which can occur due to signal processing errors and tag identification (ID) code collisions.

Tagged fish should be scanned prior to release to confirm that the tags are functioning; this is true for all telemetry tag types. The likely effects of tag ID code collisions, or cycle period between reception frequencies (used in some radio applications) relative to antenna range, on tag detection probability shall be considered and incorporated into experimental design. The percentage period during the study for which the remote array was functioning effectively shall be recorded; this is particularly important for PIT stations since tag range is low, and in all but small streams, manual tracking to determine the fate of PIT tagged fish is difficult (cf. radio, acoustic with battery-powered transmitters).

5.2.2 Acoustic telemetry

A detailed detection efficiency test shall be performed at the beginning of the study with test tag(s) of the power output to be used and repeated where possible during the study. Detection ratios of test tags within the hydrophone array should be recorded. Actual detection efficiency of tagged fish should be back-calculated from known routes and reported. “Tag drags” (moving a tag within the array) should be conducted to test the tracking capability of the system.

Reference acoustic-transmitters should be placed at several depths in known locations under typical experimental conditions and the accuracy and precision of reported transmitter positions calculated. It is a good idea to retain one or more reference transmitters (‘sentinel’ tags) for the duration of the study.

The detection range of each hydrophone should be determined under the range of experimental conditions likely to be experienced.

5.2.3 Radio telemetry

A detailed signal strength map around antennas should be generated at the beginning of the study for the tags to be used. Logger data should be analysed and signal strengths from several loggers (if present) used to create a signal strength map that enables the position of the fish to be pinpointed. The same approach should be used where one receiver is multiplexing multiple antennas.

Detection ratios of test tags within the antenna fields should be recorded. Actual detection efficiency of tagged fish should be back-calculated from known routes and reported.

Radio-transmitters should be placed at several depths in known locations during known periods of time and the accuracy and precision of reported transmitter positions calculated.

Reference transmitters can be used to compensate for variations in disturbance and the resulting signal strength recorded. It is a good idea to retain one or more reference transmitters ('sentinel' tags) for the duration of the study.

5.2.4 PIT telemetry

Because of the small range of PIT antennas, thorough testing with tags of the size and type to be used is vital. Range and detection efficiency tests should be conducted over the possible extent of experimental conditions for all tag orientations and for multiple as well as single tags (tag proximity can block detection of other tags). This should include testing of tags passed at the same speed for which fish passage through the detection field may be expected.

Regular tests of antenna efficiency should be carried out by manual checks or by automated sentinel (check) tags and recorded. Actual detection of tagged fish should be back-calculated from known routes and reported.

5.2.5 Multiple tagging scenarios

To overcome limitations of individual telemetry methods fish could be tagged with multiple tags, provided fish welfare is not compromised. For example, both acoustic and PIT tags could be used for fish moving through a wide and deep river and a narrow and shallow FPS. Acoustic telemetry will enable fish approach to the obstruction be tracked, while PIT telemetry will enable movements inside the pass to be studied.

6 Experimental design

6.1 Pre-planning

The following points shall be considered prior to conducting a study:

— **Aims and objectives** shall be clearly defined, as these will determine the study design. These could be partially pre-determined by a request to monitor a particular location, species, age/size class or catchment.

— **Potential collaborative partners** should be identified at an early stage in the planning process in order to maximize the value and outcomes of the study.

— **The study site** may be predetermined at the outset of the study. If not, then the most strategic or important site shall be identified.

— **Site logistics**. The operational and physical aspects and limitations of the site shall be identified. This should include:

  — safety of operators and equipment;

  — potential for vandalism;

  — impacts of flooding;

  — availability of a power supply;

  — access conditions;

  — predator numbers/density;

  — local sources of noise or other potential interference.