

Paper for consideration by DQWG**Proposal to improve alignment between S-44 and the existing S-57 Zones Of Confidence system**

Submitted by: Australia

Executive Summary: This paper identifies the need for reviewing the alignment between the S-44 Orders and S-57 ZOC Categories (where they overlap), as well as the scope of that review.

In developing a related paper on guidance for hydrographic offices on categorising data into a ZOC category, it was noted that there are some significant inconsistencies between survey and charting standards, even in circumstances where they clearly overlap, that contribute to confusion for both mariners and cartographers when attempting to determine the reliability of information within ports and similar waterways, as well as in adequately surveyed coastal waters.

The danger is that, within ports, ignoring the charted ZOC assessment in favour of advice from the Harbour Master becomes a learned response to ignore the ZOC assessment within well charted ports, but which is then extrapolated to ignoring the ZOC assessments elsewhere. In coastal waters, the mismatch between survey and charting standards contributes to confusion when hydrographic offices assess the data.

Related Documents: Draft publication S-67 “Mariners’ Guide To Accuracy And Reliability Of Electronic Navigational Charts (ENC)”.

Related Projects: DQWG Work Plan 2016-17, Task C: Maintain and extend as needed existing quality indicators in S-57 “IHO Transfer Standard for Digital Hydrographic Data”, including the education of both the mariner and the cartographer, and the development of documentation (IHO Task 2.5.2)

Background

At DQWG10 it was noted during the development of the hierarchical model for bathymetric data quality that the thresholds between one level and another may wish to be revised. Brief discussion agreed that finalising the model was of greater priority, so the various horizontal and vertical uncertainty thresholds were left as specified for the current ZOC categories, while achievement of seafloor coverage was largely a binary yes or no assessment, without considering the size features being detected.

However, a fundamental issue remains unresolved - the IHO has two separate standards for defining the quality of bathymetric data – one for when it is received within the office, and another when the same data is published in a product.

While this may have been justifiable when the majority of compilation, datum adjustment and generalisation from survey to chart was done manually, and there was only very limited use of data for purposes other than charting, circumstances and processes have changed significantly since S-57 was first developed in the early 1990s.

This paper identifies the need for reviewing the alignment between the S-44 Orders and S-57 ZOC Categories (where they overlap), as well as the scope of that review. The opportunity to revisit the ZOC Categories as part of this review is only likely to be a practical proposition if the changes are made as part of the proposed shift from Category of Zone Of Confidence (CATZOC) in S-57-based ENC, to Category of Bathymetric Data Quality (CATBDQ) in S-101-based ENC. This is an opportunity unlikely to arise again in the foreseeable future.

However, it is also recognised that the charting standard will always need to cater for legacy historic data – while no survey standard should specify conducting an inadequate survey, there must still be some means of indicating that a chart contains data now considered to be inadequate to meet modern requirements. So, while there may be an argument to align survey and charting standards where they overlap, the charting standard will need to extend further to cater for a much wider range of bathymetric data quality.

Discussion

High quality data...

Over the course of 15 years of lecturing to marine pilots it has become most apparent that the categories A1 and A2, and their fundamental mismatch to the survey standards applicable to ports where these ZOC ratings are typically charted, creates considerable confusion at best, and leaves the ZOC system without any credibility at worst. As an example, data used within the approaches to many major ports is categorised on the chart as S-57 ZOC A1, having a vertical uncertainty of better than 0.7m (for a 20m depth), yet when the same dataset is used in the corresponding dynamic under-keel clearance system it has an S-44 attributed vertical uncertainty better than 0.3m. While there are ways to work around this difference through additional attributions, they are exactly that – work arounds.

Port surveyors typically achieve S-44 Special Order in these areas, or much better. They are also required to achieve full feature detection of 1m³ features (or better in many ports), whereas the chart can at best describe the same area as only detecting 2m features (which is also an ambiguous measure). Consequently, it is invariably the Port surveyor's and Harbour Master's advice which is followed in the interests of maximising a ship's draft, and the chart's advice is ignored. Regrettably, not only does this create confusion, when the ZOC rating in the ENC is rightly ignored in one area, it soon becomes wrongly ignored in other areas.

There must therefore be greater alignment between survey standards and charting standards within port and port approach areas.

Moderate quality data

Within the range of normal surveys typically undertaken for coastal nautical charting, there are significant differences between the attributes associated with ZOC A2 and S-44 Order1a, and between ZOC B and S-44 Order 1b, despite their purposes being aligned.

Very low quality data / no data...

At the low quality end of the bathymetric data quality spectrum, there is little point in defining a standard in S-44 for an inadequate survey, or worse. However, as charts frequently include areas of low quality or no data, the CATBDQ categories must extend beyond (worse) than survey standards. A separate paper has been developed for DQWG consideration so

that cartographers may consistently recognise areas which are considered inadequately surveyed, or unsurveyed, to ensure consistency between hydrographic offices.

Inconsistent terminology

Finally, there is inconsistent use of the terms 'significant seafloor features', 'features' and 'depth anomalies' within the seafloor coverage descriptions. There is an excessive reliance upon notes in a separate accompanying table, making comprehension more difficult than necessary.

Actions

DQWG members are requested to:

- note this paper and the key factors within it;
- provide any suggested revisions;
- agree that the paper (or a revised version) be passed to HSPT for information in their assessment and revision of survey standards;
- agree that HSPT should be encouraged to make recommendations on the various thresholds between the various CATBDQ categories, except C, D, O and U, where they consider this appropriate.

Comparison of S-44 and Zones Of Confidence

Colour coding:

S-44 Survey Order (in yellow), versus
Zones Of Confidence Category (in white), with
Comparison comments (in grey)

S-44	Maximum allowable THU 95% Confidence level	Maximum allowable TVU 95% Confidence level	Full Seafloor Search / Feature Detection	Description
ZOC Category (note 1)	Position Accuracy (note 2)	Depth Accuracy (note 3)	Seafloor Coverage	Typical Survey Characteristics (note 5)

S-44 Special Order vs ZOC A1

S-44 Special Order	2 metres	a = 0.25 metre b = 0.0075	Full Seafloor Search Required / Cubic features > 1 metre detected and measured	Areas where under-keel clearance is critical										
ZOC A1	± 5 m + 5% depth	=0.50 + 1%d <table border="1"> <tr> <td>Depth (m)</td> <td>Accuracy (m)</td> </tr> <tr> <td>10</td> <td>± 0.6</td> </tr> <tr> <td>30</td> <td>± 0.8</td> </tr> <tr> <td>100</td> <td>± 1.5</td> </tr> <tr> <td>1000</td> <td>± 10.5</td> </tr> </table>	Depth (m)	Accuracy (m)	10	± 0.6	30	± 0.8	100	± 1.5	1000	± 10.5	Full area search undertaken. Significant seafloor features detected (note 4) and depths measured.	Controlled, systematic survey (note 6) high position and depth accuracy achieved using DGPS and a multi-beam, channel or mechanical sweep system.
Depth (m)	Accuracy (m)													
10	± 0.6													
30	± 0.8													
100	± 1.5													
1000	± 10.5													
<p>Comment – S-44 Special Order Versus ZOC A1. <u>ZOC A1 is not currently representative of Special Order areas.</u> This significant mismatch in the most obvious circumstances causes confusion. In such area ZOC A1 is irrelevant as under-keel clearances are specified by the port surveyor and Harbour Master. Even allowing for some loss of horizontal uncertainty during the chart compilation process, there is little reason to accept introduction of a doubling of vertical uncertainty, and no reason to double the achieved feature detection size. Outside port areas ZOC A1 represents less than 1% of the world's coastal waters.</p>														

S-44 Order 1a vs ZOC A1

S-44 Order 1a	5 metres + 5% of depth	a = 0.5 metre b = 0.013	Full Seafloor Search Required / Cubic features > 2 metres, in depths up to 40 metres; 10% of depth beyond 40 metres	Areas shallower than 100 metres where under-keel clearance is less critical but features of concern to surface shipping may exist.										
ZOC A1	± 5 m + 5% depth	=0.50 + 1%d <table border="1"> <tr> <td>Depth (m)</td> <td>Accuracy (m)</td> </tr> <tr> <td>10</td> <td>± 0.6</td> </tr> <tr> <td>30</td> <td>± 0.8</td> </tr> <tr> <td>100</td> <td>± 1.5</td> </tr> <tr> <td>1000</td> <td>± 10.5</td> </tr> </table>	Depth (m)	Accuracy (m)	10	± 0.6	30	± 0.8	100	± 1.5	1000	± 10.5	Full area search undertaken. Significant seafloor features detected (note 4) and depths measured.	Controlled, systematic survey (note 6) high position and depth accuracy achieved using DGPS and a multi-beam, channel or mechanical sweep system.
Depth (m)	Accuracy (m)													
10	± 0.6													
30	± 0.8													
100	± 1.5													
1000	± 10.5													
<p>Comment – S-44 Order 1a Versus ZOC A1. <u>These two standards are virtually identical.</u> This strong correlation should be maintained.</p>														

S-44 Order 1a vs ZOC A2

S-44 Order 1a	5 metres + 5% of depth	a = 0.5 metre b = 0.013	Full Seafloor Search Required / Cubic features > 2 metres, in depths up to 40 metres; 10% of depth beyond 40 metres	Areas shallower than 100 metres where under-keel clearance is less critical but features of concern to surface shipping may exist.										
ZOC A2	± 20 m	= 1.00 + 2%d <table border="1"> <thead> <tr> <th>Depth (m)</th> <th>Accuracy (m)</th> </tr> </thead> <tbody> <tr> <td>10</td> <td>± 1.2</td> </tr> <tr> <td>30</td> <td>± 1.6</td> </tr> <tr> <td>100</td> <td>± 3.0</td> </tr> <tr> <td>1000</td> <td>± 21.0</td> </tr> </tbody> </table>	Depth (m)	Accuracy (m)	10	± 1.2	30	± 1.6	100	± 3.0	1000	± 21.0	Full area search undertaken. Significant seafloor features detected (note 4) and depths measured.	Controlled, systematic survey (note 6) achieving position and depth accuracy less than ZOC A1 and using a modern survey echo-sounder (note 7) and a sonar or mechanical sweep system.
Depth (m)	Accuracy (m)													
10	± 1.2													
30	± 1.6													
100	± 3.0													
1000	± 21.0													
<p>Comment – S-44 Order 1a Versus ZOC A2. The feature detection requirements of Order 1a and ZOC A2 are comparable, though ZOC A2 allows for larger horizontal and vertical uncertainties for relatively recent legacy data. It can be reasonably assumed that ZOC A2 remains a useful category for surveys originally done to Order 1a, but which have degraded over time.</p>														

S-44 Order 1b vs ZOC B

S-44 Order 1b	5 metres + 5% of depth	a = 0.5 metre b = 0.013	Not Applicable	Areas shallower than 100 metres where under-keel clearance is not considered to be an issue for the type of surface shipping expected to transit the area.										
ZOC B	± 50 m	= 1.00 + 2%d <table border="1"> <thead> <tr> <th>Depth (m)</th> <th>Accuracy (m)</th> </tr> </thead> <tbody> <tr> <td>10</td> <td>± 1.2</td> </tr> <tr> <td>30</td> <td>± 1.6</td> </tr> <tr> <td>100</td> <td>± 3.0</td> </tr> <tr> <td>1000</td> <td>± 21.0</td> </tr> </tbody> </table>	Depth (m)	Accuracy (m)	10	± 1.2	30	± 1.6	100	± 3.0	1000	± 21.0	Full area search not achieved; uncharted features, hazardous to surface navigation are not expected but may exist.	Controlled, systematic survey (note 6) achieving similar depth but lesser position accuracies than ZOCA2, using a modern survey echo-sounder (note 5), but no sonar or mechanical sweep system.
Depth (m)	Accuracy (m)													
10	± 1.2													
30	± 1.6													
100	± 3.0													
1000	± 21.0													
<p>Comment –Order 1b Versus ZOC B. The intent of Order 1b and ZOC B are comparable as both attempt to define an “adequate” survey in support of surface navigation. ZOC B allows for larger horizontal and vertical uncertainties for relatively recent legacy data. It is odd that the survey standard has tight tolerances for horizontal and vertical uncertainties, but has no quantified feature detection requirement. Some level of feature detection requirement in relation to surface shipping (at least) should be added to the survey standard. The seafloor coverage description associated with ZOC B is highly ambiguous as it does not suggest any maximum draft to define “hazardous to surface navigation”. The feature detection / seafloor coverage requirements are both poorly defined.</p>														

S-44 Order 2 vs ZOC B

S-44 Order 2	20 metres + 10% of depth	a = 1.0 metre b = 0.023	Not Applicable	Areas generally deeper than 100 metres where a general description of the sea floor is considered adequate.										
ZOC B	± 50 m	= 1.00 + 2%d <table border="1"> <thead> <tr> <th>Depth (m)</th> <th>Accuracy (m)</th> </tr> </thead> <tbody> <tr> <td>10</td> <td>± 1.2</td> </tr> <tr> <td>30</td> <td>± 1.6</td> </tr> <tr> <td>100</td> <td>± 3.0</td> </tr> <tr> <td>1000</td> <td>± 21.0</td> </tr> </tbody> </table>	Depth (m)	Accuracy (m)	10	± 1.2	30	± 1.6	100	± 3.0	1000	± 21.0	Full area search not achieved; uncharted features, hazardous to surface navigation are not expected but may exist.	Controlled, systematic survey (note 6) achieving similar depth but lesser position accuracies than ZOCA2, using a modern survey echo-sounder (note 5), but no sonar or mechanical sweep system.
Depth (m)	Accuracy (m)													
10	± 1.2													
30	± 1.6													
100	± 3.0													
1000	± 21.0													
<p>Comment –Order 2 Versus ZOC B. The intent of Order 2 and ZOC B are only broadly comparable as both attempt to define an “adequate” survey. However, ZOC B is frequently assigned in coastal waters less than 100m deep, yet Order2 is only intended for waters greater than 100m deep. Vertical uncertainty requirements are virtually identical, but the differences in horizontal uncertainty presumably are intended to allow for legacy surveys with lower horizontal accuracy. The seafloor coverage description associated with ZOC B is highly ambiguous as it does not suggest any maximum draft to define “hazardous to surface navigation”. While the description associated with Order 2 is also ambiguous, at depths intended to be greater than 100m, this is less of an issue than the ZOC B descriptor. Some level of draft in relation to surface shipping (at least) should be added to the charting standard.</p>														

S-44 Order 2 vs ZOC C

S-44 Order 2	20 metres + 10% of depth	a = 1.0 metre b = 0.023	Not Applicable	Areas generally deeper than 100 metres where a general description of the sea floor is considered adequate.										
ZOC C	± 500 m	= 2.00 + 5%d <table border="1"> <tr> <td>Depth (m)</td> <td>Accuracy (m)</td> </tr> <tr> <td>10</td> <td>± 2.5</td> </tr> <tr> <td>30</td> <td>± 3.5</td> </tr> <tr> <td>100</td> <td>± 7.0</td> </tr> <tr> <td>1000</td> <td>± 52.0</td> </tr> </table>	Depth (m)	Accuracy (m)	10	± 2.5	30	± 3.5	100	± 7.0	1000	± 52.0	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.
Depth (m)	Accuracy (m)													
10	± 2.5													
30	± 3.5													
100	± 7.0													
1000	± 52.0													
<p>Comment – Order 2 Versus ZOC C. The intent of Order 2 (an 'adequate' survey with relatively small horizontal and vertical uncertainties) is significantly tighter than for ZOC C. <u>Order 2 and ZOC C are not comparable</u> - ZOC C is clearly intended as a category for legacy data.</p>														

S-44 Order 2 vs ZOC D

S-44 Order 2	20 metres + 10% of depth	a = 1.0 metre b = 0.023	Not Applicable	Areas generally deeper than 100 metres where a general description of the sea floor is considered adequate.
D	worse than ZOC C	Worse Than 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.
<p>Comment – Order 2 Versus ZOC D. The intent of Order 2 (an 'adequate' survey with relatively small horizontal and vertical uncertainties) is much tighter than for ZOC D. <u>Order 2 and ZOC D are not comparable</u> - ZOC D is clearly intended as a category for legacy data. <u>ZOC D is currently described as including 'data that cannot be quality assessed', which directly conflicts with ZOC U 'Unassessed'</u>.</p>				

ZOC U

U				
Unassessed - The quality of the bathymetric data has yet to be assessed				
Column: 1	2	3	4	5
Source: IHO S-57 Ed3.1 Supp 3 (Jun 2014), pp 13-14				

Proposed alignment (where applicable) between S-44 Survey Order and Category of Bathymetric Data Quality (CATBDQ) (in white), with Comparison comments (in grey)

S-44	Maximum allowable THU 95% Confidence level	Maximum allowable TVU 95% Confidence level	Full Seafloor Search / Feature Detection	Description
CATBDQ Category (note 1)	Position Accuracy (note 2)	Depth Accuracy (note 3)	Seafloor Coverage	Typical Survey Characteristics (note 5)

Very high accuracy survey – critical under-keel clearance areas

S-44 Special Order	2 metres	a = 0.25 metre b = 0.0075	Full Seafloor Search Required / Cubic features > 1 metre detected and measured	Areas where under-keel clearance is critical
CATBDQ-SP	± 5 m + 5% depth	=0.25 + 1%d Depth (m) 10 30 Accuracy (m) ± 0.6 ± 0.8	Full area search undertaken. Significant seafloor features greater than 1m ³ detected and depths measured.	Controlled, systematic survey where under-keel clearance is critical (note 6) high position and depth accuracy achieved using DGPS and a multi-beam, channel or mechanical sweep system.
Comment – Introduce new CATBDQ-SP 'Special'. This category retains the existing horizontal uncertainty associated with ZOC A1 as this is sufficient for most navigation purposes (noting it does not apply to infrastructure), and allows for use of 5m gridded data and some generalisation of depth contours. However, the vertical uncertainty and feature detection requirements are aligned to those for Special Order surveys. Notably there should be no requirement to allow for degradation of these surveys as they are in critical areas and typically subject to an appropriate re-survey program.				

High accuracy survey – less critical under-keel clearance areas

S-44 Order 1a	5 metres + 5% of depth	a = 0.5 metre b = 0.013	Full Seafloor Search Required / Cubic features > 2 metres, in depths up to 20 metres; 10% of depth beyond 20 metres	Areas shallower than 40 50 metres where under-keel clearance is less critical but features of concern to surface shipping may exist.
CATBDQ-A1 ZOC-A1	± 5 m + 5% depth	=0.50 + 1%d Depth (m) 10 30 100 1000 Accuracy (m) ± 0.6 ± 0.8 ± 1.5 ± 10.5	Full seafloor search undertaken. Undetected seafloor features larger than 2m above the general seabed (or 10% depth beyond 20m) are unlikely to exist.	Controlled, systematic survey to Order 1a achieved using DGPS and a multi-beam, channel or mechanical sweep system.
Comment – Retain CATBDQ-A1 (formerly ZOC A1), maintain alignment to S-44 Order 1a. Revise threshold depth for feature detection size to 20 metres (in lieu of 40 metres), to remove any step-change in size throughout the water column.				

CATBDQ-A2 ZOC-A2	± 20 m	= 1.00 + 2%d Depth (m) 10 30 100 1000 Accuracy (m) ± 1.2 ± 1.6 ± 3.0 ± 21.0	Full seafloor search undertaken. Undetected seafloor features larger than 2m above the general seabed (or 10% depth beyond 40m) are unlikely to exist.	Controlled, systematic survey (note 6) achieving position and depth accuracy less than ZOC A1 and using a modern survey system (note 7).
Comment – Retain CATBDQ-A2 (formerly ZOC A2), with the same feature detection and measurement requirements, but larger horizontal and vertical uncertainties for recent legacy data or mild degradation of a survey over time. Maintain link between CATBDQ-A2 as a 'degraded' representation of Order 1a.				

Adequate survey – coastal areas less than 100m / more than 100m

S-44 Order 1b	5 metres + 5% of depth 20 metres + 10% of depth	a = 0.5 metre b = 0.013 a = 1.0 metre b = 0.023	Not Applicable. Undetected features, hazardous to surface navigation drawing less than 30m draft are not expected but may exist.	Areas shallower than 100 metres where under-keel clearance is not considered to be an issue for the type of surface shipping expected to transit the area.
CATBDQ-B ZOC-B	± 50 m	= 1.00 + 2%d Depth (m) 10 30 100 1000	Accuracy (m) ± 1.2 ± 1.6 ± 3.0 ± 21.0	Full area search not achieved; uncharted features, hazardous to surface navigation drawing less than 30m draft are not expected but may exist.
<p>Comment – Noting that there is no shallowest depth quoted for the depth band, Order 1b requires some form of feature detection requirement to remain a relevant survey standard. The horizontal and vertical uncertainty requirements could be reduced to match those of Order 2 without detriment to practical coastal navigation, so long as some form of feature detection requirement is introduced.</p>				

S-44 Order 2	20 metres + 10% of depth	a = 1.0 metre b = 0.023	Not Applicable.	Areas generally deeper than 100 metres where a general description of the sea floor is considered adequate.
CATBDQ-B ZOC-B	± 50 m	= 1.00 + 2%d Depth (m) 10 30 100 1000	Accuracy (m) ± 1.2 ± 1.6 ± 3.0 ± 21.0	Full area search not achieved; uncharted seafloor features, hazardous to surface navigation drawing less than 30m draft are not expected but may exist.
<p>Comment – Order 2 Versus ZOC B. The intent of Order 2 and ZOC B are comparable as both attempt to define an adequate survey, though Order 2 does this by limiting applicability to depths greater than 100m. Order 1b and Order 2 may also be considered complimentary, but applying to different depth ranges and requiring different survey techniques to achieve the same overall navigational outcome of “adequate”. Again, ZOC B requires better definition of “surface navigation” in relation to feature detection / seafloor coverage.</p>				

CATBDQ-O	± 500 m	Not specified Depth (m) NA	Accuracy (m) NA	Oceanic areas. Full area search not achieved; uncharted features, hazardous to surface navigation drawing less than the defined depth are not expected but may exist.
<p>A specified surface layer within which surface navigation can be confidently undertaken due to a combination of extreme depth of water and frequency of successful use of a defined shipping corridor. Within this corridor risks to surface navigation are considered adequately mitigated.</p>				
<p>Comment – CATBDQ-O is to be introduced for use in S-100 and S-101 ENC, to cater for those oceanic transit routes where the quality of bathymetric data at the seabed may be poorly defined but where a combination of extreme depth and frequency of previous successful surface navigation, or a sweep by lidar or some other system to a depth defined by the relevant hydrographic authority, strongly mitigates any reasonable risk to surface navigation.</p>				

Inadequate survey

CATBDQ- C ZOC-C	± 500 m	= 2.00 + 5%d		Full area search not achieved, uncharted seafloor features and depth differences may be expected	Low accuracy survey or data collected on an opportunity basis such as soundings on passage, such that the area is considered inadequately surveyed for the depth of water and likelihood of undetected features.
		Depth (m)	Accuracy (m)		
		10	± 2.5		
		30	± 3.5		
		100	± 7.0		
		1000	± 52.0		
Comment – CATBDQ (formerly ZOC C) is clearly intended as a category for legacy data.					

Uncontrolled survey or unsurveyed

CATBDQ- D ZOC-D	worse than ZOC C	Worse Than ZOC C	Full area search not achieved, large uncharted seafloor features and large depth differences hazardous to surface navigation may be expected. Area may be unsurveyed.	Poor quality data or data that cannot be quality assessed due to lack of information that is so sparse as to be considered unsurveyed.
Comment – CATBDQ (formerly ZOC D) is clearly intended as a category for legacy data. <u>ZOC D is described as including 'data that cannot be quality assessed', which directly conflicts with ZOC U 'Unassessed'.</u>				

Unassessed

CATBDQ- U ZOC-U	Unassessed - The quality of the bathymetric data has yet to be assessed			
Comment – CATBDQ – U (formerly ZOC U) is clearly intended for data which has yet to be assessed.				

Enclosures:**Existing Zones Of Confidence Categories**

ZOC	Position Accuracy	Depth Accuracy		Seafloor Coverage	Typical Survey Characteristics
A1	± 5 m + 5% depth	=0.50 + 1% depth		Full area search undertaken. Significant seafloor features ¹ detected and depths measured.	Controlled, systematic survey ² 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.
		Depth (m)	Accuracy (m)		
		10 30 100 1000	± 0.6 ± 0.8 ± 1.5 ± 10.5		
A2	± 20 m	= 1.00 + 2% depth		Full area search undertaken. Significant seafloor features ¹ detected and depths measured.	Controlled, systematic survey ² achieving position and depth accuracy less than ZOC A1 and using a modern survey echosounder ³ and a sonar or mechanical sweep system.
		Depth (m)	Accuracy (m)		
		10 30 100 1000	± 1.2 ± 1.6 ± 3.0 ± 21.0		
B	± 50 m	= 1.00 + 2% depth		Full area search not achieved; uncharted features, hazardous to surface navigation are not expected but may exist.	Controlled, systematic survey ² achieving similar depth but lesser position accuracies than ZOCA2, using a modern survey echosounder ³ , but no sonar or mechanical sweep system.
		Depth (m)	Accuracy (m)		
		10 30 100 1000	± 1.2 ± 1.6 ± 3.0 ± 21.0		
C	± 500 m	= 2.00 + 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.
		Depth (m)	Accuracy (m)		
		10 30 100 1000	± 2.5 ± 3.5 ± 7.0 ± 52.0		
D	worse than ZOC C	Worse Than 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.
U	Unassessed - The quality of the bathymetric data has yet to be assessed				

Table 1 – Zones Of Confidence Full Table

Existing Zones Of Confidence Notes

Notes:							
1.	<p>Significant seafloor features are defined as those rising above depicted depths by more than:</p> <table border="0"> <thead> <tr> <th>Depth</th> <th>Significant Feature</th> </tr> </thead> <tbody> <tr> <td>less than 40 m</td> <td>2 m</td> </tr> <tr> <td>greater than 40 m</td> <td>10% depth</td> </tr> </tbody> </table> <p>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.</p>	Depth	Significant Feature	less than 40 m	2 m	greater than 40 m	10% depth
Depth	Significant Feature						
less than 40 m	2 m						
greater than 40 m	10% depth						
2.	Controlled, systematic surveys (ZOC A1, A2 and B) - surveys comprising planned survey lines, on a geodetic datum that can be transformed to WGS 84.						
3.	Modern survey echo sounder - a high precision single beam depth measuring equipment, generally including all survey echo sounders designed post 1970.						

Table 2 – Zones Of Confidence Notes

Existing S-44 Survey Orders

IHO STANDARDS FOR HYDROGRAPHIC SURVEYS (S-44)
5th Edition February 2008

TABLE 1
Minimum Standards for Hydrographic Surveys
(To be read in conjunction with the full text set out in this document.)

Reference	Order	Special	1a	1b	2
Chapter 1	Description of areas.	Areas where under-keel clearance is critical	Areas shallower than 100 metres where under-keel clearance is less critical but <i>features</i> of concern to surface shipping may exist.	Areas shallower than 100 metres where under-keel clearance is not considered to be an issue for the type of surface shipping expected to transit the area.	Areas generally deeper than 100 metres where a general description of the sea floor is considered adequate.
Chapter 2	Maximum allowable THU 95% <i>Confidence level</i>	2 metres	5 metres + 5% of depth	5 metres + 5% of depth	20 metres + 10% of depth
Para 3.2 and note 1 Glossary and note 2	Maximum allowable TVU 95% <i>Confidence level</i> <i>Full Sea floor Search</i>	a = 0.25 metre b = 0.0075	a = 0.5 metre b = 0.013	a = 0.5 metre b = 0.013	a = 1.0 metre b = 0.023
Para 2.1 Para 3.4 Para 3.5 and note 3	<i>Feature Detection</i>	Cubic <i>features</i> > 1 metre	Cubic <i>features</i> > 2 metres, in depths up to 40 metres; 10% of depth beyond 40 metres	Not Applicable	Not Applicable
Para 3.6 and note 4	Recommended maximum Line Spacing	Not defined as <i>full sea floor search</i> is required	Not defined as <i>full sea floor search</i> is required	3 x average depth or 25 metres, whichever is greater For bathymetric lidar a spot spacing of 5 x 5 metres	4 x average depth
Chapter 2 and note 5	Positioning of fixed aids to navigation and topography significant to navigation. (95% <i>Confidence level</i>)	2 metres	2 metres	2 metres	5 metres
Chapter 2 and note 5	Positioning of the Coastline and topography less significant to navigation (95% <i>Confidence level</i>)	10 metres	20 metres	20 metres	20 metres
Chapter 2 and note 5	Mean position of floating aids to navigation (95% <i>Confidence level</i>)	10 metres	10 metres	10 metres	20 metres