ICES Cooperative Research Report

Rapport des Recherches Collectives

No. 279

December 2005

Protocol for the Use of an Objective Mesh Gauge for Scientific Purposes

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Recommended format for purposes of citation:
ICES. 2005. Protocol for the Use of an Objective Mesh Gauge for Scientific Purposes. ICES Cooperative Research Report No. 279. 8 pp.

ISBN 87-7482-044-3

ISSN 1017-6195

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Protocol for the Use of an Objective Mesh Gauge for Scientific Purposes

1 Introduction

A mesh gauge developed by C. J. W. Westhoff under the auspices of the ICES Comparative Fishing Committee became the standard gauge for research activities in ICES countries in 1962 (ICES, 1962). In 1998/1999 the ICES Working Group on Fishing Technology and Fish Behaviour (WGFTFB) identified the need to refine mesh measurement methodologies to take account of the wider range of twines and netting types used in the netting industry since 1962. To deal with this request ICES adopted Council Resolution 1999/2B02 and established the Study Group on Mesh Measurement Methodology (SGMESH) under the Fisheries Technology Committee.

SGMESH was active from 2000 until 2003 and reported its findings and recommendations in *ICES Cooperative Research Report No. 266* (Fonteyne and Galbraith, 2004). The Study Group recommended that all parties concerned should adhere to the specifications defined in the report, whether they are scientists, fisheries inspectors, netting manufacturers, or fishers. As advice derived from selectivity data determines mesh size regulations, it is logical that all stakeholders should use the same system of mesh measurement. The principle of using a longitudinal measuring force to stretch the meshes (as in the ICES Mesh Gauge) was maintained but the measuring force was changed from 4 kgf to 40 N or 100 N, depending on whether the mesh opening is smaller than 55 mm or equal to or larger than 55 mm. Until an instrument capable of making objective measurements, not subject to human influence, with the new measuring forces became available, SGMESH recommended that for scientific purposes the existing ICES gauge with 4 kgf measuring force was to be used and that a conversion formula should be applied to deliver a mesh opening equivalent to that obtained using a force of 100 N.

The development and testing of an objective mesh gauge was the objective of the European R&D and Demonstration Project "Development and testing of an objective mesh gauge", known as the OMEGA project (Anon., 2005). Scientists, fisheries inspectors, and netting manufacturers took part in extensive laboratory and field tests. As a result of these tests the measuring forces proposed by SGMESH were to some extent modified to correspond better to current mesh measurements practices by fisheries inspectors and netting manufacturers. Information on the project's progress and results was presented to WGFTFB to consider the new mesh gauge as a possible new standard. At its 2005 meeting WGFTFB recommended that the OMEGA mesh gauge be used as the new standard mesh measurement tool for scientific studies (ICES, 2005). This recommendation was confirmed by the Fisheries Technology Committee (FTC) at the ICES Annual Science Conference held in Aberdeen, Scotland, UK, from 20–24 September 2005. FTC also recommended that the "Protocol for the use of an objective mesh gauge" be published in the *ICES Cooperative Research Report* series and strongly recommended the use of the OMEGA gauge by the other stakeholders, in particular organisations responsible for control and enforcement in the Northeast Atlantic. ICES adopted these recommendations (C.Res. 2005/1/FTC08, 2005/4/FTC01, and 2005/4/FTC02).

An objective mesh gauge measures the opening of a mesh by stretching it between two jaws until a set force is reached. The key feature of such a gauge is that manual force is not used to stretch the meshes. Force is applied by an internal mechanism. Thus the measurement made of the opening of a mesh is independent of the operator. Extensive trials of such a gauge showed it to be suitable for use on both active and passive fishing gears by:

a) fishery inspectors to enforce the conservation regulations;

b) scientists to study mesh selection;

c) net makers to check mesh sizes during the manufacture of sheet netting;

d) fishers to check that their nets conform to the regulations.

An objective mesh gauge, suitable for use in all branches of the fishing industry, provides a common standard of measurement and assists the integration of the scientific, industrial, and enforcement aspects of fishery management. It should ensure that all inspectors will obtain the same values of mesh size and that netting supplied to fishers will not subsequently be found to be undersized. It will also be possible to manufacture netting with exactly the mesh sizes requested by customers. Fishers will be able to check mesh sizes before and during fishing operations using the same objective method as the inspectors.

Detailed background information on the technical aspects of objective mesh gauges is given in Annexes 1 to 5.

2 Specification of an Objective Gauge

The gauge should have two jaws, one fixed and one movable, each 2 mm thick with rounded edges to ensure that the jaws slip easily over the twine. It may be electrically driven and must be able to apply selected longitudinal forces, in the range 5 to 180 N, to the meshes with a precision of 1 N. If the gauge is battery powered, it must be capable of making 1000 measurements, according to a typical pattern of use by a fisheries inspector, before requiring to be recharged. A built-in system for measuring the applied force is needed. A mesh should be stretched at a constant speed of 300 ± 30 mm/min by the movable jaw. The gauge must be able to measure meshes from 10 to 300 mm and may have detachable jaws for use on small and large meshes. The measurement precision should be 1 mm.

The structure of the gauge must be rigid and not distort under load. The body must be light yet robust and should weigh no more than 2.5 kg. The gauge should be made of materials resistant to corrosion under marine conditions. It should be water resistant to standard IP56, be unaffected by dust and be stable in operation over a temperature range of -10 to +40° C. The gauge should be able to withstand temperatures between -25 and +65° C during storage and transportation.

Gauge operation should be controlled by software which should provide a menu of functions and enable the gauge to self-test the electronic and mechanical parts when started. It must be possible to operate the gauge with one hand and the functions should be accessed via external buttons. Data should be shown on an integral display able to present each measurement, the number of measurements made in a series, and the mean value. A store should hold at least 1000 measurements and it must be possible to transmit data to a computer. Test procedures for checking the measuring force and the distance measured should be provided. Some netting will creep under load. The gauge should respond to this condition by re-applying the set force, requiring a suitable algorithm in the controlling software, as described in Annex 5.

3 Measurement Procedure

a) Mesh Type

The mesh dimension to be measured depends on the mesh type:

Diamond mesh: The netting is stretched in the direction of the long axis of the mesh, the N-direction (Figure 1). If, in knotless netting, the N-direction cannot be determined, then the longest axis of the mesh should be measured.

Square mesh: The netting is stretched first in the direction of one diagonal of the mesh then in the other diagonal direction. The largest measurement is considered to be the mesh opening.

Meshes turned by 90°: the same procedure as for square mesh.

b) Preparation of the Gauge

The operator selects the appropriate size of jaw for the meshes to be measured.

If small or large jaws are selected they are then fitted.

The operator ensures that the jaws are clean.

The gauge is then started by the operator and performs a self-check.

If functioning correctly, the gauge will show on the display that it is ready for use. If not, it will display an error message, close down and cannot be used.

The operator enters the gauge menu.

The operator selects the force to be applied. The recommended forces are for set nets: 10 N for all mesh sizes; and for codends: 20 N for mesh sizes < 35 mm; 50 N for mesh sizes ≥ 35 mm and < 55 mm; 125 N for mesh sizes ≥ 55 mm.

The operator enters the jaw type in the menu.

The gauge is then ready to make and record a sequence of mesh measurements.

c) Insertion and Operation of the Gauge

The operator holds the gauge in one hand and inserts the jaws into the mesh opening. The fixed jaw is located in the knot nearest to the operator, as shown in Figure 1:

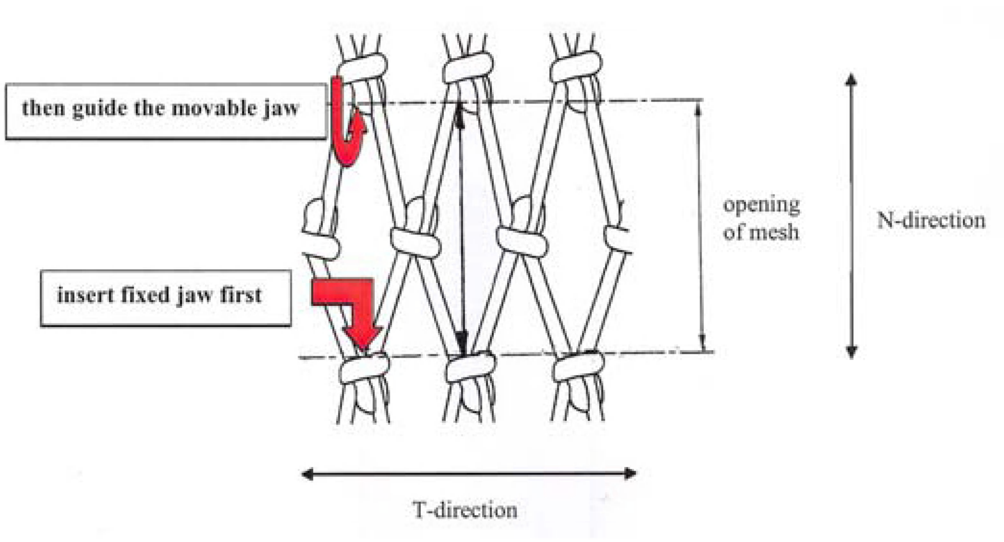

Figure 1. Insertion of the gauge.

The gauge is activated and the jaws open until the movable jaw reaches the opposite knot and stops when the set force is reached. Care must be taken to ensure that the largest opening is measured with the jaws at the sides of the knots. The gauge should be held steady, until it has performed its measurement algorithm and obtained a final value of mesh size. A command is then given to accept or reject this measurement. The movable jaw is then retracted ready to make the next measurement.

On set nets, it may be more convenient to locate the movable jaw first in the knot furthest from the operator whilst stretching the twine gently by hand. This alternative procedure should be carried out with caution as excess force may be applied to the mesh and the twine must be released before the gauge applies the set force to the mesh.

d) Selection of Meshes

For scientific purposes 40 meshes in two or more parallel lines of up to 20 meshes are to be chosen for measurement. When measuring codends or extensions care must be taken to observe previous recommendations (Wileman *et al.*, 1996) with regard to nearness of selvedges, mendings, etc.

e) Acceptance of Measurement

After making each mesh measurement, the operator must decide whether to accept or reject the measurement before saving it in the data store. Possible reasons for rejection are:

- the jaws did not locate in the longest opening position;
- the operator lost a firm grip on the gauge;
- the value is unrealistic.

If the measurement is deemed acceptable the operator then saves the reading. If a measurement is deemed unacceptable, but the operator accepts it in error, then the series of measurements must be cancelled and started again.

f) Determination of Mean Mesh Size

After measuring a series of meshes, the operator instructs the gauge to calculate the mean mesh opening. This is rounded to the nearest 0.1 mm and displayed. The operator then instructs the gauge to end the sequence. The saved data include all accepted measurements, date, time, and a unique identifier. The gauge is then ready for another sequence of measurements.

For square meshes and meshes turned by 90°, the software shall contain a suitable function to select automatically the largest diagonal of each mesh to calculate the mean mesh size. The saved data however, must include all measurements made. This allows verification of the selection procedure.

4 Calibration

Intermediate verification of length measurement is performed by inserting the jaws of the gauge into slots of different lengths in a calibrated rigid test plate. This can be done at any time.

Intermediate verification of force measurement is performed by hanging calibrated weights on the fixed jaw containing the load cell, with the gauge held vertical and secure. The weights can only be used under stable conditions.

5 Training

Operators should carry out several series of measurements to become familiar with the functions of the gauge before using it to make measurements. They should also practice the verification procedures.

It is strongly recommended that organizations using the gauge ensure that all operators receive adequate training in the use of the instrument.

Technical Aspects of Mesh Measurement

Annex 1: Mesh Size

Fishery conservation regulations refer to the "mesh size" of a fishing net. This is defined as the "opening of mesh" in international standards (EN ISO 1107:2003). For knotted netting, the size of a mesh is the longest distance between two opposite knots in the same mesh when fully extended in the N-direction[1] (Figure 2).

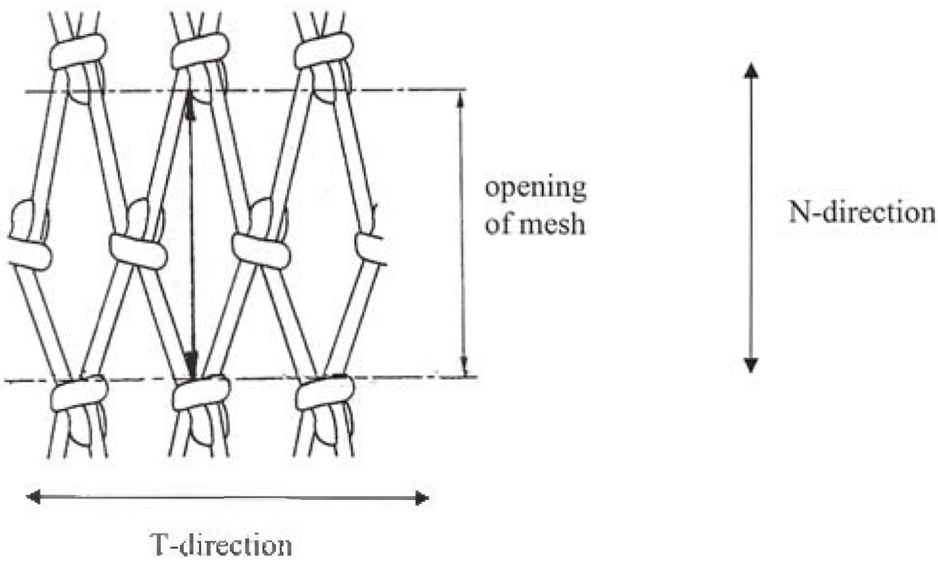

Figure 2. Opening of mesh.

For netting with square meshes or meshes turned by 90°, the netting is stretched first in the direction of one diagonal of the mesh (N-direction) then in the other diagonal direction (T-direction). The largest measurement is considered to be the mesh opening.

For knotless netting, the size of a mesh is the inside distance between two opposite joints in the same mesh when fully extended along its longest possible axis.

1 N-direction: the direction at right angles (Normal) to the general course of the netting yarn.
T-direction: the direction parallel to the general course of the netting yarn (Twinewise).

Annex 2: Mesh Measurement Methods

On codends and attachments, mesh size opening is normally measured for control purposes with a wedge gauge. This is a 2-mm thick metal wedge with tapered edges. It is inserted vertically into the netting and manual force is applied to stretch the meshes horizontally. The mesh size is read off a graduated scale on the wedge, at the upper edge of the twine, regardless of twine thickness. The human factor can be significant when measuring with a wedge gauge and critical when the mesh size is close to the limit. If, during an inspection, the outcome is not acceptable to the fisher, he may ask for re-measurement with a weight or dynamometer exerting 2 or 5 kgf, depending on the mesh size, and the result is then conclusive.

On set nets, mesh size opening is measured with a simple calliper gauge. The jaws of the gauge are inserted into a mesh and then pushed apart with light hand force until the mesh is firmly stretched. The mesh size is then read off a graduated scale on the gauge.

Scientists measure mesh opening when studying the size selectivity of fishing nets. Up until 2006 they used the gauge developed for the International Council for the Exploration of the Sea (ICES); a device similar to a calliper gauge which applies a controlled spring force to the mesh. The recommended measuring force was 4 kgf. This gauge normally produced measurements smaller than those obtained with the wedge gauge.

Net makers measure mesh sizes during manufacture to produce sheet netting with mesh sizes as close as possible to customer requirements. They use the wedge gauge, the ICES gauge and also spring-loaded wedge gauges, such as the Utzon gauge. The international standard EN ISO 16663–1:2003 specifies a method for the determination of the mesh opening using a flat wedge gauge.

Fishers measure mesh sizes to ensure that their nets continue to conform to regulatory requirements after prolonged use at sea, as mesh shrinkage may occur due to wear or sand absorption. They normally use a wedge gauge.

Annex 3: Stretching Force

Fishing nets are constructed from a variety of materials and twine types, e.g. twisted or braided, and woven in single, double, or triple form. The mesh shape can be diamond or square. Thus the strength and stiffness of netting varies widely and different forces are needed to stretch the meshes fully for size measurement. In recent years, there has been a trend in the fishing industry to use codends constructed from much heavier and stiffer twine, e.g., double 6-mm braided twine. This requires a longitudinal force much greater than 5 kgf to stretch a mesh fully. Force requirements for mesh measurement were investigated during the EU OMEGA Project, using an objective mesh gauge on the types of netting used for active and passive fishing gears. Based on the extensive data collected during this work, the recommended forces are:

For set nets of all mesh sizes, 10 N;

For codends of mesh size <35 mm, 20 N; of mesh size ≥ 35 mm and < 55 mm, 50 N; of mesh size ≥ 55 mm, 125 N.

Annex 4: The OMEGA Project – Development and testing of an Objective MEsh GAuge

The OMEGA project (Anon., 2005) evolved from the perceived need for an objective mesh gauge for fisheries inspection, research, and the fishing industry. Improving the methodology for mesh size measurement should contribute to better implementation of technical conservation measures and hence the effectiveness of fishery management.

An EU project evaluating mesh measurement methodologies (Fonteyne *et al.*, 1998) showed that the present EU regulation was not sufficiently precise and allowed variation in both the construction of the official wedge gauge and the operating procedure. It was recommended that a new, more objective mesh gauge be developed. The conceptual design of a new mesh gauge was produced during a further project (Fonteyne *et al.*, 2002). A proposal to build and test an objective mesh gauge was then presented to the European Commission and was accepted for funding. The OMEGA project started in October 2002 and was completed in February 2005.

The design of the new gauge avoids the application of manual force by using a mechanism to apply a pre-selected force to stretch the mesh through extensible jaws. The mesh size measured is the calibrated extension distance of the jaws. The result is independent of manual force and of friction between gauge and twine. Force is applied with a precision of 1 N and mesh size is measured to an accuracy better than 0.5 mm. Figure 3 shows a prototype of the OMEGA gauge.

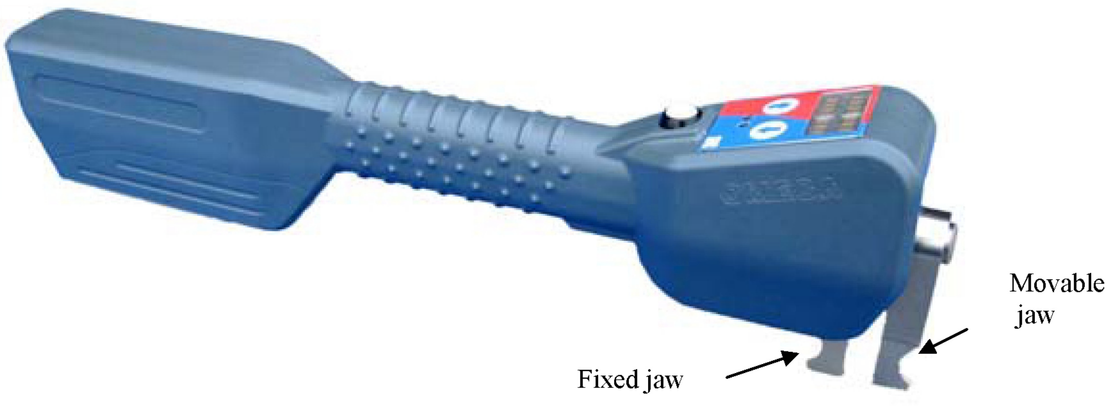

Figure 3. OMEGA mesh gauge.

The partners in the OMEGA project were fisheries research institutes, fisheries inspection agencies, and a cooperative of two private companies. The latter were chosen from a group of interested European instrument makers following intensive consultation and a selection process (Fonteyne *et al.*, 2002). The coordinator of the project was the Ministry of Small Enterprises and Agriculture, Agricultural Research Centre – Sea Fisheries Department, Belgium.

The new instrument was tested and compared with existing mesh gauges in the laboratory, at sea, at harbours and in the netting industry. Future users were invited to evaluate the new gauge. As an integral part of the project, a protocol was written to guide operators in the design and use of such gauges.

Annex 5: Measurement algorithm

To allow for creep in a stretched mesh:

1) Extend the jaw into the mesh at a constant speed of 300 ±30 mm/min, until the measurement force is reached;

2) Stop the motor, and wait 1 second;

3) If the force drops below 80% of the pre-set measurement force extend the jaw into the mesh until the measurement force is reached once more.

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