

## Paper for Consideration by Data Quality Working Group

### Methodology for the display of quality information

<b>Submitted by:</b>	DQWG (Chair)
<b>Executive Summary:</b>	Conditional visualization methodology of quality of bathymetric data
<b>Related Documents:</b>	NCWG3-08.4A, S-57 Supplement Number 3 – June 2014_EN, S-57 Appendix B.1 Annex A UOC Edition 4.1.0_Jan18_EN, IHO ECDIS presentation library users' manual edition 3.2 May 2000 Annex A of Appendix 2.
<b>Related Projects:</b>	Action Item 35 from HSSC9 (ongoing)

#### Introduction / Background

HSSC-9 has requested the Data Quality Working Group to further develop the conditional visualization methodology of quality of bathymetric data in liaison with NCWG, NIPWG, ENCWG, S-101PT (ref HSSC9/35). This paper will address the underlying issues from producers and users perspective, the current way data quality is symbolized and portrayed and propose new methodology based on lessons learned from existing methods.

#### Analysis/Discussion

##### 1. Harmonizing the quality of bathymetric data values from HOs:

IHO Publication S-57 Appendix B.1 Annex A UOC Edition 4.1.0\_Jan18\_EN, Use of the Object Catalogue for ENC, provides guidelines on 1) data quality description and 2) quality, reliability and accuracy of bathymetric data. See Annex-I of this paper for full details. The Zone of Confidence table is given in Annex II.

IHO CL50/2017 (dated 29 August 2017) requests HOs to provide meaningful CATZOC information in ENCs, (that is, values other than CATZOC = 6 (data not assessed) for areas of bathymetry).

S101\_Data Classification and Encoding Guide\_Final 0.0.2 provides the S-101 Metadata Feature: Quality of Bathymetric Data. The major differences between S-57 M\_QUAL and S-101 M\_QUAL are the inclusion of the attributes 1) Data assessment and 2) Category of temporal variation. The details of S-101 M\_QUAL are provided in Annex III.

At present there are too many areas in the world classified with a CATZOC value 6 (data not assessed). During the development of S-101, the DQWG decided to overcome this issue by adding a new attribute value: Assessed (Oceanic). This way the HO has a means to provide information to the mariner that the area is assessed as deeper than 200 meter and causing no hazard to surface navigation based on the (limited) information available to the HO.

In case of an area of dynamic seabed where the HOs resurvey capacity is unable to constantly monitor this, the attribute Category of temporal variation is included in S-101 to inform the mariner and setting the appropriate quality level (upgrade/downgrade) with time.

#### Conclusion:

The new datamodel in S-101 gives more and better options for HOs to meet the requirements of IHO CL50/2017.

2: Presentation of quality of bathymetric data in current S-52 and S-57 structure

The S-52 presentation library presents M\_QUAL as an area filled with a staggered pattern that have no rotation, are bordered by a dashed line in chart grey with a width of 0.6 mm. The pattern is staggered across the screen at a constant distance. The minimum distance between the symbols is 14 mm, the maximum distance is 100 mm. Display priority = 4 (0=lowest priority, 9=highest priority).

There are three major disadvantages to this symbology method to inform the end user:

- 1) the staggered pattern is displayed over the entire chart on top of all other items with a lower display priority, thus cluttering the screen, users will most likely turn this feature off.
- 2) the symbols are very similar, only by counting the number of stars inside the symbol, the value of quality is apparent. This is not very intuitive.
- 3) the symbols may lie over a depth area with two different quality levels. However, the symbol is truncated in a such a way that it takes the underlying value at the pivot point of the bounding box to display the quality value inside the bounding box thus giving a false sense of quality at another part of the symbol.

3. Conditional symbology procedure (current in S-52)

The current symbology procedure is taken from the S-52 presentation library. Two examples are highlighted, 1) filling a depth area and 2) calculating and displaying safety contours.

**Example A:** filling a depth area according to mariner settings:

An object of the class "depth area" is coloured and covered with fill patterns according to the mariners' selections of shallow contour, safety contour and deep contour. This requires a decision making process provided by a sub-procedure. Objects of the class "dredged area" are handled by this routine as well to ensure a consistent symbolization of areas that represent the surface of the seabed.

Conditional symbology procedure for symbolization of objects of the class DEPARE (depth area) and DRGARE (dredged area)			
Statement	Condition	YES	NO
Get the value of DRVAL1 and DRVAL2	Is the value of the attribute DRVAL1 given?	Do nothing here	Set the value to -1 metre. (intertidal area)
	Is the value of the attribute DRVAL2 given?	Do nothing here	Set equal to value of DRVAL1 +0.01m (deeper)
Perform the symbology procedure SEABED 01 to symbolize this area. Pass the values of DRVAL1 and DRVAL2 on to SEABED 01.			
Is the object which was calling the procedure of the class dredged area?		Select the area pattern DRGARE 01, show it on top of the area's colour fill.	Do nothing here
		Symbolize the boundary with a dashed line.	
Get the value of the attribute restriction. (RESTRN)	Is the value of the attribute restriction given?	Perform the symbology procedure RESCSP 01 to complete the symbolization of DRGARE. Pass the value of the attribute RESTRN on to it.	
Symbolization is complete, exit procedure.			

**Example B:** SAFETY\_CONTOUR depth value entered by the mariner

Startup values: The ECDIS manufacturer is responsible for setting SAFETY\_CONTOUR to 30 metres. This value should stay in operation until the mariner decides to select another safety contour.

Conditional symbology procedure for symbolizing objects of the class depth contour (DEPCNT) and line depth areas (DEPARE as a line)			
Statement	Condition	YES	NO
Get the object which is calling this procedure.			
As a default, indicate that the line object is not a safety contour by setting the local variable "SAFE" to FALSE.			
	1. Is the calling object a line "DEPARE"?	Note: for the safety contour (SC) to include the line DEPARE, it is required that $DRVAL1 \leq SC \leq DRVAL2$	Go to CONTINUATION A
Get the value of DRVAL1 and DRVAL2			
	2. Is the value of attribute DRVAL1 given?	Do nothing here.	Set DRVAL1 equal to 0.0 (low water line).
	3. Is the value of attribute DRVAL2 given?	Do nothing here.	Set DRVAL2 equal to DRVAL1.
	4. Is the value of DRVAL1 less than or equal to the value of the safety contour?	Go to condition 5	The following procedure selects the next deeper contour as the safety contour if that contour is separating safe and unsafe depth areas, or dredged areas. This is determined by the DRVAL1 attribute of the adjacent depth or dredged areas. Go to condition 6.
	5. Is the value of DRVAL2 greater than or equal to the value of the safety contour?	Indicate that the line is a safety contour by setting the local variable "SAFE" to TRUE.	Do nothing here.
6. For each occurrence of the object classes DEPARE and DRGARE which is adjacent to the line, carry out this loop:			
Get the value of the attribute DRVAL1	7. Is the value of the attribute DRVAL1 given?	Go to condition 8.	Indicate that the line is a safety contour by setting the local variable "SAFE" to TRUE. Go to condition 9
	8. Is the value of DRVAL1 less than the safety contour? ( $DRVAL < SC$ )	Indicate that the line is a safety contour by setting the local variable "SAFE" to TRUE. Go to condition	Get the next adjacent area of the object class DEPARE or DRGARE.
	9. Stop examining area objects. Exit loop.		
Go to CONTINUATION B -> Portrayal			

CONTINUATION A			
Statement	Condition	YES	NO
This object is a depth contour.			
Get the value of the attribute VALDCO	1. Is the value VALDCO given?	Do nothing here.	Set VALDCO equal to 0.0
	2. Does the value of VALDCO equal the value of the safety contour (VALDCO=SC)?	Indicate that the line is a safety contour by setting the local variable "SAFE" to TRUE.	The following procedure selects the next deeper contour as the safety contour if that contour is separating safe and unsafe depth areas, or dredged areas. This is determined by the DRVAL1 attribute of the adjacent depth or dredged areas. Go to condition 3.
	3. Is the value of VALDCO greater than the object safety contour (VALDCO>SC)?	Go to condition 4.	Do nothing here.
	4. For each occurrence of the object classes DEPARE and DRGARE which is adjacent to the line, carry out this loop:		
Get the value of attribute DRVAL1	5. Is the value of the attribute DRVAL1 given?	Go to condition 6.	Indicate that the line is a safety contour by setting the local variable "SAFE" to TRUE. Stop examining area object, exit loop.
	6. Is the value of DRVAL1 less than the safety contour (DRVAL1<SC)?	Indicate that the line is a safety contour by setting the local variable "SAFE" to TRUE. Stop examining area object, exit loop.	Get the next adjacent area of the object class DEPARE or DRGARE.
Return to main program.			

Remarks:

Currently the following depth contours are mandatory provided by the HOs: 0, 2, 5, 10, 20, 30, 40, 50, 100 and 200 m. In future the 15m line will also be included in S-101.

CONTINUATION B			
Statement	Condition	YES	NO
Set local variable "DEFAULT" to not applicable	1. Is the line object a safety contour?	Make sure that the contour is shown in all scales (attribute "SCAMIN" equals "INFINITE") Include this depth contour object in the DisplayBase Category (IMO PS App 2.1.2) Set OVERRADAR flag to ensure that contour is shown on top of radar. Set viewing group to "13010" Set display priority to "8".	Do nothing here. Go to condition 7.
	2. Is the calling object a DEPCNT?	Go to condition 3.	The calling object must be a line DEPCNT and will include the safety contour. Go to condition 7.
	3. Is the value of the attribute VALDCO > the value of the safety contour?	Go to condition 4.	The line object is the safety contour. Go to condition 7.
	4. Is the value of the safety contour <= 10m?	Go to condition 5.	Go to condition 6
	5. Is the quotient VALDCO/SC <= 1.67?	Set local variable "DEFAULT" = SMALL. Go to condition 7.	Set local variable "DEFAULT" = BIG Go to condition 7.
	6. Is the quotient VALDCO/SC <= 1.33?	Set local variable "DEFAULT" = SMALL Go to condition 7.	Set local variable "DEFAULT" = BIG Go to condition 7.
7. For each spatial component of the object, perform this loop:			
Get the spatial component			
Get the value of the attribute QUAPOS.	8. Is the value of the attribute QUAPOS given?	Go to condition 9.	Do nothing here, go to condition 11.
	9. Is the value of the attribute QUAPOS equal to 2,3,4,5,6,7,8 or 9 (not surveyed/precisely known/calculated)	Go to condition 10.	Do nothing here, go to condition 11.
	10. Is the line object a safety contour?	Symbolize the line object with a dashed line, 2 units wide, colour "DEPSC" "LS (DASH,2,DEPSC)". Go to condition 7.	Symbolize the line object with a dashed line, 1 unit wide, colour "DEPCN" "LS(DASH,1,DEPCN)". Go to condition 7.
	11. Is the line object a safety contour?	Yes, go to condition 12.	Set viewing group to "33020". Symbolize the line object with a solid line, 1 unit wide, color "DEPCN" "LS(SOLD,1,DEPCN)".
	12. Does the value of the local variable DEFAULT = BIG?	Symbolize the line objects with a solid line, 5 units wide, colour "CHGRF" and solid line, 1 unit wide and solid line, 1	Symbolize the line object with a solid line, 2 units wide, color "DEPSC" "LS(SOLD,2,DEPSC)".

		unit wide, colour "DEPSC" "LS(SOLD,5,CHGRF); LS(SOLD,1,DEPSC)".	
Symbolization is finished, exit procedure.			

Remarks:

The safety contour, which separates safe water from unsafe water, is probably the most important feature on the ECDIS display. This procedure examines all objects of the class DEPCNT and DEPARE (line) and highlights any depth contour that matches the safety contour depth value entered by the mariner. Any DEPARE (line) that contains that value is also highlighted. But while the mariner is free to enter any safety contour depth contour value that he thinks is suitable for the safety of his ship, the SENC only contains a limited choice of depth contours. If the depth value entered by the mariner is not found in a given area, then the contours or line depth areas that separate safe from unsafe water are symbolized as safety contours. That is to say that where there is no matching contour, the next deeper contour is selected as a default safety contour by examining the contours bounding the depth areas. If the difference between the value entered by the mariner and the default value actually selected is large, the default safety contour is symbolized the same way as a normal contour. If the difference is small, the default safety contour is symbolized by a broader line of equal prominence. The criteria for a "small" or a "large" difference are given in the conditional procedure. If the underlying survey reliability is not optimal, the safety contour line is drawn as a dashed line, indicating to take caution interpreting this line as a decision tool. The attribute QUAPOS is optional and if not available, the line is drawn as a solid line giving a false sense of quality.

Outcome of the conditional procedure between value of depth contour and safety contour:

Value depth contour	Broad line if value safety depth >	Depth difference entered safety depth and displayed safety contour.
2 m	1.2 m	0.8 m
5 m	3 m	2 m
10 m	6 m	4 m
20 m	15 m	5 m
30 m	23 m	7 m
40 m	30 m	10 m
50 m	38 m	12 m
100 m	75 m	25 m
200 m	150 m	150 m

Harmonizing the quality of bathymetric data values from HOs, presentation of quality of bathymetric data in current S-52 and S-57 structure and conditional symbology procedure (current in S-52) are explained by two images in summary:

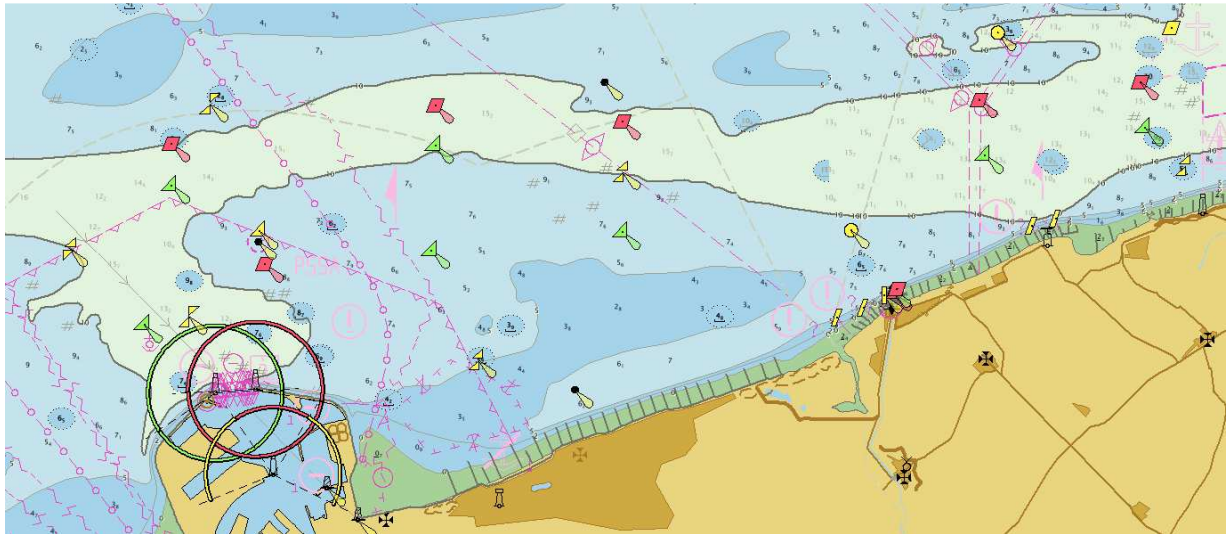


Figure 1: "normal" view with safety contour = 10m.

Figure 1 shows an area from two adjacent countries. The image is built up with 4 depth shades, safety contour = 10m, safety sounding = 10m, shallow water = 5m and deep water = 30m. The depth areas in this region are -2 to 0m, 0 to 2m, 2 to 5m, 5 to 10m and 10 to 20m. The safety contour is drawn as a thick line because the value of the safety depth is exactly the same as the nearest available depth contour. The port in the south west has a navigation leading line of 136 degrees. The compilation scale of the chart is 90.000. The chart is displayed at scale 108.000.

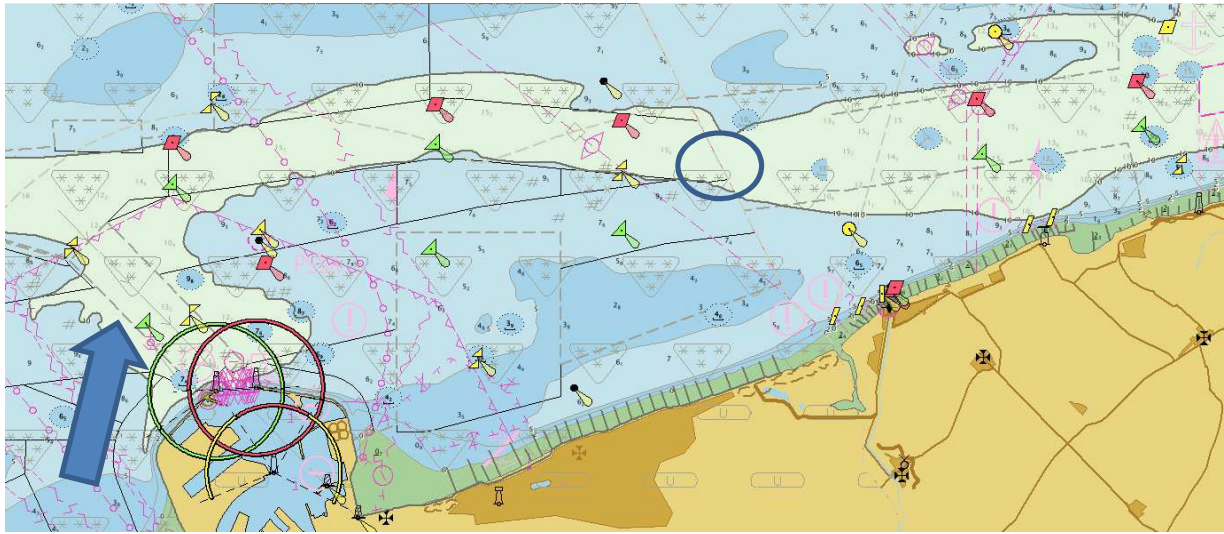


Figure 2: same view with Meta objects shown.

Figure 2 shows the same view but now with Meta Objects on. The object M\_QUAL (an area within which a uniform assessment of the quality of the data exist) with attribute CATZOC (category of zone of confidence in data) is shown in grey with a triangle symbol facing down and star symbols (three crossing lines) inside. The number of stars inside each triangle represents the confidence level.

- 6 stars means zone of confidence A1
- 5 stars means zone of confidence A2
- 4 stars means zone of confidence B
- 3 stars means zone of confidence C
- 2 stars means zone of confidence D
- U means data not assessed.

The blue circle in the center indicates the maritime boundary between the two countries. The blue arrow indicator one boundary of an M\_QUAL area, displayed as a dashed grey line. Regardless of the attribute values of CATZOC, this line is always drawn the same way.

When inspecting the CATZOC values very carefully, the following items are worth noting:

- 1) the western country has 7 different M\_QUAL objects in this view, but that is not apparent by the way the M\_QUAL objects are displayed.
- 2) the route to the port has CATZOC=B, whereas the deeper water to the port has CATZOC=A1.
- 3) the M\_QUAL value at the port is not quite clear from this view but is set to Unassessed. The port has a dock area and not a depth area.
- 4) the route deeper than 10m has CATZOC=A1 in the western country and CATZOC=A2 in the eastern country.
- 5) not visible but present, the western country has entered values for the object \_M\_SREL (an area within which a uniform assessment of the reliability of source survey information exists), thus enabling the mechanism to draw the safety contour as a dashed line when the appropriate attribute values are present. The eastern country does not use M\_SREL.



From these two images the following conclusions can be drawn:

- 1) the symbology of M\_QUAL fails in a sense that it is very difficult to relate the symbol to a certain area. The boundaries of the areas are unclear. The value of CATZOC is also unclear, only by zooming in and counting, it becomes clear what is meant.
- 2) there is no harmonised encoding of CATZOC across a maritime boundary of two adjacent ENC datasets, when using the same transportation route.
- 3) the entry to the port has a lower quality than its nearby waters.
- 4) it is not directly apparent that the M\_QUAL at the port has a value of Unassessed.
- 5) M\_SREL should not be used as input for a conditional symbology procedure, M\_QUAL value CATZOC is mandatory and should be used as input.

#### 4. Lessons learned

From the current practise of computing the nearest safety contour and the way it is symbolized we learn that the thickness of the line is an indication of importance. The smaller the difference between the allowable depth for the vessel and the depth value of the contour line, the thicker the line gets. Another lesson is that if unreliable data is used as a basis for computing the safety contour, the line changes appearance from solid to dashed.

For the symbology of area objects there are four different options present of which the staggered method is the one not to be used. The other ones are:

- 1) with an opaque colour fill (e.g. depth areas);
- 2) with a transparent colour fill (e.g. traffic separation zone);
- 3) with a symbol or text located on a position inside the area (e.g. traffic arrow).

For future developments it would be good to have the M\_QUAL object and Quality of Bathymetric Data attribute to be displayed as an area from one of the three options above.

Display priority is now set to a fixed level of 4. By using the conditional symbology procedure, it would be good to investigate if quality of information can be displayed at a higher priority as it becomes more important to the end user.

At present the depth contour value is calculated and displayed regardless of underlying quality of bathymetric data. At best the M\_SREL is used to change appearance. One way of using conditional priority is to highlight a nearby deeper contour if the safety contour selected is based on poor quality. The table below explains this procedure:

	M_QUAL value					
Value depth contour	1	2	3	4	5	U
2 m	2m	2m	5m	5m	5m	avoid
5 m	5m	5m	10m	20m	30m	avoid
10 m	10m	10m	20m	20m	30m	avoid
20 m	20m	20m	30m	40m	50m	avoid
30 m	30m	30m	40m	50m	50m	avoid
40 m	40m	40m	50m	100m	100m	avoid
50 m	50m	50m	100m	100m	100m	avoid
100 m	100m	100m	100m	100m	100m	avoid
200 m	200m	200m	200m	200m	200m	avoid

Table 2: value depth contour combined with M\_QUAL value.

For the mariner, the now standard practise of drawing a safety contour remains. If however the vessel approaches the safety contour and the underlying M\_QUAL of the depth area has a quality of 3 or less, a another depth contour line is changing appearance (becomes thick, higher display priority), to warn the mariner he is approaching a safety contour with less than required quality and to take caution. This will allow the mariner enough time to reconsider entering the area near the safety contour. This is an early warning system.

Another complete different approach is to create a ship centered symbol. This symbol has display priority = 9 as a default value, but the value decreases (higher priority) and the symbol becomes more visible if conditions are met that are a hazard to safe navigation appears. This mechanism should include existing objects (depth areas, depth contours) but may include other objects (areas or single objects) that are hazardous for navigation and should be avoided by the mariner. The list of objects can be a mandatory short list with user input to add to the equation. The benefit is that under normal conditions this symbology will not interfere with other items of more importance to the mariner being displayed on the screen.

### **Conclusions**

The new datamodel in S-101 gives more and better options for HOs to meet the requirements of IHO CL50/2017. The present conditional symbology procedure has already some very good computations and presentation procedures. The current staggered display of quality of bathymetric data should not be used in the future and be replaced by any of the three remaining methods to display an area. Priority of display can also be made a conditional statement, causing the information to appear on top as it becomes more important for safety of navigation. A ship-centre symbology is another option to be investigated.

### **Recommendations**

- More depth contour lines provided by the HO at smaller interval will provide more flexibility for the end user to have a depth contour line highlighted as a safety contour close to the user entered value;
- The current staggered pattern symbology of CATZOC should not be used in S-101;
- Decide how to display an area of Quality of Bathymetric Data;
- Default starting values for conditional symbology have to be agreed upon and implemented;
- Objects and attributes designed for conditional symbology have to be mandatory fields in S-101 and other S-1xx;
- Harmonised encoding of CATZOC (Quality of Bathymetric Data in S-101) for shipping routes crossing maritime boundaries;
- Make display priority part of the conditional symbology, high risk to navigation means high priority portrayal.
- Consider the benefits of a screen wide symbology (as present) against a ship centered symbology or a combination of both.

### **Justification and Impacts**

Present unknown, depending on outcome of discussion.

### **Action Required of Data Quality Working Group**

The DQWG is invited to:

- a. note this paper;
- b. provide feedback;
- c. propose items for conditional symbology;
- d. propose symbology ideas.

## Annex – I      Quality of bathymetric data (S-57)

The meta object M\_QUAL defines areas within which uniform assessment exists for the quality of bathymetric data, and must be used to provide an assessment of the overall quality of bathymetric data to the mariner. Areas of a cell containing depth data or bathymetry must be covered by one or more M\_QUAL, which must not overlap.

Meta object:      Quality of data (M\_QUAL) (A)  
Attributes:      CATQUA      CATZOC      DRVAL1  
                    DRVAL2 - the maximum depth to which the quality information applies.  
                    POSACC      SOUACC      SURSTA      SUREND      TECSOU  
                    VERDAT      INFORMNINFOM

### Remarks:

- Wherever possible, meaningful and useful values of CATZOC should be used (that is, values other than CATZOC = 6 (data not assessed)) for areas of bathymetry. For areas of unstable seafloors, the attribute SUREND may be used to indicate the date of the survey of the underlying bathymetric data.
- A CATZOC category indicates that the depths encoded within a M\_QUAL area meet the minimum criteria described in the CATZOC definition table. A CATZOC category may be further sub-divided by specifying depth and positional accuracy, and sounding technique, using the attributes POSACC, SOUACC and TECSOU, within separate M\_QUAL areas.
- DRVAL1 must not be used on a M\_QUAL object, unless a swept area occupies the entire M\_QUAL area (see clause 5.6).
- DRVAL2 must not be used on a M\_QUAL object, except to specify the maximum depth to which the CATZOC category applies. When DRVAL2 is specified, the CATZOC category applies only to depths equal to or shallower than DRVAL2. No quality information is provided for depths deeper than DRVAL2.
- POSACC must not be used on a M\_QUAL object, except to specify a higher positional accuracy of the depths than the CATZOC category indicates. When DRVAL1 is specified, POSACC must not be used - there is no positional accuracy information provided for any underlying depths in this circumstance.
- SOUACC must not be used on a M\_QUAL object, except to specify a higher accuracy of the depths than the CATZOC category indicates. When DRVAL1 is specified, SOUACC refers only to the accuracy of the swept depth defined by DRVAL1 - there is no depth accuracy information provided for any underlying depths in this circumstance.
- TECSOU must not be used on a M\_QUAL object to specify a lower quality than the CATZOC category indicates.
- When the M\_QUAL area contains soundings from multiple surveys of different techniques, the attribute TECSOU must not be used. TECSOU may be populated with multiple values only where the M\_QUAL area is covered by a survey or surveys that have used multiple common techniques, for example an area covered by multiple surveys all using a modern echosounder combined with a sonar or mechanical sweep system.
- When the M\_QUAL area contains data from only one survey, the date of survey, if required, must be specified using the attribute SUREND. When the M\_QUAL area contains data from two or more surveys, the date of the oldest survey, if required, must be specified using the attribute SURSTA, and the date of the most recent survey, if required, must be specified using SUREND.
- Additional quality information may be given using the meta object M\_SREL.
- Where M\_QUAL areas are encoded over land, CATZOC should be set to 6 (unassessed).
- M\_QUAL may either be encoded over wet areas only, or alternatively a single M\_QUAL object may be created for the whole cell over wet and dry areas, but see 1st bullet point above.
- When M\_QUAL and the meta object M\_ACCY are encoded in a cell, they should not overlap.

- When both M\_QUAL and M\_ACCY objects are used in a cell, the area covered by these objects should equal the area of data coverage for the cell.
- POSACC on the M\_QUAL applies to bathymetric data situated within the area, while QUAPOS or POSACC on the associated spatial objects qualifies the location of the M\_QUAL object itself.
- As a result of some disasters, for example earthquakes, tsunamis, hurricanes, it is possible that large areas of seafloor have moved and/or become cluttered with dangerous obstructions. Emergency surveys may subsequently be conducted over essential shipping routes and inside harbours. Outside these surveys, all existing detail is now suspect, whatever the quality of the previous surveys. In such cases, the CATZOC value should be reclassified to value 5 (zone of confidence D) in the affected areas outside the area covered by emergency surveys.

**Annex II Zone of Confidence Table**

Value	ZOC <sup>1</sup>	Position accuracy <sup>2</sup>	Depth accuracy <sup>3</sup>	Seafloor coverage	Typical Survey Characteristics <sup>5</sup>
1	A1	± 5m + 5% depth	0.5m + 1% depth	Full area search undertaken. Significant seafloor features detected <sup>4</sup> and depths measured.	Controlled, systematic Survey <sup>6</sup> high position and depth accuracy achieved using DGPS or a minimum three high quality lines of position (LOP) and a multibeam, channel or mechanical sweep system.
2	A2	± 20m	1.0m + 2% depth	Full area search undertaken. Significant seafloor features detected <sup>4</sup> and depths measured	Controlled, systematic survey <sup>6</sup> achieving position and depth accuracy less than ZOC A1 and using a modern survey echosounder <sup>7</sup> and a sonar or mechanical sweep system.
3	B	± 50m	1.0m + 2% depth	Full area search not achieved; uncharted features, hazardous to surface navigation are not expected but may exist.	Controlled, systematic survey achieving similar depth but lesser position accuracies than ZOCA2, using a modern survey echosounder <sup>7</sup> , but no sonar or mechanical sweep system.
4	C	± 500m	2.0m + 5% depth	Full area search not achieved, depth anomalies may be expected.	Low accuracy survey or data collected on an opportunity basis such as soundings on passage.
5	D	> ZOC C	> ZOC C	Full area search not achieved, large depth anomalies may be expected.	Poor quality data or data that cannot be quality assessed due to lack of information.
6	U	Unassessed – the quality of the bathymetric data has yet to be assessed.			

Remarks:

To decide on a ZOC Category, all conditions outlined in columns 2 to 4 of the table must be met.

Explanatory notes quoted in the table:

1: The allocation of a ZOC indicates that particular data meets minimum criteria for position and depth accuracy and seafloor coverage defined in this Table. ZOC categories reflect a charting standard and not just a hydrographic survey standard. Depth and position accuracies specified for each ZOC category refer to the errors of the final depicted soundings and include not only survey errors but also other errors introduced in the chart production process. Data may be further qualified by Object Class 'Quality of Data' (M\_QUAL) sub-attributes as follows:

- a) Positional Accuracy (POSACC) and Sounding Accuracy (SOUACC) may be used to indicate that a higher position or depth accuracy has been achieved than defined in this Table (e.g. a survey where full seafloor coverage was not achieved could not be classified higher than ZOC B; however, if the position accuracy was, for instance,  $\pm 15$  metres, the sub-attribute POSACC could be used to indicate this).
- b) Swept areas where the clearance depth is accurately known but the actual seabed depth is not accurately known may be accorded a 'higher' ZOC (i.e. A1 or A2) providing positional and depth accuracies of the swept depth meets the criteria in this Table. In this instance, Depth Range Value 1 (DRVAL1) may be used to specify the swept depth. The position accuracy criteria apply to the boundaries of swept areas.
- c) SURSTA, SUREND and TECSOU may be used to indicate the start and end dates of the survey and the technique of sounding measurement.

2: Position Accuracy of depicted soundings at 95% CI (2.45 sigma) with respect to the given datum. It is the cumulative error and includes survey, transformation and digitizing errors etc. Position accuracy need not be rigorously computed for ZOCs B, C and D but may be estimated based on type of equipment, calibration regime, historical accuracy etc.

3: Depth accuracy of depicted soundings =  $a + (b*d)/100$  at 95% CI (2.00 sigma), where d = depth in metres at the critical depth. Depth accuracy need not be rigorously computed for ZOCs B, C and D but may be estimated based on type of equipment, calibration regime, historical accuracy etc.

4: Significant seafloor features are defined as those rising above depicted depths by more than:

	Depth	Significant feature
a	< 40 m	2 m
b	> 40 m	10% depth

A full seafloor search indicates that a systematic survey was conducted using detection systems, depth measurement systems, procedures, and trained personnel designed to detect and measure depths on significant seafloor features. Significant features are included on the chart as scale allows. It is impossible to guarantee that no significant feature could remain undetected, and significant features may have become present in the area since the time of the survey.

5: Typical Survey Characteristics - These descriptions should be seen as indicative examples only.

6: Controlled, systematic surveys (ZOC A1, A2 and B) - surveys comprising planned survey lines, on a geodetic datum that can be transformed to WGS 84.

7: Modern survey echosounder - a high precision single beam depth measuring equipment, generally including all survey echosounders designed post 1970."

**Data assessment:** IHO Definition: The categorisation of the assessment level of bathymetric data for an area.

1) **Assessed**

IHO Definition: The quality of the bathymetric data has been assessed.

2) **Assessed (Oceanic)**

IHO Definition: The quality of oceanic bathymetric data (depths deeper than 200 metres) has been assessed, however details are not required.

3) **Unassessed**

IHO Definition: The quality of the bathymetric data has yet to be assessed.

Remarks:

- No remarks.

Category of Temporal Variation:

All allowable values (note definitions that have been added/amended from the current version of the DCEG):

**Category of temporal variation:** IHO Definition: An assessment of the likelihood of change over time.

1) **Extreme event**

IHO Definition: Indication of the possible impact of a significant event (for example hurricane, earthquake, volcanic eruption, landslide, etc.), which is considered likely to have changed the seafloor or landscape significantly.

2) **Likely to change and significant shoaling expected**

IHO Definition: Continuous or frequent change (for example river siltation, sand waves, seasonal storms, ice bergs, etc.) that is likely to result in new significant shoaling.

3) **Likely to change but significant shoaling not expected**

IHO Definition: Continuous or frequent change (for example sand wave shift, seasonal storms, ice bergs, etc.) that is not likely to result in new significant shoaling.

4) **Likely to change**

IHO Definition: Continuous or frequent change to non-bathymetric features (for example river siltation, glacier creep/recession, sand dunes, buoys, marine farms, etc.).

5) **Unlikely to change**

IHO Definition: Significant change to the seafloor is not expected.

6) **Unassessed**

IHO Definition: Temporal variation not assessed or cannot be determined.

Remarks:

- No remarks.



Restricted enumerate list for Quality of Bathymetric Data:

<b>S-101 Attribute</b>	<b>S-57 Acronym</b>	<b>Allowable Encoding Value</b>	<b>Type</b>	<b>Multiplicity</b>
Category of temporal variation		1 : extreme event 2 : likely to change and significant shoaling expected 3 : likely to change but significant shoaling not expected 5 : unlikely to change 6 : unassessed	EN	1,1

Restricted enumerate list for Quality of Non-Bathymetric Data:

<b>S-101 Attribute</b>	<b>S-57 Acronym</b>	<b>Allowable Encoding Value</b>	<b>Type</b>	<b>Multiplicity</b>
Category of temporal variation		1 : extreme event 4 : likely to change	EN	0,1