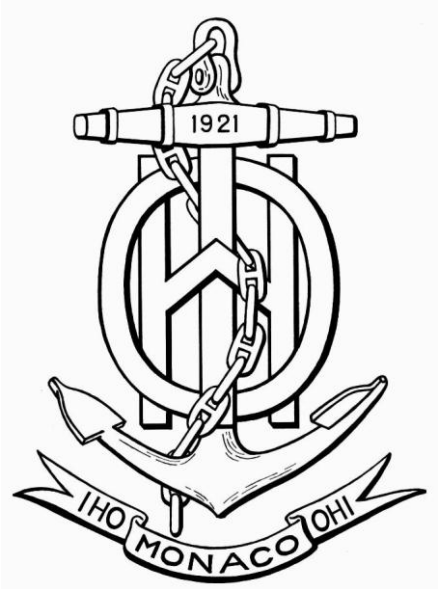
INTERNATIONAL HYDROGRAPHIC ORGANIZATION



S-67

MARINERS' GUIDE TO ACCURACY OF ELECTRONIC NAVIGATIONAL CHARTS (ENC)

Edition 0.5

July 2017

S-67

MARINERS' GUIDE TO ACCURACY OF ELECTRONIC NAVIGATIONAL CHARTS (ENC)

Edition 0.5

July 2017

Published by:

The International Hydrographic Organization
4b, quai Antoine 1er
B.P. 445
Monaco, MC 98011 Cedex
MONACO
<info@iho.int>
<www.iho.int>

Contents

1. Accuracy of Nautical Charts

All charts, whether paper or electronic, contain data which varies in quality due to the age, accuracy and completeness of individual surveys. A chart can be considered as a jigsaw of individual surveys pieced together to form a single image. Most charts contain a mixture of individual surveys of differing quality.

In general, remote areas away from shipping routes tend to be less well surveyed, and less frequently, while areas of high commercial traffic are re-surveyed frequently to very high levels of accuracy and completeness, particularly where under-keel clearances are small.

Traditionally, mariners have relied upon familiar, but often ambiguous indicators used on paper charts, usually in a source diagram. The details and interpretations often varied widely between nations, though most simply said how old a survey was, rather than how good. The variations in method, detail and interpretation render this type of quality information unsuitable for use in an electronic system such as ECDIS, as it prevents use of automated checking routines to look along a planned route to confirm suitability.

To address this, the International Hydrographic Organization developed and published a new international system to be used by all nations within their S-57 Electronic Navigational Charts (ENC). This is the "Zones Of Confidence" system, often referred to as "ZOC". The degree of reliance which can be placed in the depth information within an ENC can be consistently determined by understanding the Zone of Confidence assessment for an area, then applying a common-sense approach.

2. Zones of Confidence

All S-57 ENC use the Zones Of Confidence (ZOC) system. There may be several different ZOC areas within each individual ENC. These assessments enable mariners to assess the limitation of the hydrographic data from which the ENC was compiled, and to assess the associated level of risk to navigate in a particular area.

The ZOC system only applies to the bathymetry (depths, contours, submerged rocks and reefs, etc) – it does not apply to the accuracy of charting the high water line, wharves, navigation aids, pipelines and so on.

There are five basic levels within the ZOC system. Each differing level of quality is referred to as a 'category' within the overall ZOC system. Each category is therefore labeled as 'CATZOC' [1] when queried within the ENC. The categories range from 'very high confidence' to 'unsurveyed'. There is an additional category for 'Unassessed'. The impact upon mariners of the various categories is discussed in Section 5.

[1] CATZOC is a mandatory attribute within the 'M_QUAL' quality information layer within ENC. Other optional M_QUAL attributes include the dates of a survey, the vertical or horizontal accuracy, or details of the survey technology used. Population of these optional details is generally less common.

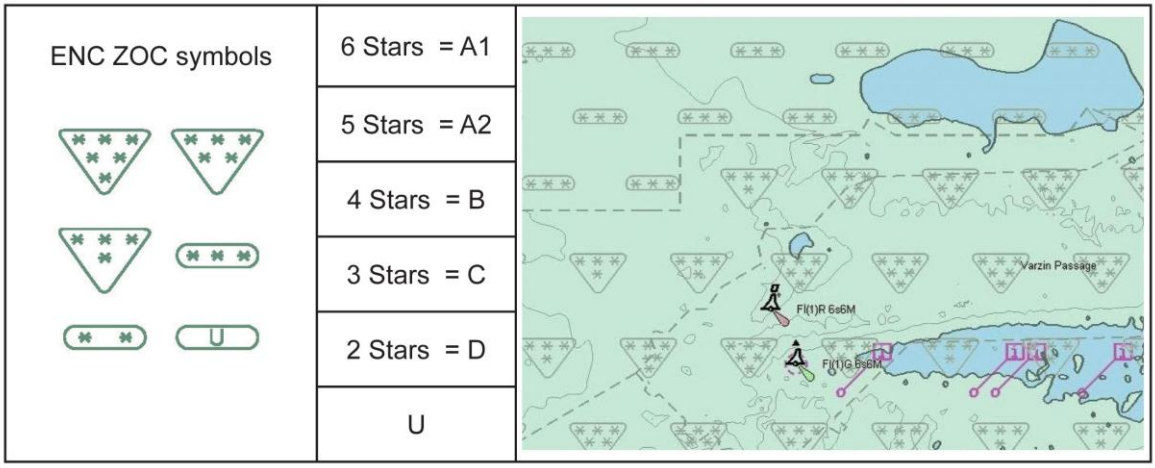
The various ZOC categories are:

Category	Confidence level	General description - survey characteristics
A1	Significant seafloor features detected and depths measured	High position and depth accuracy achieved using DGPS and a multi-beam, channel or mechanical sweep system.
A2	Significant seafloor features detected and depths measured.	Position and depth accuracy less than ZOC A1, achieved using a modern survey echo-sounder and a sonar or mechanical sweep system.
B	Uncharted features, hazardous to surface navigation are not expected but may exist.	Similar depth accuracy as ZOC A2 but lesser position accuracy than ZOC A2 (generally pre-dating DGPS), using a modern survey echo-sounder, but no sonar or mechanical sweep system.
C	Depth anomalies may be expected.	Low accuracy survey or data collected on an opportunity basis such as soundings on passage.
D	Large depth anomalies may be expected.	Poor quality data or unsurveyed.
U	Unassessed.	The quality of the bathymetric data has yet to be assessed. (Mariners should assume poor data quality until the area has been assessed).

The full version of this Table may be found in Section 7 at the end of this publication.

3. ENC ZOC Symbols

In the ENC the different ZOC quality levels are denoted by a series of symbols containing a varying number of stars, enclosed within a triangle or ellipse. This symbol is repeated throughout each area of equal quality. The symbols can be made visible or be hidden on the ECDIS screen depending upon the mariner's needs at any particular time. The various categories range from six stars (excellent) down to two stars (very poor). There is an additional category for areas which are 'Unassessed'.



Zones Of Confidence symbols, categories and depiction on an ENC.

4. The components of an assessment

Assessments are made based upon four criteria, following which a single ZOC rating is derived for each area of differing quality. The lowest rating for any individual component within that area determines which ZOC category is assigned.

Individual assessment criteria are:

- typical survey characteristics
- seafloor coverage (this relates to the possibility that something may have been missed and is therefore not on the chart)
- position accuracy
- depth accuracy (this relates to what has been detected and is therefore charted, not what might or might not remain undetected)

Of these, the most important is the assessment of feature detection (seafloor coverage), as this determines the minimum clearance that should be maintained between a ship's keel and the seabed in most areas, and where any additional precautions may need to be taken.

The next most important factor is position, at least for ZOC categories C and D. As there is a risk of undetected 'surprises' in these areas, the sensible approach is to avoid these areas wherever possible, and particularly in coastal waters. The position accuracy for these categories gives some idea of how far away from these areas a ship should remain.

It is only in areas where full seafloor coverage has been achieved that depth accuracy is relevant. In areas where this has not been achieved, the safety margin a mariner should leave for the possibility of an uncharted 'surprise' is much larger than the allowance for the charted depths.

One significant limitation of the ZOC system is that it provides little information about when a survey was conducted, or whether the seabed is stable. While the date can be provided in another data field within an ENC, this is rarely done, and may be difficult for mariners to access. In areas where the seabed is subject to change, national hydrographic offices should downgrade the assigned ZOC category, restoring it only once a replacement survey is incorporated into a chart. However, it is wise to note areas of sandwaves, dates within dredged channels, and any other notes that channels may have changed.

Mariners should not require a detailed understanding of survey characteristics, as long as they understand the implications for shipping within each different ZOC category. The major contributing factors are discussed further in Section 5, with the implications for shipping in each ZOC area discussed in Section 5.

The IHO Zones Of Confidence table in Section 7 explains the six ZOC categories in greater detail. In particular, it includes specific vertical accuracies of charted features at a range of depths, as well as how accurately those features may be positioned, and the confidence (or risk) that all seabed features have (or have not) been detected. This table has been extracted from the S-57 standard for convenience.

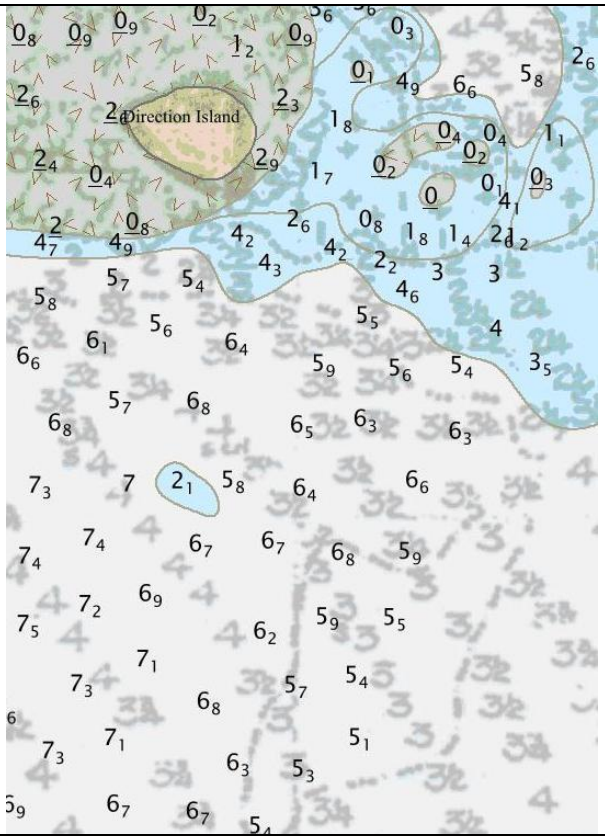
4.1 Seafloor coverage

This is by far the most important factor in assessing and categorizing a survey. It is an assessment of how thoroughly the surveyor conducted their work. Did they miss anything? Was it potentially small or very large? Ultimately, the question of whether there are still any nasty surprises in an area is far more important than the accuracy of the survey – it only once there is confidence that nothing has been missed (and therefore nothing left off the chart) that the question of how close a ship can pass to the charted seabed becomes relevant.

The possibility of dangers being missed typically arises from older surveys, which simply were not as effective as using modern systems.

In this example, the older handwritten survey from 1899 includes quite accurate depths wherever they were measured. For example, the 4 fathom depth, measured by leadline near the isolated shoal, closely matches the modern 7 metre depth. Other depths also agree well, where they exist.

However, the quality of seafloor coverage in the 1899 survey is very poor as it did not detect the existence of the isolated 2.1 metre shoal found during the modern survey. It proves that the 1899 survey, if it was the only survey in this area, could not be trusted for any vessel with a draft greater than 1.5 – 2 metres.



It is only in ZOC areas A1 and A2 where full seafloor feature detection has been achieved. It is therefore only in these areas that the accuracy of the charted depths directly defines where a ship can go, and how deep the draft of that ship can be.

Even then, according to the ZOC system, there is a very small possibility that a significant feature may remain undetected (less than a maximum size of 2 cubic metres for depths less than 40 metres). More information is available in the ZOC A1 and A2 sections of this publication.

ZOC B, C and D areas result from surveys that were progressively less detailed. In these areas there is an increasing possibility of undetected features absent from the chart (ranging from a small rock or shoal through to a submerged reef).

In a ZOC B area there is unlikely to be anything affecting surface navigation, though it remains possible. The hydrographic office responsible for the chart will have (or should have) made their assessment based upon the quality of the survey, the depth of water and the size of vessels using the area. More information is available in the ZOC B section of this publication.

In a ZOC C area there is a strong possibility of undetected features, or charted features significantly out of position. These areas can be considered inadequately surveyed. More information is available in the ZOC C section of this publication.

In a ZOC D area there is a very strong likelihood of large undetected features absent from the chart. As these areas either have no systematic survey, or are completely unsurveyed, these features may well be as large as an entire submerged reef rising to just below the surface. If contemplating entering a ZOC D area, extensive precautions should be taken, in order to ensure there is sufficient time to react to dangers as they are revealed. More information is available in the ZOC D section of this publication.

4.2 Position accuracy

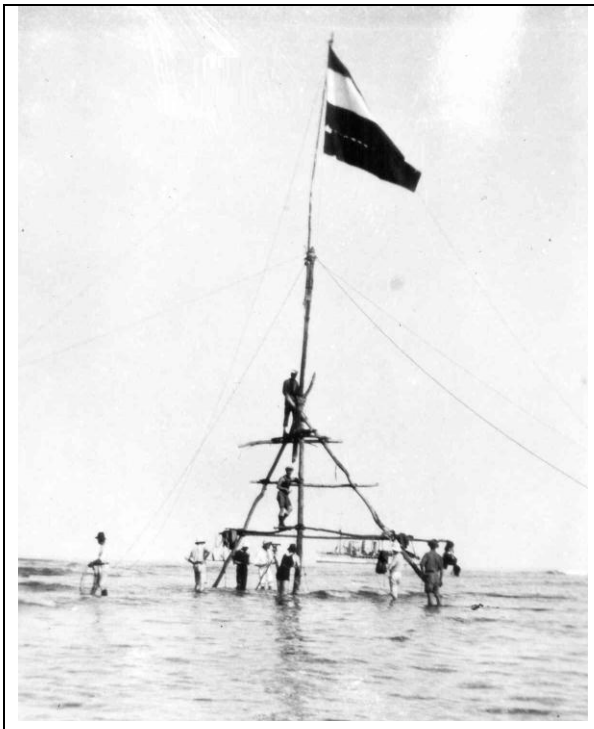
The next most important factor in most circumstances is accuracy of position of the bathymetry, including reef edges, depth contours, each specific depth, or a charted seabed feature or obstruction. Positioning accuracy is typically determined based upon an understanding of the positioning systems used during the hydrographic survey, as well as any loss of accuracy transferring older data from the survey to the chart, or between older datums and WGS84.

Most ships using modern satellite based navigation systems can be navigated with much greater accuracy than the charts they are using. While some parts of a chart will be based upon modern surveys, away from the most critical areas most charts still rely upon older and less detailed surveys.

It is only since the 1990s that satellite based navigation systems for survey ships have been widely available. These give a positioning accuracy of seabed features somewhere in the range of 2 to 20 metres.

From the late 1940s to the 1990s survey ships depended upon shore-based electronic positioning systems transmitting their signal over short or medium ranges, giving accuracy of around 20 to 100 metres. In coastal areas, this means that anything the ship found could be up to 100 metres from where it was thought to be.

Prior to this, survey ships used sextants to measure angles between a system of prominent marks, or flag poles built on towers established ashore, with surveyors ‘angling’ for hours at a time. A second row of towers could be built in shallow water or on reefs to extend the network further offshore, but with a further reduction in accuracy. Depending upon how accurately the towers were placed, accuracy of 50 to 500 metres was possible for the survey ship. So again, when something was found, particularly offshore, the true position could quite easily be up to 500 metres from where it was surveyed to be.



Up to early 1940s: Survey flag on an offshore reef to extend horizontal sextant control further offshore could achieve accuracy typically between 50 – 500 metres compared to GNSS on modern ships.

Late 1940s to mid 1990s: Shore based electronic position fixing systems could achieve accuracy typically between 20 – 100 metres compared to GNSS on modern ships.

Further offshore, where surveys were based entirely upon celestial navigation, positions could be considerably less accurate, typically no better than 1 to 2NM, and frequently worse.

While modern satellite imagery can be used to correct the position of many isolated offshore features that are islands, drying features or perhaps breaking in rough weather, anything more than a few metres below the surface is likely to remain unseen, and therefore possibly well out of its true position. The latter includes many subsurface features still on some charts that have been reported over time, often by the crews of old sailing ships, and often based upon dead reckoned positions; these could be many miles out of their true position.

However, the accuracy of position of features on a chart is only part of avoiding navigating too close a potential hazard. Using the example of a rock surveyed to a 20 metre positional accuracy in the approaches to a port, this does not mean that a ship can pass just over 20 metres from it. The more correct distance in this example is likely to be over 55 metres:

20m	chart accuracy +
15m	half ship's beam +
15m	GNSS accuracy +
5m	ship orientation / motion =
55m	Total offset

4.3 Depth accuracy

Depth accuracy refers to how well the depth of a known feature has been measured below chart datum – it clearly does not refer to the accuracy of something which remains undetected. The margin allowed by a ship's Master for the possibility that something remains undetected within a survey is a separate concern influenced by the seafloor coverage.

The three biggest factors affecting depth accuracy in relatively shallow coastal waters are the accuracy of the tidal observations, the motion of the survey ship and the setup of the echo sounder. Old leadline surveys actually contain very accurately measured depths, however they have a high risk of not detecting shoaler depths nearby. In contrast, a modern multibeam echo sounder misses very little, but requires careful setup and use to deliver accurate results.

5. Impact of ZOC categories upon mariners

Put in simple terms, mariners should be able to navigate with confidence in areas with ZOC A1 and A2 classifications. It is also unlikely that an uncharted danger affecting surface navigation exists in ZOC B areas. In ZOC C areas mariners should exercise a degree of caution since hazardous uncharted features may be expected, particularly in reef and rocky areas. However, a very high degree of caution is required for ZOC D areas, as these contain either very sparse data or may not have been surveyed at all. Finally, it is good practice for mariners to treat ZOC U areas with the same degree of caution as ZOC D areas.

To put this in perspective, the following table is an overall analysis of over 14 million square kilometers of coastal ENC [2] from 32 nations, acquired to support a world cruise in 2015:

Category	% area of English Channel	% area of Singapore & Malacca Straits	% area of world's coastal ENC	Confidence
A1 (6 stars)	3.6%	1.4%	0.7%	Very Good
A2 (5 stars)	9.4%	0.2%	1.0%	Very Good
B (4 stars)	62.9%	2.5%	30.5%	Good
C (3 stars)	21.3%	76.2%	21.8%	Fair
D (2 stars)	2.8%	1.1%	20.5%	Low
Unassessed (U)	0.0%	18.5%	25.4%	Low

Beyond coastal waters the vast majority of ENC show deep water areas as ZOC C, ZOC D, or Unassessed. This reflects the very sparse level of surveying or passage sounding undertaken across the world's oceans. Despite this, in the majority of oceanic areas, the very much greater depths can reduce the risk to surface shipping despite the low ZOC assessment.

5.1 An alternative way to assess ZOC (using the star symbols)

An alternative way to assess confidence might be to think about the number of stars symbolizing each area. Even if the specifics are not considered, most people (mariners are people) understand that if something is given more stars in an assessment than another, the one with more stars is considered to be 'better'.

A good example that works similarly to ZOCs might be choosing a hotel from listings on a website. Everyone knows that a six star hotel is better than a three star hotel, and will try very hard to stay away from a two star hotel. Equally, when a listed hotel hasn't been assessed, most people are unsure so tend to assume it isn't very good.

Zones Of Confidence work exactly the same way. Wherever possible ships should be kept in those areas rated with a higher number of stars (preferably four or more, three only when necessary), while those areas with only two stars, or unassessed, should be considered very carefully and avoided if circumstances permit. This is particularly important when planning to enter unfamiliar or little-used areas.

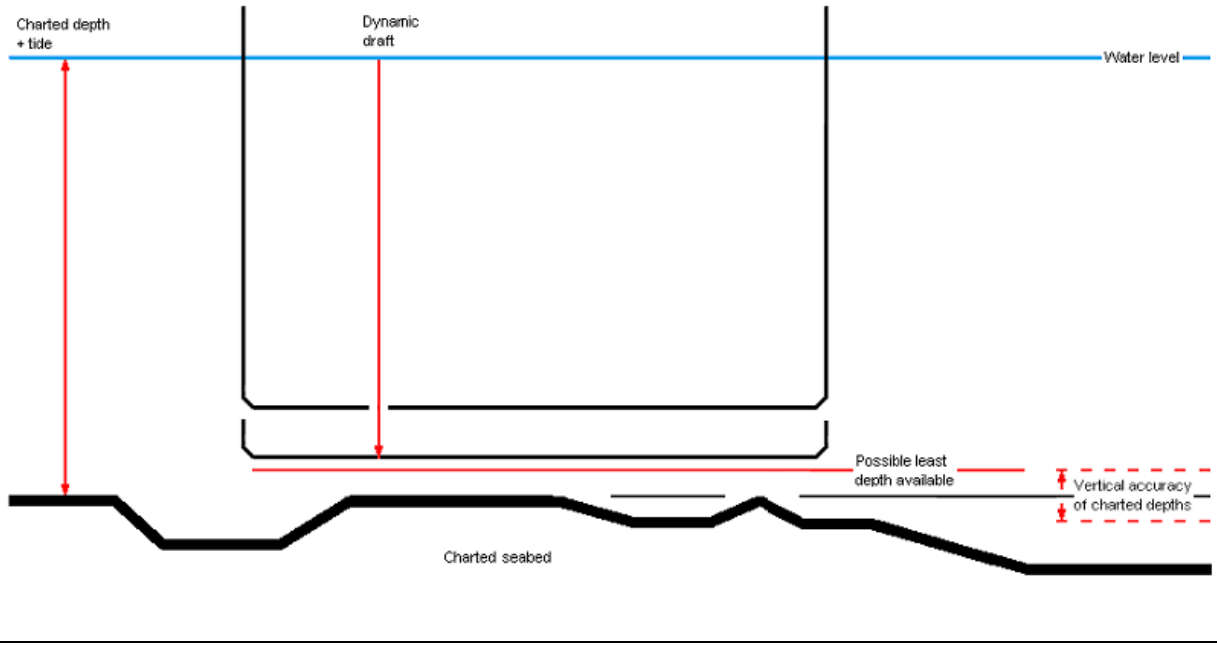
[2] From Navigation Purpose 3 and 4 ENC produced by 32 nations in 2015, covering 14,218,244 SQ KM. The analysis did not include ports.

5.2 ZOC A1 (6 stars)

Surveys within this category have met the requirements for full seabed search. ZOC A1 is only achievable with recent technology, and is usually subject to a program of regular re-survey.

ZOC A1 surveys generally only cover those areas of minimal under-keel clearance in harbours and shallow channels. The likelihood of any remaining undetected features is extremely low, and is most likely to be the result of undetected silting, or a channel which moves as a result of storms or seasonal changes. A very high degree of confidence can be had that there are no uncharted features between the charted depths or other features already shown on the chart.

In practical terms, if the Harbour Master can positively confirm that there are no undetected features within the channel or depicted area, mariners should make an allowance for an under-keel clearance at least equivalent to the quoted depth accuracy for the area. For a 10-20m draft ship this would be an allowance of at least 0.6 to 0.8m in a ZOC A1 area, plus allowances for squat, settlement and the accuracy of tidal predictions.



ZOC A1 – Full area search undertaken. Significant seafloor features detected (Annex A, note 4) and depths measured.

Vertical uncertainty (accuracy) approximately 0.6 – 0.8m (Annex A, table, and text below).

However, in port areas, it will often be wise to contact the Harbour Master. Possible advice may include:

- The channel depth is a maintained depth or a safe clearance depth – this depth has been determined by the port, taking into account all uncertainties for the accuracy of the survey. Only allowances for ship motion, tide, squat / settlement need to be made to ensure the specified depth is not exceeded. A specified and up to date maintained depth or a safe clearance depth supersedes a ZOC category.

- The channel has been surveyed to “Special Order” but a maintained depth or a safe clearance depth has not been charted. While still within the overall ZOC A1 category, these surveys have achieved vertical accuracy better than +/- 0.25m. If the Harbour Master can advise that Special Order has been achieved, *and that there is no possibility of undetected seafloor features* (through either an extremely detailed survey, bar sweep to a specified depth or a high volume of

previous deep draft traffic), then only allowances for ship motion, tide, squat / settlement need to be made beyond a 0.25m margin for survey accuracy. Standards and confidence such as this are rare.

- If there remains the possibility of undetected features in a port then an *additional* 1 metre margin between seabed and keel should be considered as the minimum.

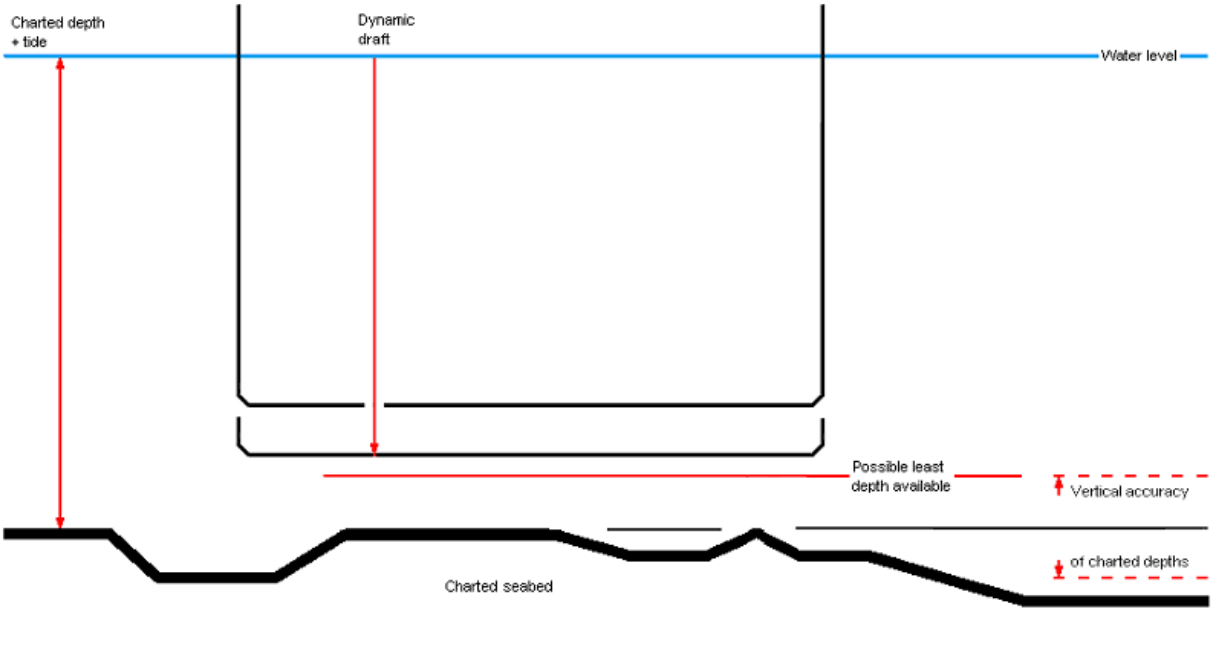
In normal ZOC A1 areas where "Special Order" has not been achieved, or cannot be confirmed, an *additional* 2 metres margin between seabed and keel should be considered as the minimum, in addition to allowances for ship motion, tide, squat / settlement. This will be common outside specific dredged and maintained channels and maneuvering areas.

5.3 ZOC A2 (5 stars)

Surveys within this category have also met the requirements for full seabed search. They have the same level of confidence as ZOC A1 that there are no uncharted features lying between the charted depths or other features already shown on the chart. However, the safety margins the Master should allow in a ZOC A2 area are larger than those in a ZOC A1 area.

Surveys meeting ZOC A2 requirements are generally undertaken in those port areas used by smaller vessels (such as outside the dredged channel), as well as port approach areas and coastal shipping routes. ZOC A2 areas may be subject to a program of periodic re-survey but this is likely to be less frequent.

In practical terms, mariners should make an allowance for an under-keel clearance at least equivalent to the quoted depth accuracy for the area. For a 10-20m draft ship this would be an allowance of at least 1.2 to 1.4m in a ZOC A2 area, plus allowances for squat, settlement and the accuracy of tidal predictions.



ZOC A2 – Full area search undertaken. Significant seafloor features detected (Annex A, note 4) and depths measured.

Vertical uncertainty (accuracy) approximately 1.2 – 1.4m (Annex A, table, and text below).

If the Master considers that there is the possibility of undetected seafloor features, such as in an area where depths may change due to silting, it may be wise to allow an additional 2m safety margin.

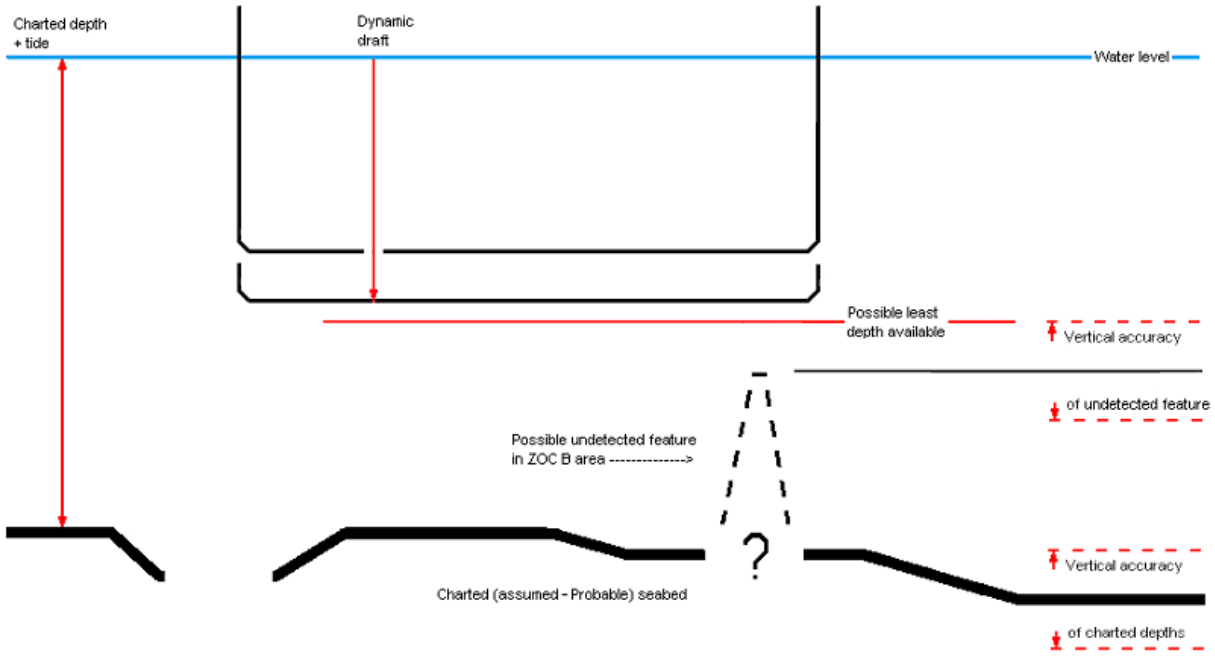
5.4 ZOC B (4 stars)

ZOC B typically includes well conducted coastal surveys prior to the late 1990s. Many sea lanes regarded as adequately surveyed carry a ZOC B classification, and have proven entirely suitable over time. Some surveys are still conducted to this standard away from shipping routes.

While the vertical accuracy of charted depths (the 'known' depths) is the same as for ZOC A2, the size of possible undetected features is not actually specified, leaving both hydrographic offices and mariners with a degree of uncertainty.

In assigning ZOC B to an area, the national hydrographic office responsible for the ENC has assessed that 'undetected features hazardous to surface navigation are unlikely but may exist'. The likelihood of something uncharted affecting surface shipping should therefore be low. In making that assessment, the hydrographic office is likely to have considered 'surface navigation' as shipping that draws no more than 10 to 15 metres when underway (even though vessels with greater draft now exist). This draft estimate is likely to vary from one hydrographic office to another. In making the assessment, they will have then applied a margin between the charted depths and this 10 to 15 metres threshold to allow for the possibility of undetected features. This forms the best estimate of the limits of those areas which are suitable for surface navigation, but which are not ZOC A1 or A2.

As a general recommendation, it would be prudent to allow *at least* an additional 5 metres margin in areas within well used ZOC B shipping routes, and 10 metres in other ZOC B areas. These margins should be increased where the nature of the seabed is irregular (such as a coral or rocky seabed), or subject to change (such as a sandwave area).



ZOC B – Full area search not achieved; uncharted features, hazardous to surface navigation are not expected but may exist.

Vertical uncertainty (accuracy) of surveyed features approximately 1.0m (Annex A, table). However, the potential size of undetected features is not specified.

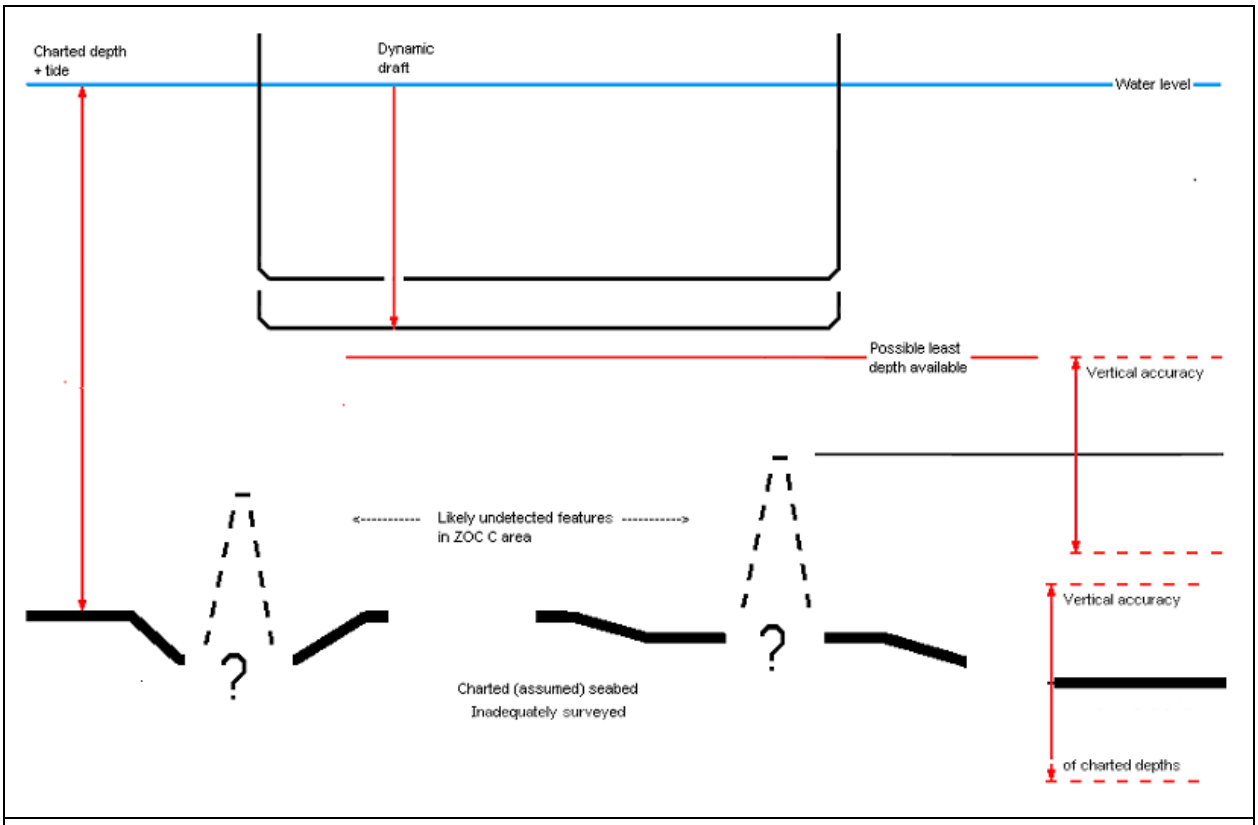
5.5 ZOC C (3 stars)

It is the expectation that uncharted features hazardous to surface navigation are likely to exist that is the key difference between this category and ZOC B. ZOC C covers a broad range of surveys, including:

- those which may be very thorough but just fail to meet the higher accuracy ZOC B standard – many offshore survey positioning systems in the 1950s to early 1990s could only provide around 80 to 100m accuracy;
- older systematic surveys best described as 'historic' - conducted to the standards of their time but limited by the technology of that era;
- passage sounding.

Even in a relatively busy coastal zone a typical ZOC C area is unlikely to have included a comprehensive sonar sweep to ascertain the presence of depth anomalies between adjacent survey lines, instead relying primarily upon the survey ship's echo sounders only. Some hydrographic offices would consider all or parts of ZOC C as 'inadequately surveyed', particularly in depths of 30 to 40 metres or less. Depth contours may possibly be shown as dashed, or some individual depths may be enclosed by a circle on the ENC, both indicating them to be approximate.

Caution is therefore advised when navigating close to shore or adjacent reefs, where depths may rise rapidly from the sea floor, or where the nature of the seabed appears likely to be irregular or subject to change.



ZOC C – Full area search not achieved, depth anomalies may be expected.

Vertical uncertainty (accuracy) of surveyed features approximately 2.0m (Annex A, table). However, the potential size of undetected features is not specified and may be significantly larger than the accuracy of known features.

5.6 ZOC D (2 stars)

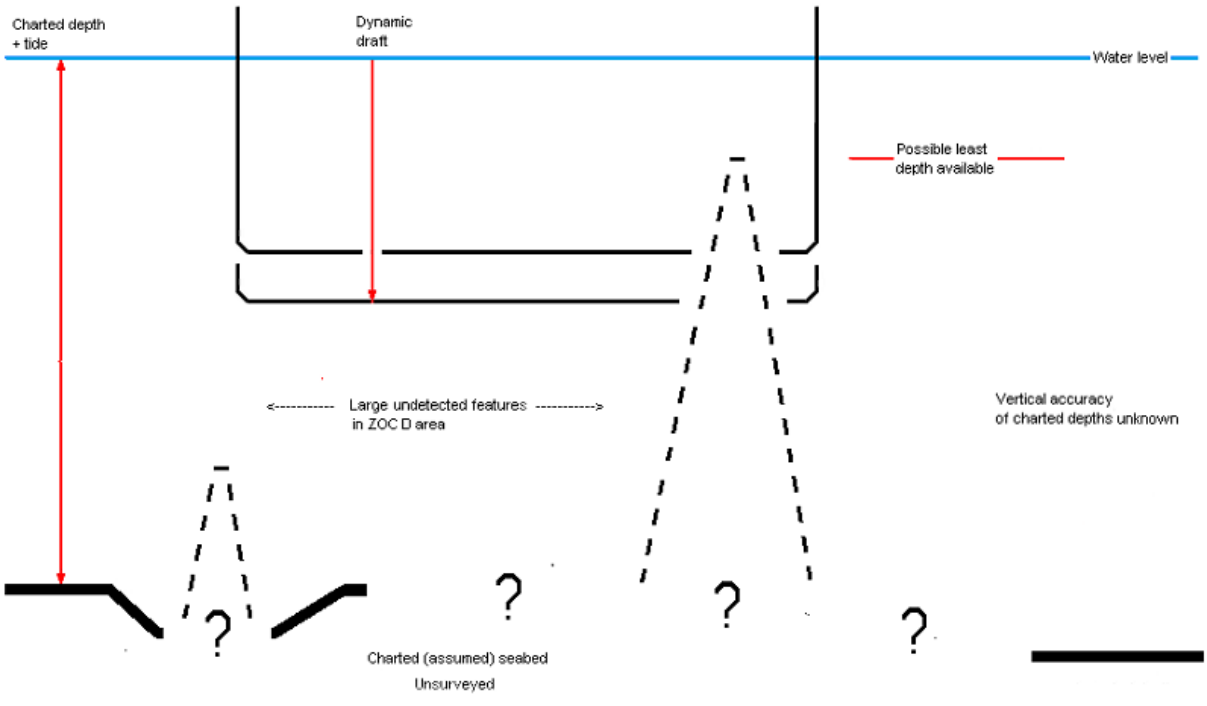
Soundings in ZOC D areas are similarly sourced from historic surveys, but in this case those conducted with large distances between adjacent survey lines, or simply soundings collected on an opportunity basis by ships undertaking routine passage.

Large depth anomalies may include:

- Uncharted features rising from the seafloor to the sea surface in coastal areas – 20 and 50 metre high pillars in 20 and 50 metres of water have been found in former ZOC D areas;
- Uncharted seamounts or very poorly positioned coral atolls in oceanic areas;
- Uncharted shoals in Arctic and Antarctic areas, rising several hundred metres from the seafloor, with gradients too steep for a vessel at sea speed to stop or turn away in time.

Although many ZOC D areas will appear blank (unsurveyed), some may show a few broken depth contours (insufficient information to estimate where they lie), or a few depths enclosed by a circle (approximate). These should not be considered an invitation to disregard the ZOC D assessment made by the hydrographic office when compiling the ENC.

In attempting to navigate a ZOC D area, while following a line of depths on the chart may be better than navigating the white space between, it still remains a very poor precaution. Passage soundings typically come from low accuracy and often very old sources – a small difference in position, combined with the earlier ship passing close to, but not detecting, a significant shoal, can be the difference between an uneventful passage and the probable loss of a ship.



ZOC D – Full area search not achieved, large depth anomalies may be expected.

Undetected features may rise as high as the sea surface.

5.7 ZOC U (U)

This category is used to indicate areas where survey information included has not been assessed for accuracy. This may occur when:

- newly received information has been included, as an urgent precaution, prior to the data being assessed;
- the area depicted is on a small scale ENC, (smaller than 1:500,000) where the same area is also covered at a larger scale, and the larger scale contains the ZOC assessment;
- the national hydrographic office has only limited resources, so has initially published a large number of their first-generation ENC faster than their survey assessment teams can complete assessments;
- depiction at small scale, particularly when it is already provided on larger scale ENC, may be so visually complex as to make the differing areas indistinguishable when viewed on screen. In these cases mariners should refer to the larger scale ENC for precise detail.

6. Summary

Put in simple terms, mariners should be able to navigate with confidence in areas with ZOC A1 and A2 classifications. It is also unlikely that an uncharted danger affecting surface navigation exists in ZOC B areas. In ZOC C areas mariners should exercise a degree of caution since hazardous uncharted features may be expected, particularly in reef and rocky areas. A very high degree of caution is required for areas assessed as ZOC D, as these contain either very sparse data or may not have been surveyed at all. Finally, it is good practice for mariners to treat ZOC U areas with the same degree of caution as ZOC D areas.

Within ports, the Pilot or Harbour Master may advise that higher accuracy surveys have been conducted that allow for smaller under-keel clearances (subject to tides, speed, weather and maneuvering margins). In the absence of this advice, smaller under-keel safety margins should not be assumed.

In coastal shipping areas the most common assessments likely to be encountered are:

- ZOC B – around 30% of the world’s coastal waters,
- ZOC C – around 20% of the world’s coastal waters,
- ZOC D – around 20% of the world’s coastal waters, and
- ZOC U – around 25% of the world’s coastal waters.

While these percentages may vary from place to place, the key point to note is that the standards of surveying in port are only very rarely encountered outside those ports. Ships are therefore at greatest risk away from ports, even though depths may be deeper. An understanding of how much confidence can be placed in the data within an ENC is therefore most important.

7. Zones Of Confidence Categories

ZOC Category (note 1)	Position Accuracy (note 2)	Depth Accuracy (note 3)		Seafloor Coverage	Typical Survey Characteristics (note 5)
A1	± 5 m + 5% depth	=0.50 + 1%d		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) 10 30 100 1000	Accuracy (m) ± 0.6 ± 0.8 ± 1.5 ± 10.5		
A2	± 20 m	= 1.00 + 2%d		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) 10 30 100 1000	Accuracy (m) ± 1.2 ± 1.6 ± 3.0 ± 21.0		
B	± 50 m	= 1.00 + 2%d		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) 10 30 100 1000	Accuracy (m) ± 1.2 ± 1.6 ± 3.0 ± 21.0		
C	± 500 m	= 2.00 + 5%d		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) 10 30 100 1000	Accuracy (m) ± 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				
Column: 1	2	3		4	5

Source: IHO S-57 Ed3.1 Supp 3 (Jun 2014), pp 13-14

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:

Note 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.

Note 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.

Note 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.

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

Depth Significant Feature
a. <40m: 2 m
b. >40m: 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.

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

Note 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.

Note 7. Modern survey echo-sounder - a high precision single beam depth measuring equipment, generally including all survey echo-sounders designed post 1970.

This page
intentionally blank