**Guidance for Encoding and Charting Meaningful Bathymetric Data Quality Information in S-101 ENCs**

Data Quality Working Group

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This guidance document has been developed by the Data Quality Working Group (DQWG) under the authority of the Terms of Reference (TOR) that was agreed upon by the Hydrographic Services and Standards Committee (HSSC) at the 9th meeting in Ottawa, Canada. Within the TOR item number iv in section 3 (Procedures), part b states: *Provide guidance on data quality aspects to hydrographic offices, in particular to ensure harmonized implementation.*

Since the approval of this work item in the TOR the working group has been collecting best practices from member states on the charting and encoding of data quality. Based on those best practices this guidance document has been developed. This guidance document will focus on data quality for bathymetric data in S-101 ENCs. Specifically how to encode and chart the **Quality of Bathymetric Data** object. While this document focuses on future ENCs based on the S-101 product specification there will be relevant information for current ENCs base in S-57. This is due to the understanding that S-101 ENCs will initially be derived from converting S-57 ENCs via a converted that was developed by the S-100 working group. Parts of this document can be applied to S-57 ENCs before they are converted in order to derive quality S-101 ENCs. Examples of this guidance that applies to current ENCs are minimum size of polygons, aggregation of data and quality changes due to temporal variation.

1. **Introduction**

The feature types in S-101 ENCs that capture data quality for depth information are **Quality of Bathymetric Data** and **Quality of Survey**. **Quality of Bathymetric Data** is the object that will be used to express data quality for depth information. **Quality of Survey** will be used in conjunction with **Quality of Bathymetric Data** and is used to express more information about the individual surveys that make up the depth information in a given geographic area. Guidance for the encoding and charting of **Quality of Survey** will not be discussed in this document. **Quality of Bathymetric Data** is mandatory for areas with depth information while **Quality of Survey** is optional. Both objects cannot overlay **Land Area**. The only occasion where **Quality of Bathymetric Data** is optional over non-**Land Areas** is over an **Unsurveyed Area** when no depth information is present. An example of this is and **Unsurveyed Area** with no **Sounding**, **Obstruction** or other feature objects that contain an attribute with a depth value (**value of sounding**, **depth range minimum value**, **value of depth contour** and so on).

Show a graphics of above

The charting of **Quality of Bathymetric Data** is not required on S-101 datasets that have a maximum display scale 1:700000 and larger (Data Classification and Encoding Guide 3.7.1 para 4). Although the recommendation of the Data Quality Working Group is that all ENCs have assessed **Quality of Bathymetric Data** objects on all depth areasat all scales. The use of the attribute value 2 - assessed (oceanic) in the attribute **data assessment** will make this considerably less of a burden for hydrographic offices (see S-101 encode guidance below).

The meta object **Quality of Non-Bathymetric Data** will not be discussed in the document. Please see the S-101 Annex A, Data Classification and Encoding Guide (DCEG) for guidance on how to chart and encode **Quality of Non-Bathymetric Data.**

When converting S-57 ENCs to S-101 ENCS the object **M\_Qual** and will be converted into the **Quality of Bathymetric Data** object in S-101. The object **M\_SREL** with by converted to **Quality of Survey**.

1. **Assessment**

The term ‘assessed data’ refers to an **M\_QUAL** objects with a value of 1 through 5 for the **CATZOC** attribute in S-57. The term ‘unassessed data’ in S-57 refers to an **M\_QUAL**s object with a **CATZOC** attribute value of 6. For S-101 the term ‘assessed data’ refers to a **Quality of Bathymetric Data objects** with the attribute **data assessment** encoded with a value of 1 (Assessed) or 2 (Oceanic) and when value 1 is used all other appropriate attributes are encoded (see S-101 encode guidance below).

While both the **CATZOC** attribute for M\_QUAL in S-57 and the **data assessment** attribute for the **Quality of Bathymetric Data** in S-101 have values of unassessed it is not recommended that these values be used when there is depth information present and the area is the largest charted scale. For reasons of convenience unassessed is allowed on objects that cover land areas in S-57. Also for both S-57 and S-101 unassessed is allowed when either an **M\_QUAL** objects or **Quality of Bathymetric Data** object cover an unsurveyed areawhere there is no depth information in its entirety.

Show a graphics of above QoBD over unsurveyed area.

A meaningful assessment of data quality objects in both S-57 and S-101 is highly recommended. ENC with assessed quality information make the ENC considerably more useful. This usefulness typically surpasses that of a paper chart with a source diagram or ZOC diagram given that these diagrams are typically one tenth the size of the chart.

* Assessment of data in S-57

Please keep in mind that this assessment will drive the attribution in S-101 when S-57 ENC data sets are converted to S-101 data sets. For that reason that the following recommendations are made for S-57 data sets.

Assessment of data in S-57 data is to follow current rules set in Appendix A - Chapter 2 Attribute Catalogue ([CATZOC](https://www.iho.int/iho_pubs/standard/S-57Ed3.1/31ApAch2.pdf#page=112)). Assigning of an attribute value should follow the rules in the ZOC table and in the remarks section of the CATZOC attribute section. Charting principles and rules for degradation of CATZOC value will be found in Appendix B.1 Annex A - Use of the Object Catalogue for ENC section [2.2.3.1 Quality of bathymetric data](https://www.iho.int/iho_pubs/standard/S-57Ed3.1/S-57%20Appendix%20B.1%20Annex%20A%20UOC%20Edition%204.1.0_Jan18_EN.pdf#page=19).

As mentioned previously in this document, the use of unassessed on M\_QUAL objects is allowed when the M\_QUAL object overlaps with land. The DQWG recommends that simply not charting an M\_QUAL object over land would make a less redundant ENC.

Not charting M\_QUAL over unsurveyed objects that have no death information in the entirety of the object is also recommended. For example an unsurveyed area with no soundings, underwater rocks, or depth Contours. This recommendation is the result of the [S-58 check 550](https://www.iho.int/iho_pubs/standard/S-58/S-58_ENC_Validation_Checks_e5.0.0_Jun14_EN.pdf#page=30).

The reasons of efficiency the unassessed attribute for CATZOC may also be used on M\_QUAL object on small-scale ENCs that have larger scale coverage available in the same geographic area. This is not recommended on any ENC with at usage band of 6 through 4. A statement should be placed in the attribute INFORM telling the Mariner that larger scale coverage with data assessment is available. It is also the recommendation of the DQWG that generalization (aggregation) of CATZOC values and M\_QUAL geometries is used vertically at a minimum from usage band for 6 to 4. Vertical integration through generalization of CATZOC values and M\_QUAL geometries through all usage bands is preferred and is highly beneficial to Mariners during route planning.

* Assessment of data in S-101

The attribute data assessment is mandatory and can only have one of the following allowable attribute values: 1) Assessed, 2) Oceanic, 3) Unassessed. Just like the guidance for S-57 Unassessed should not be used over areas with bathymetry. Oceanic can only be used in the depths deeper than 200 metres but is not required. It is up to the hydrographic office to decide whether or not the attribute Oceanic in these deeper waters. The purpose of the Oceanic attribute is to give hydrographic offices the option of encoding areas of deep open ocean with an attribute other than assessed. This would allow such areas to be displayed differently and present no warnings for low quality surveys that typically cover such areas. These low quality surveys are typically very appropriate for the depth of water.

*Note: Attribution of the Quality Bathymetric Data object when data assessment is populated with Oceanic needs to be discussed by the data quality working group. Particularly which attributes (if any) are mandatory when Oceanic is populated. This could result in a large change in the DCEG, making almost every attribute conditionally mandatory based on the attribute data assessment.*

1. **Encoding of attributes with assessed data.**

* Encoding in S-57

In S-57 the only required attribute in the metadata object M\_Qual is CATZOC. CATZOC attribute values are composites being made up of all the different components that make the quality in a hydrographic survey once it is charted. For example horizontal accuracy, bottom coverage and feature detection. Refer to the Use of the Object Catalogue for ENC section [2.2.3.1 Quality of bathymetric data](https://www.iho.int/iho_pubs/standard/S-57Ed3.1/S-57%20Appendix%20B.1%20Annex%20A%20UOC%20Edition%204.1.0_Jan18_EN.pdf#page=19) for proper encoding of other non-mandatory attributes. For example the proper use of DRVAL1 And SOUACC.

* Encoding in S-101

In S-101 the components of charted hydrographic surveys are now individual attributes that composite together to make 5 quality levels. These 5 quality levels are the bases for the display in future S-101 ECDIS systems. At this time the display and symbols of the categories has not been completed. Level 1 being the highest level of data quality and level 5 being the lowest.

Attribution should be considered and encoded in 7 different stages in the following priority:

1. Data assessment

2. Category of temporal variation

3. Full seafloor coverage achieved / significant features detected

4. Least depth of detected features measured

5. Vertical uncertainty

6. Horizontal position uncertainty

7. Survey date range.

**Mandatory Quality of Bathymetric Data attributes**:

* **data assessment** - A mandatory attribute with the values of 1: assessed, 2: assessed (oceanic) and 3: unassessed. This should be the first attribute considered when charting a **quality of bathymetric data** object. It is not recommended that unassessed be used except where a quality bathymetric data object is covering a land area object. As stated above value 2: **assessed (ceanic)** can only be used in water deeper than 200 metres. In all the other cases with charted bathymetry value 1: **assessed** should be used, including if the hydrographic office wishes to in water deeper than 200 metres.
* **category of temporal variation** - A mandatory attribute used to assess the level of change in the bathymetry that will affect surface navigation.

Values:

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

Whenever possible, meaningful and useful values for this attribute must be used for areas of bathymetry. When making the transition from S-57 to S-101, the default value of this attribute = 5: **unlikely to change**. After an extreme event (for example earthquakes, tsunamis, hurricanes) has taken place and the charted area has not yet been resurveyed the value should be set to 1: **extreme event** and the Quality Level drops to 5. In case the seafloor is likely to change and significant shoaling expected before a re-survey is performed and published, the **category of temporal variation** value should be set to 2: **likely to change and significant shoaling expected**; resulting in QoBD value = 5. Set the value to 3: **likely to change but significant shoaling not expected** when there is a mobile seafloor but the changing seafloor does not affect the depths given on the resulting chart. For example an area of sand waves that are constantly moving but never rise above the charted shoal depths. Use the value 5: **unlikely to change** when it is known that the seafloor is unlikely to change over a significant amount of time. This value can also be used in a changeable area when the area is surveying and recharting frequency allows the chart to accurately represent the seafloor. Whenever possible avoid the use of value 6 : **unassessed.**

* **full seafloor coverage achieved** - A mandatory attribute, with a data type of boolean. So the only value are 1: true or 2: false. Full seafloor coverage was achieved for the area if this attribute is set to 1 or true.
* **features detected** - A mandatory complex attribute with three sub attributes. Two of which are mandatory, **least depth of detected features measured** and **significant features detected** are mandatory. **Size of features detected** is the third sub attribute and it is optional.
  + **least depth of detected features** - An attribute that states whether or not the survey(s) that resulted in the charted bathymetry had the ability to detect the least depth for detected features. Furthermore the least depths was used for the depth values of these features.
  + **significant features detected** - An attribute that states whether or not significant features were detected by the survey(s) for the charted bathymetry in the area covered by the object.
  + **size of features detected**- As stated above this is an attribute that is optional but can be used to state the size of features detected in cubic metres.
* **horizontal position uncertainty**
* **vertical uncertainty**

**Optional Quality of Bathymetric Data attributes**:

* **depth range maximum value**
* **depth range minimum valu**e

The below table will help better understand which attributes and their values will result in which level of quality bathymetric data. (QoBD = Quality of Bathymetric Data)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| QoBD value | data assessment | Category of temporal variation | full seafloor coverage,  features detected | least depth of detected features measured | vertical uncertainty | horizontal position uncertainty |
| 1 | 1: assessed | 5: unlikely to change | YES | YES | 0.50 (fixed)  0.01 (variable) | 5.00 (fixed)  0.05 (variable) |
|  |  |  |  |  |  |
| 2 | 1: assessed | 3: likely to change but significant shoaling not expected.  5: unlikely to change | YES | YES | 1.00 (fixed)  0.02 (variable) | 20.0 (fixed) |
|  |  |  |  |  |  |
| 3 | 1: assessed | 3: likely to change but significant shoaling not expected. | NO | NO | 1.00 (fixed)  0.02 (variable) | 50.0 (fixed) |
|  | 5: unlikely to change |  |  |  |  |
| 4 | 1: assessed | 3: likely to change but significant shoaling not expected. | NO | NO | 2.00 (fixed)  0.05 (variable) | 500.0 (fixed) |
|  | 5: unlikely to change |  |  |  |  |
| 5 | 1: assessed | 1: extreme event  2: likely to change and significant shoaling expected  3: likely to change but significant shoaling not expected.  5: unlikely to change | NO | NO | greater than  2.00 (fixed)  0.05 (variable) | greater than  500.0 (fixed) |
| O | 2: assessed (oceanic) | VOID | VOID | VOID | VOID | VOID |
| U | 3: unassessed | 6: unassessed | NO | NO | Not available | Not available |

After an extreme event (for example earthquakes, tsunamis, hurricanes) has taken place and the charted area has not yet been resurveyed, the Quality Level drops to 5.

1. **Stacking of Data Quality Objects.**

Overlapping of **Quality of Bathymetric** Data objects is allowed. This would be done when there are different bathymetric quality needs to be at the same point but at different depths. The most common example of this is when a chart depicts a swepth area.

Show a graphics

See S-101 Annex A (Data Classification and Encoding Guide) section 3.7.1 **Quality of bathymetric data** paragraph 7 for more information.

1. **Minimum Size**

**Quality of Bathymetric Data** objects should not be charted in a size that is too small for properly display with the future symbolization. When the symbolization is developed guidance will be added to this document.

*Add minimum size for S-57 here. From the minutes: When two CATZOC areas become too small, the lesser value of the two should be used when the areas merge. The minimum size of a CATZOC area should be the same minimal size of any DEPARE that can be visualized in a chart on screen at the compilation scale. This will allow the visualization of CATZOC to, for example, a narrow approach channel to a port at the compilation scale. (Example: approach Houston port is 122m wide, compilation scale 1:25.000, symbol size 4.88 mm).*

1. **Aggregation**

The Meta feature Quality of Bathymetric Data defines areas within which uniform assessment exists for the quality of bathymetric data, and is used to provide an assessment of the overall quality of bathymetric data to the mariner. Areas of a dataset at maximum display scale 1:700000 and larger containing depth data or bathymetry must be covered by one or more Quality of Bathymetric Data features, which may overlap vertically. At maximum display scales smaller than 1:700000, Quality of Bathymetric Data features must be encoded where no larger maximum display scale ENC data is available.

*From the minutes: Generalization (aggregation) of adjacent CATZOC areas from a large-scale chart to a small-scale chart was discussed. One member noted that in paper charts the source data diagram is usually 1/10th of the scale of the complete chart. Mariners tend to over zoom when using the ENC. In an ENC, the size of a CATZOC area can be a lot smaller. Its current symbol is 17 mm wide, being too large to visualize small important areas with a higher CATZOC value, for example the final approach to a port. It was agreed that in general, CATZOC values should be assigned to the chart at the largest scale and smaller scale charts should inherit these values.*