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Water quality — Visual seabed surveys using remotely operated and/or towed observation gear for collection of environmental data

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National foreword

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A list of organizations represented on this committee can be obtained on request to its secretary.

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Water quality - Visual seabed surveys using remotely operated and/or towed observation gear for collection of environmental data

Qualité de l'eau - Études visuelles des fonds marins utilisant un matériel d'observation commandé à distance et/ou tracté pour la collecte de données environnementales

Wasserbeschaffenheit - Visuelle Meeresbodenuntersuchungen mittels ferngesteuerter Geräte und/oder Schleppgeräten zur Erhebung von Umweltdaten

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Contents

Page

Foreword

This document (EN 16260:2012) 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of an identical text or by endorsement, at the latest by April 2013, and conflicting national standards shall be withdrawn at the latest by April 2013.

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

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Introduction

Information on the habitats, biotopes, substrates and species diversity on the seabed is an important part of ecosystem-based environmental management, and necessary in order to evaluate the consequences of various anthropogenic activities. Implementing European Directives and required monitoring of substrates and species diversity will require documentation and monitoring of different types of seabed types using inter-comparable and generally non-destructive methods. Many seabed areas are difficult, if not impossible to investigate using traditional sampling such as grabs and dredges or may host fragile communities such as cold-water coral reefs. Visual surveillance using geo-referenced positions is essential to allow revisiting of locations, documentation of environmental conditions and detection of changes in species composition which otherwise would be difficult to achieve. The equipment and methods described here may also be used in combination with acoustic equipment for seabed characterisation.

The methods presented in this European Standard are particularly suitable for seabed mapping and monitoring at depths below depths achievable using traditional SCUBA diving, and in cases where safety or economical issues limit the use of SCUBA diving. They are also suitable for the description of distribution and occurrence of large and scattered organisms on substrates, where sampling with grabs do not provide representative results. For investigations on soft seabed substrate please refer to EN ISO 16665 [1] and for investigations on shallower hard seabed to EN ISO 19493 [2].

This European Standard is also suitable within the operational depth of SCUBA-diving, e.g. for large scale surveys and mapping of the seabed composition, characteristic plant and animal species occurrence and depth distribution.

Remotely Operated Vehicles (ROVs) and passive tethered observation platforms are used for mapping and environmental surveys of the seabed via video and still photographs. However, the methods used and the results obtained can be rather variable without proposed consideration of geographic positioning, taxonomic precision and quantification. It is therefore important that the methods used are standardised in order to compare results.

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

1 Scope

This European Standard describes methods, requirements and equipment for remote visual surveillance of organisms and the seabed using still photography and video recording to ensure precise and reproducible data. The main aims of the methods are to record or monitor seabed conditions and organisms on and just above the seabed in a reproducible way at a resolution that is appropriate to the aims of the survey.

In caves and overhangs this standard may not be suitable due to technological limitations related to navigation and movement of the observation platform.

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 14996, *Water quality — Guidance on assuring the quality of biological and ecological assessments in the aquatic environment*

3 Terms and definitions

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

3.1
sonar altimeter
acoustic instrument measuring the elevation above seabed

3.2
box-in-test
test to determine alignment/attitude errors in the navigational data, involving four different positions of the vessel relative to a fixed transponder

3.3
drop camera
video and/or still camera that is either lowered down to the seabed or suspended just above it, generally used for imaging at a single location, or manoeuvred along a set transect using the ships propulsion system on the surface

3.4
frame grab
still image obtained from video record

3.5
geographic precision
accuracy with which a given point can be relocated within a geodetic reference system

3.6
geographic resolution
lowest unit of measurement at which a geographic distribution can be reproduced

3.7
kalman filtration
sequential smoothing method where the most likely result is achieved through a combination of earlier results using the relevant measuring point

Note 1 to entry: This type of data filter is often integrated in navigation software packages, but can also be applied separately [3].

3.8
locality
geographic description of a place or an area where samples are collected, covered by one or more sampling stations

Note 1 to entry: Description is based on habitat, terrain, depth and name of geographic area.

3.9
macrofauna
animal species ranging from 1 mm to 50 mm

3.10
megafauna
animal species larger than 50 mm

3.11
monitoring
investigation via repeated sampling to record eventual changes in environmental conditions or community composition over time

3.12
morphological species
organism that belong to a unidentified species that clearly can be distinguished from other observed, identified or unidentified species, and that may be described based on shape and colour and size

3.13
observation platform
passive sampling gear comprising a supporting construction onto which a video camera and light and/or a still camera (and environmental sensors if required) can be mounted

Note 1 to entry: An observation platform can be tethered to a fixed point or towed.

3.14
PAL-standard
analogue television colour encoding system used as a standard for video recording

Note 1 to entry: Video format used in most European countries

3.15
reference location
location representing presumed natural environmental conditions

3.16
remotely operated vehicle
ROV
remotely operated motorised underwater vehicle equipped with video and/or still camera and often has the capacity to mount additional equipment such as sonar, environmental probes, manipulator arms and sampling equipment

3.17
sample
single photograph, frame grab or uninterrupted video sequence

3.18
sampling station
geographically defined area where still photographs or video recordings are taken

Note 1 to entry: Still photographs cover a defined area, which for practical purposes can be represented by a point on a map. Video recordings carried out by means of a vehicle in motion cover a larger sampling area and the location of the start and end of the line become more important when repeating or relocating sampling stations. Therefore, for video recordings, the starting point is used as the station position.

Note 2 to entry: A station is defined by its geographic position, together with any additional information on features on the seabed (for example rocky outcrops or large stones) recognisable by either direct observation or by acoustic surveillance (for example multi-beam echo-sounder or side-scan sonar). The station is delimited at the given level of precision.

3.19
still image
single photograph or frame grab

3.20
spin-test
test to identify navigational offset errors, involving rotation of the ship above a fixed transponder

3.21
transect
defined and continuous line or belt of pictures or video sequences across a delimited area

Note 1 to entry: The position of the transect can be random or located to reveal different (various gradients of) environmental conditions (for example gradually increasing depth etc.).

3.22
video sequence
continuous part of a video film

4 Principle

Remotely operated vehicles (ROVs) and passive tethered observation platforms are used for mapping and for environmental surveys of the seabed. Still photographs and video recordings are used in a variety of ways to obtain visual data for mapping and/or monitoring the seabed and organisms on or near the seabed. This European Standard gives guidance with respect to sampling strategies, geographic positioning, taxonomic identification and quantification and determination of seabed substrates and/or the organisms living on or above the seabed.

5 Equipment

5.1 General

The technical specifications for the equipment used shall be described when reporting the results. The requirements made for the equipment are dependent on the aims of the survey. For mapping and monitoring, a colour camera should be used together with underwater positioning equipment. The positioning equipmen should have an appropriate error margin for the survey objectives with a minimum of ≤ 2 m, with a relative tolerance of + 5 % of the water depth (measured in metres) for depths equal or greater than 20 m and ≤ 3 m, with a relative tolerance of + 3 % of the water depth for depths shallower than 20 m, respectively.

EXAMPLE Water depth: 15 m appropriate error margin: ≤ 3 m + (15 m × 0,03) ≤ 3,45 m
Water depth: 40 m appropriate error margin: ≤ 2 m + (40 m × 0,05) ≤ 4 m

5.2 Cameras and light

Video recordings and still photographs should not contain electric or electronic noise. The minimum requirements of cameras (video recordings and still photographs) differ for the three types of investigations (pilot surveys, mapping and trend monitoring). For pilot surveys (see 7.4) low light, composite video PAL standard should be used. A colour camera is not a requirement for this type of survey. The minimum requirement for mapping (see 7.5) is a high resolution PAL colour camera (e.g. 400 TV lines). The application of a colour HD (high definition), 1080 interlaced is recommended. Still photographs for use in trend monitoring (see 7.6) should document an area of between 0,25 m^2 and 1 m^2 with a good image quality (focus and contrast) with a minimum resolution of 1 080 x 1 560 pixels (HD-format, equivalent to 300 DPI at 9 cm × 13 cm). Lights should be strong enough to provide a fully illuminated surface, at heights ≤ 3 m above seabed surface.

5.3 Sonar altimeter

The elevation above seabed should be measured by a sonar altimeter or by using trigonometry.

NOTE Estimation of height using trigonometry demands that the distance from camera lens to the centre of the image and the camera’s inclination angle is known. The distance is from the lens to the centre of the image from the width of the field view (scaled by parallel laser points) and the angle of view.

A simpler method for keeping constant height above the seabed is to use a rope with weight, or a chain suspended from the observation platform. This method is not suitable for sensitive habitats such as coral habitats and sponge communities. Furthermore, it may also represent a safety hazard since the rope may stick to obstacles on the seabed. As far as possible, an even height (1 m to 3 m for mapping) and speed (0,5 kn to 2 kn for pilot surveys and 0,5 kn to 1 kn for mapping) should be maintained. Ideally the lower the speed, the better; but with certain sites it would be impossible to keep speeds consistently down to these levels without resorting to just working at slack water only. An increased video frame capture-rate would allow better slow-motion replay and therefore allow a camera to travel quicker over the seabed. In all cases the camera should travel at an appropriate speed such that images obtained using video or still photograph are not overly blurred.

5.4 Data recording equipment

Video records should be stored in a format (e. g. storage of video files on a hard disc or directly recorded onto a DVD burner or a DV tape recorder), that avoids loss of data quality when copying. For video recordings, the position should be inserted as text on the image, or logged in a data file where the time of the video recording can be used to synchronize the time logged together with the GPS signal, as well as other environmental data (depth, temperature, angle of camera etc.). Alternatively these data can be stored on the audio track of the video. These audio data should always follow the picture and should not be stored on a (or several) separate file(s).

6 Positioning

6.1 General

Geographic references for observations should be accompanied by information on the accuracy obtained using the combination of equipment and method. Positioning should be carried out with reference to a grid net or geodetic reference system.

NOTE 1 Examples on grid-net systems are EUREF89 (European Reference Frame 1989), and UTM coordinate system (Universal Transverse Mercator coordinate system). Examples for geodetic reference systems are ETRS89 (European terrestrial reference system 1989) and WGS-84 (World Geodetic system 1984).

For the purpose of mapping shallow (< 15 m) coastal areas using a drop camera the ship's GPS can be used without hydro acoustic positioning, except for pilot surveys (see 6.3). If using an ROV in open sea areas and in areas with strong currents, the ROV shall be equipped with a sufficiently strong motor or "garage" to avoid drift from the targeted locality (at a fixed position or between two fixed positions). If a towed platform is used in similar areas the observation platform should be heavy enough to prevent too large offset, which will disable reliable hydroacoustic positioning.

Geographic references (beyond general locality: approximately ± 100 m) should be based on hydro-acoustic positioning. When using a towed observation platform or drop camera, its position at the seabed can be estimated from the vessel's position by correcting for deviations in relation to the observation platform (cable length, angle and direction). In all cases, the method used shall be documented.

NOTE 2 There are several sources of errors in the positioning of underwater equipment. The main components in underwater positioning provide transmission of satellite signals to the ship and calculation of the distance and direction to the observation platform. The quality of underwater positioning is mainly depending on how the ship is equipped, but the setting and calibration of this equipment is also very important.

6.2 Calibration of positioning equipment

For mapping and monitoring the hydro-acoustic positioning equipment needs to be calibrated on an annual basis. If a calibration has been performed for instance by comparison with a transponder placed on the seabed, values for the error should be provided in the report. If such a calibration has not been made the errors provided by the producers of the equipment should be used instead.

Filtering of navigational data can significantly reduce noise. The recommended method for this is Kalman filtering [3].

NOTE Many GPS navigation systems on the market already "smoothen" the position, based on previous positions and estimated compass direction, before they are shown in the display. The method used for filtering varies, but most common is the *Kalman filtering*. A simpler method for filtering navigational data is to remove deviant recordings that are obvious outliers from the remainder of the recordings. Deviant values can be replaced by a value derived from the running mean of five records (two before and two after the point of the deviant record) in the series of navigational recordings. If filtering of navigational data is used, the method used should be documented when reporting the results.

The geographic resolution can be obtained by comparing the distances covered by video sequences of similar lengths with the distance as calculated using speed.

6.3 Positioning of the different types of survey

For pilot surveys, positioning may refer to the position of the vessel. The positions of video transects should as a minimum be defined by the vessel´s start and end positions. The precision of positional information should fulfil the requirements of Order-2 in S-44 [4] (≤ 20 m, with a relative tolerance of + 5 % of water depth in meter).

Approximate positions along a towed transect may be calculated based on speed of the equipment together with the compass direction.

For a drop camera, a calculated position for where it hit the seabed is satisfactory. This position is estimated based on the offset between the location of the ship positioning system's centre point and the location on the ship where the drop camera is deployed.

For mapping, positions should be recorded at regular intervals (at least one record per 10 s) during the video recordings. The precision of the positional information should as a minimum be ≤ 2 m, with a relative tolerance of + 5 % of water depth in meter for water depth ≥ 20 m and ≤ 3 m, with a relative tolerance of + 3 % for water depth < 20 m.

For trend monitoring using still photography, the positioning shall be accurate enough to allow relocation of the exact location on the seabed in order to be able to follow developments in individuals/populations using positional data for markers and/or photographs/video recordings from previous surveys. See Table 1 for an overview of the recommended minimum quality requirements of the different methods for positioning.

The exact positioning of hanging or towed video with a standard vehicle is almost impossible. Therefore, it is recommended that if an exact position is required, it should be done by placing or choosing a well recognizable obstacle on the sea floor (see 7.6.2). For ROV exact positioning is possible.

For a description and comparison of different crude positioning methods suitable for pilot surveys see Coggan et al 2007 [5].

6.4 Underwater positioning

The degree of accuracy varies depending on the type and aim of the investigation. Where a high accuracy of geographic positions is required, use of the Ultra Short Base Line/Super Short Base Line system (USBL/SSBL-system) should be carried out with reference to appropriate calibration of at least the USBL-system, satellite navigation system and gyro- and navigational software. If this is not available, or changes have been made to the set-up since the last calibration, the system should be re-calibrated. During calibration, a ”box-in-test” (see NOTE 1) and a ”spin-test” (see NOTE 2) should be carried out in accordance with the manufacturers instructions for the equipment/software.

NOTE 1 During a "box-in-test", all four quadrants of a transponder's position is recorded. The vessel is aligned in four different positions such that by the end of the procedure, recordings are made of where the transponder has been relative to the bow, stern, port- and starboard sides of the vessel.

NOTE 2 In a spin-test, the vessel rotates directly over the transponder whilst the positions are recorded.

The use of an LBL-system (Long Base Line) for positioning during a survey should be carried out with reference to a calibration report.

To provide quantitative or semi-quantitative data, the geographic position of the observation platform on the seabed should be known alongside the error margin (see 6.2).

If using hydro-acoustic positioning equipment, the position should be recorded continuously during the survey. When using a towed observation platform, the vessel's positions may be used, after correction for the known deviation, provided that the vessel's course and speed are stable.

Calculation of the spatial extent of structures should not be based on hydro-acoustic underwater positioning if the error margins of the recordings exceed 10 % of the extent of the structure.

For underwater positioning, the precision of the equipment should be documented.

NOTE 3 Hydroacoustic signals are influenced by the sound velocity of the water (which varies with temperature and salinity). Thus, estimates of sound velocities should be performed at the start of a survey and when moving into areas with different water characteristics. These data should be used for calibration of the positioning equipment as explained by the navigation system's user manuals.

7 Collecting data

7.1 Quality assurance and quality control

Vessels used for the investigations shall be in accordance to the relevant safety standards and manned by crew qualified to carry out their required tasks.

Equipment and methods used shall have documented technical specifications (see 7.3 and Table 1) which allow an assessment of the quality of the results. Quality assurance and quality control measures shall be included in all parts of the investigation.

All procedures shall be described, and all tasks and parts of the work shall be performed in a standardised and reproducible way. The investigation shall be undertaken by qualified personnel with a relevant education. The reader is referred to EN 14996 on the quality assurance of biological and ecological investigations. The overall goal is to ensure documentation and tracking of all fieldwork procedures, samples and equipment from start to end of an investigation.

For quantitative image analysis, the aim should be to take the pictures perpendicular to the surface unless alternative angles provide better quality data to ensure a correct calculation of area and best possible identification of organisms. Alternative angles of alignment may benefit certain surveys design e.g. cameras may be angled forwards where this can improve image ID. Calculation of area may be carried out on sloping surfaces if the image can be scaled (for example by parallel laser points at known distances) and if the angle of the camera relative to the seabed is known.

7.2 Survey plan

A survey programme should be designed in accordance with the aims of the investigation, required precision of results, local topographical and hydrographical conditions in the survey area, information on local sources of pollution, experience from previous investigations and any other factors that can be of significance for the surveys. The survey programme shall be established before commencement of the survey, but appropriate modifications may be made during the fieldwork, as judged necessary.

Visual surveys of the seabed should be carried out by still photography or video, and may be divided into three main types as follows:

— Pilot survey, see 7.4;

— Mapping, see 7.5;

— Trend monitoring, investigations over time, see 7.6.

Table 1 gives an overview of the recommended minimum requirements of the three main survey types.

NOTE Mapping using still photographs and video does not provide complete information about the total species diversity in an area, but provides important additional information about the epi-flora and fauna represented and their local spatial distribution, that traditional sampling gear cannot provide.

7.3 Transect surveys

Except for pilot survey, the camera should be at least 3 m or closer to the seabed in order to identify organisms with a size < 10 cm, or to estimate percentage composition of seabed substrates, but this will depend on video quality. Records from a greater height can only be used for mapping of dominating species > 10 cm or qualitative registration of coarser seabed substrates (cobble, boulder and bed rock).

For quantitative mapping of flora and fauna, the areas covered shall be estimated based on the field of vision and the distance travelled. For calculation of observed area, the photographic field shall be scaled using laser points or calculated using the lens and camera angles together with height above the seabed. Height shall be recorded to the nearest decimetre. The angle of the lens and the angle of the camera relative to the seabed shall be recorded in degrees.

NOTE On a sloping or uneven seabed calculation of areas based on trigonometry using height above the seabed is complicated and not practical. In such cases laser scaling points are needed.

For mapping where the field of vision is 1,5 m to 3 m, a distance of 10 cm between the laser points is recommended. For pilot surveys conducted at a greater height above the seabed and a wider field of vision, the distance between the laser points can be increased to 20 cm.

The length of transects to be covered in order to ensure comparable results is dependent on the aims of the survey. For mapping of species diversity and abundance distribution, the transect length should as a minimum ensure that a further 10 % increase in transect length would not result in more than a 10 % local (within the transect) increase in recorded taxa. In practice, this is equivalent to approximately 400 m in areas with a uniform habitat. In areas of habitat heterogeneity, this length should be increased to 500 m. It can be difficult to control the distance covered in ”real time” and therefore it may be practical to calculate the distance covered based on the speed of the ROV or vessel in the case of towed observation platforms. See Table 1 for recommended transect length for the different types of surveys.

In areas with homogeneous substrate types and evenly distributed flora and fauna shorter transects may be sufficient to represent the diversity of taxa. However, this shall be documented by a graph showing the cumulative numbers of taxa in relation to distance along a video transect from the general survey area.

7.4 Pilot survey

A pilot survey is used as a reconnaissance survey for future more comprehensive recording and surveying of environmental conditions. This type of survey is not suitable for recording changes over time, with the exception of major changes in dominant organisms and seabed conditions (underwater sediment slide, seabed trawl marks etc.). The requirements for methodology and reproducibility are generally relatively simple.

NOTE Side scan sonar is a very helpful tool for the pilot survey and should be used - as far as possible - to identify potential habitats (e.g. mussel banks, boulders/stones, ripple fields, seagrass meadows) for further visual seabed surveys.

No particular requirements are made for identifying the location or number of stations, but the stations should be as far as possible representative for the area under investigation. Precise station positions and water depth shall be recorded.

7.5 Mapping

This is a survey to describe the distribution of seabed types and organisms in a given area. Visible organisms should be identified to lowest possible taxonomic level required by the survey objectives and their abundance should be estimated. Seabed types shall be described in accordance with Table 2, and the relative composition shall be determined.

The survey shall be carried out using semi-quantitative or quantitative methods (see Clause 8). The specified requirements for numbers of stations and station positioning are determined in accordance with the aims of the investigation (requirement of geographical resolution) and size of the mapping area.

Transects for video recording and still photography can be located as single lines in a variety of directions and locations, or in a pattern of parallel lines. The distance between transects and still photographs should be determined by the demand for geographical resolution in accordance with the aims of the survey. Knowledge of the degree of spatial variation of habitat, species and/or biotopes is used to inform the survey design to produce reliable maps. For areal mapping where this variation is not known, transects should be paralleled separated with a distance of maximum 50 m. Information from more widely scattered transects can be used for generating areal maps combined with prediction and verification. Still photographs should be more than 20 m apart, corresponding to one photograph per minute at a stable speed of 0,7 kn. These photographs provide data for statistical analysis and are also helpful in providing a reference photograph for segments of the video. Additional photographs can be taken of particular species or habitats of interest.

The total length of transects should be determined by the aims of the mapping. If the aim is a representative description of species diversity of observed flora and fauna (large macrofauna and flora and megafauna), the total length of transects on a location should be at least 500 m. Minimum transect length should take into account any distances covered during deployment and retrieval time. This will be longer with increasing water depth.

Mapping using video recordings/still photographs is often used to ground-truth/validate acoustic remote sensed data such as multibeam/sidescan data. The minimum number of validation samples needed for that purpose should depend on the number of ground-types that have been provisionally identified from the acoustic data. Positions should be recorded on the images at all times. To avoid loss of data electronic and image figures should be separated.

For mapping of smaller areas or single habitats the length of individual transects should be adjusted to fit the shape of the area or the extent of the habitat. For areas smaller than 500 m in longest direction the required minimum distance of 500 m transect length is not relevant. In addition to positioning of start and end points geographical positions should be recorded continuously along the transects. Start and end point noted on a log sheet for each transect, and continuous recording of positions and time should be logged by a computer with exact reference to starting time of video record. Alternatively, the positions and time should be recorded as a text overlap on the video records and/or on the sound track of the video.

7.6 Trend monitoring

7.6.1 General

The aim of this type of survey is to investigate seabed types and assemblages of organisms, or one or more selected seabed-dwelling taxa over time, in order to document natural variations and any changes over time due to environmental or anthropogenic influences. Changes may be detected in the abundance and distribution of individual species, selected indicators such as individual size, and observed mortality, or the composition of seabed substrates. Monitoring can be carried out at fixed locations by random or random stratified transects or repeated parallel transects. Again, the survey design is dependent on the objectives of the survey and knowledge of variability at the location. Care should be taken when repeating transect in the same location using towed sledges over the bottom, as this in itself can affect the data over time. The survey shall be carried out using semi-quantitative or quantitative methods following a predefined plan. A reference location or reference area should be sampled (see 7.7) to ensure that the data can be used for comparison with the environmental conditions in adjacent areas.

7.6.2 Trend monitoring at fixed stations

Trend monitoring at fixed stations is carried out by collecting still photographs from a unit area that can be identified and relocated by means of markers or naturally occurring points of reference, such as large rocks or bedrock features. The sampling area to be monitored may be marked using positioned air-filled glass buoys anchored to the seabed with lead weights (gas filled objects are clearly detected by sonar, and therefore facilitate relocation). The geographical position of the marker shall be noted in order to revisit the exact area. An area in the immediate vicinity of the marker can be photographed to help relocate the sampling location.

NOTE Gas filled objects reflect strongly on sonar and aids locating the areas.

Trend monitoring at fixed locations requires the use of a stills camera that can be positioned to take still photographs from exactly the same position on the seabed. A video camera may also be used to obtain images from fixed points, but is more suited to trend monitoring along transects. When photographing the fixed locations, the ROV shall be positioned at the same place and in the same direction relative to the marker, for each sampling session. Photographs or video recordings from previous field surveys can be used as references for exact positioning. Information concerning each photograph should be noted in the sampling logbook, as described under the section for recording, see 8.7. A minimum of three fixed locations should be photographed at each station in order to ensure that these are representative of the area at large.

7.6.3 Trend monitoring using video transects

Trend monitoring using transects is suitable for documentation of changes within areas with only slight variations in habitat/seabed type. Parallel transects give representative observations and are also suitable for mapping of local distributions of organisms and seabed types. A minimum of three transects is required. The minimum combined length of the transects is dependent on the aims of the individual survey. If the aim is to detect changes in the diversity of organisms, the combined transect lengths should be at least 500 m. The number and length of transects should be adjusted in accordance with the aim of the investigation and the local conditions. In all other aspects the surveys are carried out as described for transect survey as described in 7.3.

Table 1 — Recommended minimum quality requirements for the parameters included within pilot surveys, mapping and trend monitoring

Method	Parameter	Pilot survey	Mapping	Trend monitoring
Video transects	Number/distribution	No specific requirements	variable[a]	3 transects
	Total length (per location)	No specific requirements	500 m[b]	500 m[b]
	Average speed over seabed	2 kn	1 kn	1 kn
	Height over seabed (max)	No specific requirements	3 m[c]	3 m[c]
	Image quality (size of detectable objects)[d]	4 cm	1 cm	1 cm
	Accuracy of positioning	≤ 20 m, relative tolerance + 5 % of depth Start and end	≤ 2 m, relative tolerance + 5 % of depth[e] Running positions	≤ 2 m, relative tolerance + 5 % of depth[e] Running positions
	Depth recording	Start point, end point max. depth, min. depth	For each position	For each position
Still photographs	Number	1 per 100 m[a]	1 per 30 m[a]	5 per station
	Area	0,25 m^2 to 4 m^2	0,25 m^2 to 2 m^2	0,25 m^2 to 1 m^2
	Image quality (size of detectable objects)[d]	20 mm	5 mm	2 mm
	Accuracy of positioning	≤20 m, relative tolerance + 5 % of depth For each photo	≤ 2 m, relative tolerance + 5 % of depth[e] For each photo	0 (marker on the seabed)
	Depth recording	For each photograph	For each photograph	For each photograph

[a] Depending on required geographical resolution and the size of the mapping area, see 5.3.

[b] Only required for investigation of biological diversity.

[c] For mapping species > 10 cm a greater height from the seabed can be used.

[d] Image quality is here in the sense of identification of objects/organisms (size of object that can be identified, but not necessarily species determined).

[e] For water depth ≤ 20 m: 3 m with a relative tolerance of 3 % of the depth.

Video sequences or still photographs shall be calibrated with regard to field width either by controlling the height over ground or by at least two parallel laser pointers with calibrated distance between them.

NOTE For pilot surveys and mapping in depths less than 15 m it is also possible to give an estimation of the position of the under water system to the measured ship position including the estimated failure. The accuracy of the ship position is necessary.

7.7 Reference location

As part of surveys of areas affected by natural or human caused factors, a reference location outside the impacted area should be selected. Reference locations are decided according to whether a control or other reference needs to be provided. This is not necessarily a different location but can be the same location at a different point in time. Reference locations should to a largest possible degree represent the natural state without influence of any local sources, and should provide a measure of natural temporal and spatial variation in benthic communities. Reference locations should be included in surveys where comparison of the flora and fauna outside the influenced area is needed, or where knowledge about the natural variation is crucial. If reference locations are used these should be comparable with the impact locations, and the investigations should be performed in similar ways under similar conditions.

8 Image analysis

8.1 General

In this European Standard two types of image analyses are described:

— analyses of video sequences;

— analyses of still images (photographs or video ”frame grabs”).

The analyses should be standardised with respect to distance covered, e. g. by counting the numbers of organisms recorded per unit time. For colonial or encrusting organisms, the most common means of quantification is an estimate of the percent coverage of a specified unit area.

The choice of analytical approach depends on the objective of the survey and the characteristics of the habitat.

8.2 Analyses of video sequences

For quantitative analyses of video, the sequence lengths (sample size) should not be less than four times the error margins of the navigational data. For a navigational uncertainty of > 5 m, the use of video sequences < 20 m will carry an error margin of over 50 % of its actual length, thus the shortest sequence should not exceed 40 m. Solitary taxa should be counted within the video sequences, whereas encrusting and colonial taxa should be estimated as percentage coverage (see Table 3) from a representative subset of frozen video images.

8.3 Analyses of still images

Quantitative data should be presented as numbers of individuals or colonies per unit area, or as percent coverage. The percent coverage should either be measured directly, or by means of a ”point count” method with 100 points evenly distributed along parallel lines placed both horizontally and vertically on the picture. The extent of coverage of organisms or habitats is then given as the percent of the points that coincide with organisms or substrate. In cases where the image is not taken perpendicular to the seabed, the network of points should be adjusted such that the distance between the points reflects the perspective of the image. For analysis of flora and macrofauna, the standard unit area is given as a 50 cm × 50 cm frame. This area should be marked as a central field on the images after photographing/recording.

8.4 Seabed substrates

Seabed substrates should be classified in accordance with the EN ISO 14688-1 for granulometric composition, see Table 2.

Table 2 — Particle size fractions and categories of seabed substrate for visual surveys of the seabed

EN ISO 14688-1		**Survey type and minimum category**	
Grain size	**Seabed substrate**	**Pilot**	**Mapping/Trend**
≤ 0,002 mm	Clay	Mud	Mud
> 0,002 mm to 0,063 mm	Silt		
> 0,063 mm to 2,0 mm	Sand	Coarse sediment	Coarse sediment
> 2 mm to 63 mm	Gravel		
> 63 mm to 200 mm	Cobble	Very coarse sediment	Cobble
> 200 mm to 630 mm	Boulder		Boulder
> 630 mm	Larger boulder/Bedrock[a]	Larger boulder/Bedrock[a]	Larger boulder/Bedrock[a]

[a] The definition of seabed type “bedrock” varies between standards. In EN ISO 14688-1 it is not defined as a particle with a certain minimum size because it is not part of the “soil”

Boulder with an extension larger than the visual field should be interpreted as bedrock as long as there are no clear indications of a separation from likely buried bedrock. For the finer sediment fractions, silt and clay, which are difficult to distinguish on video recordings, the combined term “mud” should be used. In the same way, sand and granule are combined as sand/granule. Recognition of mud and sand is based on structure in the image and not identification of single grains. Identification of grain size can be aided by letting the observation platform/ROV touch the seabed to stir up some sediment. In cases of uncertainty about the seabed substrate category a sediment sample should be taken for ground truthing. This can be made using a grab from the ship or using a small sediment corer mounted on the ROV or the towed observation platform.

If the percent composition of seabed types is to be recorded, this should be estimated as described above for analyses of flora and macrofauna from still images, following the scales given in Table 3.

8.5 Taxonomic identification

Identification of organisms should be carried out by personnel with documented education or experience within relevant areas of marine taxonomy. If the competence is not documented, the identification should be controlled by experts. Where available, identifiers should participate in national/international ring tests and other efforts towards taxonomic standardisation. Responsible institution should establish an image based reference collection from each investigation to document the taxonomical quality.

Images in a reference collection should as a minimum requirement be labelled with reference to the following data:

— Identification to lowest confident taxonomic level. If possible, species level is recommended;

— Geographic spatial location (with clear reference to which geodetic datum was used)/station number and water depth;

— Date and time of observation;

— Scientific name of the observed taxon according to ERMS (European Register of Marine Species);

— Morphological species if relevant;

— Information relating to copyright/freedom of use;

— Name of identifying person.

The nomenclature used should be in accordance with recent editions of general faunal works and an agreed regularly updated literature checklist or relevant catalogues of benthic fauna, such as the European Register of Marine Species (ERMS) [6] and/or World Register of Marine Species (WoRMS) [7]. Where a taxon is not listed in a catalogue, the reference to the original description should be given together with any additional identification literature used. Where a taxon has changed its name since list publication, then the new reference should be cited.

8.6 Identification and quantification of organisms

For mapping and monitoring surveys of biological communities and diversity of flora and megafaunal organisms should be identified to lowest possible taxonomic level.

Abundances should be recorded as numbers per unit area, for example per 10 m^2 for mapping and per m^2 for trend monitoring using still images covering a smaller area. A qualitative abundance scale (Table 3) can be used if quantification is of little relevance, for example for colonial organisms and in areas with mass occurrences of organisms. There are several similar scales that can be used for example the SACFOR scale.

NOTE The SACFOR scale provides intervals for relative abundance, relating to growth form and size of organisms.

Table 3 — Scale for calculation of extent of coverage for qualitative recordings of organisms

Interval-code	Coverage (colonial/encrusting organisms) or substrate %	Mass-occurring organisms (number of individuals or colonies per m^2)
6	100	>100
5	75 > 100	50 > 100
4	50 > 75	25 > 50
3	25 > 50	10 > 25
2	10 > 25	5 > 10
1	0 > 10	1 > 5
0	Not present	Not present

Alternatively, abundance quantification may be carried out on sub-samples (”frozen” video images). It is often not possible to identify specimens with certainty, and also there may be considerable variation between individuals within the same taxon. In such cases ‘morphological species’ should be used if their form, colour and size is described. For this purpose, a photographic reference collection should be included for all taxa and ‘morphological species’ in the reporting of results.

8.7 Reporting and archiving

8.7.1 Field report

Before recording, the storage medium (e.g. video cassette, DVD, or data file and hard disk) should be clearly labelled with the project or assignment code, station and sample number. Information on the date, time, geographic position and depth (metadata) should be noted on the form (see Annex A) at the start and end of recording. For mapping and trend monitoring, the same metadata should be logged during the video recording, or for each picture taken. Each still photograph should be given a separate sample number. This information can be stored as text directly on the recording/photograph or as a separate data file. The required frequency of logging of time and geo-references depends on the method and type of survey. If the observations are to be geo-referenced or quantified in relation to area, geographic data should as a minimum be logged at the beginning of each interval that marks a sequence in the video recording. The minimum geographic resolution should not exceed the limits set by the relative accuracy of the logged geographic data set. Additional information that may be useful during interpretation of results, for example weather conditions or limitations of the vessel shall also be noted on the registration form. Annex A gives an example for a registration form.

Information on geographic position, depth and time, together with height above the seabed and camera angle if appropriate, should be recorded with reference to the image material in the form of time codes. This should be stored either as text on the video recordings or as a separate date file. For stored data files a record of time of sampling, given as GPS-time, for the start of the video recording (see informative Annex A) should be included.

As minimum the following information should be recorded during fieldwork:

— project identifier or contract code;

— institute responsible for the recordings;

— person(s) who carried out the recordings;

— locality identifier (station and sample/image number);

— date and time (start – stop);

— geographic datum and the method used (6.1);

— geographic coordinates (start point – end point);

— geographic coordinates for fixed reference points (for photographing);

— error margins for geographic positioning (specified by the manufacturer);

— type of equipment;

— water depth (start, stop, maximum and minimum for transect; or for each still photograph as appropriate);

— general description of seabed type (for example: mud, sand/granule, cobble, boulder, larger boulder);

— remarks on special observations.

8.7.2 Survey report

After survey, a report should be provided including all information noted in the forms (see Annex A) as well as a description of methods and equipment used and a copy of calibration report for hydroacoustic positioning equipment if such methods have been used.

Annex A
(informative)

Example for a fieldwork registration form for visual seabed surveys

Form 1 – Registration form for visual seabed surveys should be filled out during all types of surveys. This form provides general information about the project and the methods, as well as geographical positions for start and end points for inspection at each location. For trend monitoring using still photography of closely situated areas start and end points will often be identical.

Form 2 – Registration form for still photographs. This form is not relevant for video transects where still photography is not used.

The user of these forms is allowed to copy the present forms given below.

Form 1 – Fieldwork registration form for visual seabed surveys

Project no./name:	**Date:**
Responsible institution:	**Aim:**
Project leader:	
Personnel in field:	

Positions from:		**Geographic datum:**		**Video storage medium:**	
Map	☐	EUREF 89	☐	DV	☐
GPS	☐	WGS 84	☐	VHS	☐
DGPS	☐	ED 50	☐	DVD	☐
		UTM	☐	Hard disc	☐
		Other	☐	Other	☐

Field view calculation using:		**Trigonometric values:**
Laser points:	☐	Angle of view:
Trigonometry:*	☐	Camera angle:
*Demands logging of height above seabed and camera angle if varying		

Surveyed locations and video transects

Date and time:	**Locality no.:**	**Transect no.:**	**Position, start:**	**Position, end:**

Form 2 – Fieldwork registration form for still photography

Project no./name:	**Date:**
Responsible institution:	**Station no.:**
Project leader:	**Persons in field:**
Geographic datum:	

Ref. point no.:	**Time:**	**Latitude:**	**Longitude:**	**Depth:**	**Image no.:**

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